No. 81 August 2023

Union Internationale de Spéléologie (UIS)

Commission on Volcanic Caves

e-NEWSLETTER

No. 81 - August 2023

Contents

Members and countries ..... Page 04
Editorial ..... Page 05
President's column..... Pages 06-07
Lava caves at the Virunga Volcanoes in Uganda. By J. Dreybodt ..... Pages 08-21
The Agropits (shafts) in Masdache, Lanzarote. A posible natural Occurrence in Pahoehoe lavaflow. By Laurens Smets ..... Pages 22-27
New lava tubes data of Cumbre Vieja (La Palma—Canary Islands). By Alfred Montserrat-Nebot ..... Pages 28-30
An appreciation of the second edition of *Volcanoes: Global Perspectives*. By Annie Bosted ..... Pages 31-35
4th International Planetary Caves Conference– May 4-7, 2023, Haría, Lanzarote, Spain. By Stephan Kempe ..... Pages 36-54
ISV21 Symposium (Galápagos . Ecuador—April 15th-20th, 2024) ..... Pages 55-57

http://www.uis-speleo.org/

vulcAnospeleology
WWW.VULCANOSPELEOLOGY.ORG
UIS Commission on Volcanic Caves

http://www.vulcanospeleology.org/

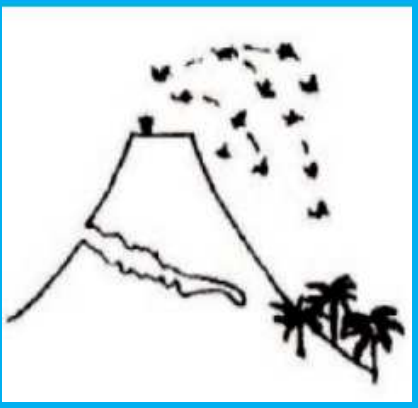
The Commission on Volcanic Caves Newsletter has been published regularly since December 22, 1993. The Newsletter is available free of charge to all members of the commission, and to others who are interested in Volcanic caves.

vulcAnospeleology
WWW.VULCANOSPELEOLOGY.ORG
UIS Commission on Volcanic Caves

UIS COMMISSION ON VOLCANIC CAVES

MISSION STATEMENT

The UIS Commission on Volcanic caves encourages exploration and scientific investigation on volcanic caves, and hosts the International Symposium on Vulcanospeleology about every two years



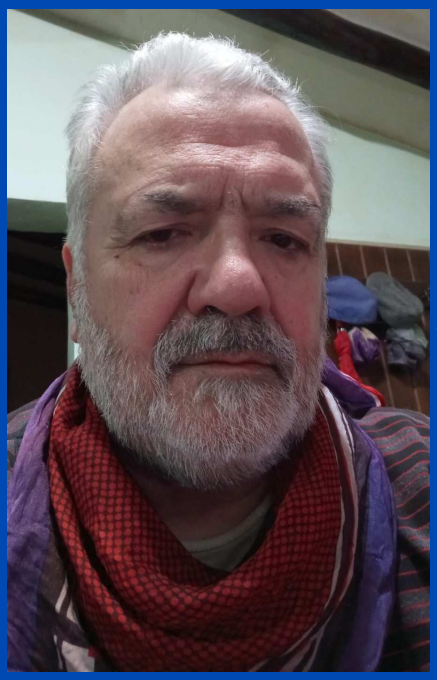
COVER PHOTOS

Top:
Karamara Cave
by H. Koeble

Bottom:
Inside Tubo Rojo.
by David Sanz (IGME-CSIC)

Members of the Commission on Volcanic Caves include:

Barcelos, Paulo	Portugal
Barone, Nicola	Italy
Bell, Peter	Australia
Benassi, Andrea	Italy
Benedetto, Carlos	Argentina
Binney, Frank	USA
Bolger, Terry	Laos
Borges, Paulo	Portugal
Bosted, Ann	USA
Bosted, Peter	USA
Brush, John	Australia
Buhrich, Alice	Australia
Bunnell, David	USA
Butler, David	Australia
Chavdarian, Charles	USA
Collett, Phil	United Kingdom
Cooper, Ben	United Kingdom
Cornish, Bob	USA
Costa, Manuel Paulino	Portugal
Davis, Emily	USA
De Swart, Herman	Netherlands
Espinasa-Pereña, Ramón	Mexico
Foran, David	USA
Forti, Paolo	Italy
Francis, Tim	United Kingdom
Frantz, Bill	USA
Frantz, Peri	USA
Fröhlich, Dominik	Germany
Frumkin, Amos	Israel
Garlan, Arnaud	France
Gillieson, David	Australia
Gracanin, Tomislav	USA
Haemers, René	Netherlands
Honda, Tsutomu	Japan
Kempe, Stephan	Germany
King, Lisa	USA
La, Phuc	Vietnam
Lario, Javier	Spain
Laumanns, Michael	Germany
Lillington, Andrew	United Kingdom
Lindenmayr, Franz	Germany
Linn, Scott	USA
Locke, Christa	Germany
Luong, Tuat	Vietnam
Kim, Lyoun	Republic of Korea
Marchington, Neil	USA
McKinnon, Janine	Australia
Medville, Douglas	USA
Medville, Hazel	USA
Middleton, Gregory	Australia
Mills, Kirsty	United Kingdom
Mills, Martin	United Kingdom
Montserrat-Nebot, Alfred	Catalonia (Spain)
Mouret, Claude	France
Nunes, Joao	Portugal
Oromí, Pedro	Spain
Plowman, Cathie	Australia
Priolo, Giuseppe	Italy
Richards, Bob	USA
Rose, Mary	USA
Rowe, Paul	New Zealand
Smets, Laurens	Netherlands
Smith, Garry	Australia
Smith, Stephen	USA
Starr, Linda	USA
Stefánsson, Árni Björn	Iceland
Stenner, Christian	Canada
Stoffels, Dirk	Australia
Szentes, George	New Zealand
Ton Ngoc, Bao	Vietnam
Toulkeridis, Theofilos	Ecuador
Tunney, Richard	Australia
Urban, Jan	Poland
Van der Pas, Jan-Paul	Netherlands
Van Tran Tan	Vietnam
Veni, George	USA
Wachter, Florian	Germany
Warner, Michael	USA
Whitby, Jenny	Australia
Whitby, Gary	Australia
Woo, Kyung-Sik	Republic of Korea
Wools-Cobb, David	Australia



Editorial

It is a huge commitment for me, who has never edited a publication in English, to accept this challenge of doing so at 71 years old. And to do it from a potentially extraordinary territory for Volcanospeleology such as Payunia, but where in parallel we do not have a critical mass of speleologists to make large-scale explorations.

I find it a little uncomfortable to deal with specialists who, as in this issue, provide research work that is really superior.

I must thank President John Brush for his spirit of service and patience in helping and counseling me through this process.

It would have been easier to use the format of other publications that were in my charge, but I considered it fair to maintain the traditional format, with the aim of, nothing less!, respecting our own history.

It is an honor that Theophilos Toulkeridis is once again in charge of the organization of our biennial symposium, in a country where fantastic theories about the underground world flourished years ago. In addition, Theo is an honorary member of my Argentine federation, and my pride is double then.

Finally, I am pleased that our committee has not confused our activity with political positions, as has often happened. All cavers in the world are colleagues and friends, whether they are scientists or not, and no matter what country they belong to.

I thank you again for the trust placed in me and I apologize for writing these lines in the first person singular.

Malargüe, Mendoza, Argentina, August 2023

Carlos Benedetto
carlos_benedetto@fade.org.ar
+54 9 2604094916

President's Column

Dear fellow members

In this issue of the newsletter, I would like to mention several important matters.

Jim Werker. It is with deep sadness that I note Jim's passing on 13 April 2023. Jim was perhaps best known in caving circles for his highly-regarded cave conservation and restoration efforts. He was also a keen vulcanospeleologist and participated in several International Symposiums on Vulcanospeleology. A memorial celebration of Jim's life was held in Hillsboro New Mexico on 11 June. We hope to include a cave-oriented memorial to Jim in the next issue of this newsletter.

Vice President. Gregory Middleton, who has been the Commission's VP for many years, has advised that he intends stepping down at the time of the ISV next year. Greg has been a strong supporter of the Commission's activities over several decades and his wide experience and sound advice have been very helpful to me and to the wider Commission.

The Commission is now seeking expressions of interest in taking on this important, but not particularly onerous, role. Ideally, it would be preferable for the new VP to be announced and endorsed at the Commission's meeting during ISV21 next April to facilitate a smooth handover.

Please contact me (warwillah@gmail.com) if you are interested in being considered for this important role.

White Nose Syndrome. Over this current (southern hemisphere) winter, I have been assisting researchers who are investigating cave-roosting bat populations in southeastern Australia. The study covers important winter-roosting sites in both karst and volcanic caves. The objectives of the research are to (a) quantify the probable extent and degree of exposure of the bats to White Nose Syndrome (WNS) if it is introduced to Australia; (b) to provide key information about the winter biology of Australian cave-roosting bat populations to quantify the risk of morbidity from WNS; and (c) to provide evidence-based advice to direct future management actions. As many of you would be aware, WNS is a fungal

pathogen that has been decimating cave bat populations in parts of North America over the last decade. The fungus is most active at temperatures of 5-16˚C, thus exposing susceptible bats to considerable risk at many cave sites in North America - and potentially also - in southeastern Australia.

It is possible that humans may have inadvertently facilitated the introduction and/ or subsequent wider distribution of WNS in America. If WNS is introduced to areas that are currently WNS-free, such as Australia, the potential for adverse impacts on cave bat populations is high. As many commission members are regular visitors to caves, often in far off places, we all need to be diligent in preventing cross-contamination by properly cleaning and decontaminating all clothing and gear when moving from one cave site to another. This should be our standard practice. However, when travelling from areas where WNS has been identified, gear that cannot be completely contaminated, should simply not be taken into WNS-free areas.

ISV21

I am advised that planning for next year's ISV21 in the Galapagos Islands is progressing well and that many new caves have been found since the last ISV there in 2014. More info appears in this newsletter.

I look forward to seeing many of you in the Galapagos Islands next April.

John Brush
President, UIS Commission on Volcanic Caves

Lava caves at the Virunga Volcanoes in Uganda

by J. Dreybrodt
Contact: joerg.dreybrodt@gmail.com

Introduction

It is an experience I have had several times. You find new caves by reading articles and books, not necessarily by looking at satellite pictures or local jungle bashing. The expedition to Uganda was not planned and happened only because we faced difficulties with permissions with the authorities in Rwanda. Here former expeditions conducted in 2003-2007 by Swiss-German teams led by Michael Laumanns, discovered a high density of lava caves with the longest of several km length at the southern side of the Virunga mountains. These mountains mark the border between Rwanda, Uganda and the Democratic Republic of Congo (DRC). The original project was to build on these findings and conduct a bio speleological survey in combination with the visit to areas not investigated. The proposal is well received by the Rwanda Development Board and the Nyungwe National Park authorities. The application process and fees were transparent, but it turned slow when film and photo permits were necessary and responses came only after sending reminders. We ran out of time for arranging logistics. This is when I remembered the Uganda section in the Africa Atlas from the BHB series with only a few pages

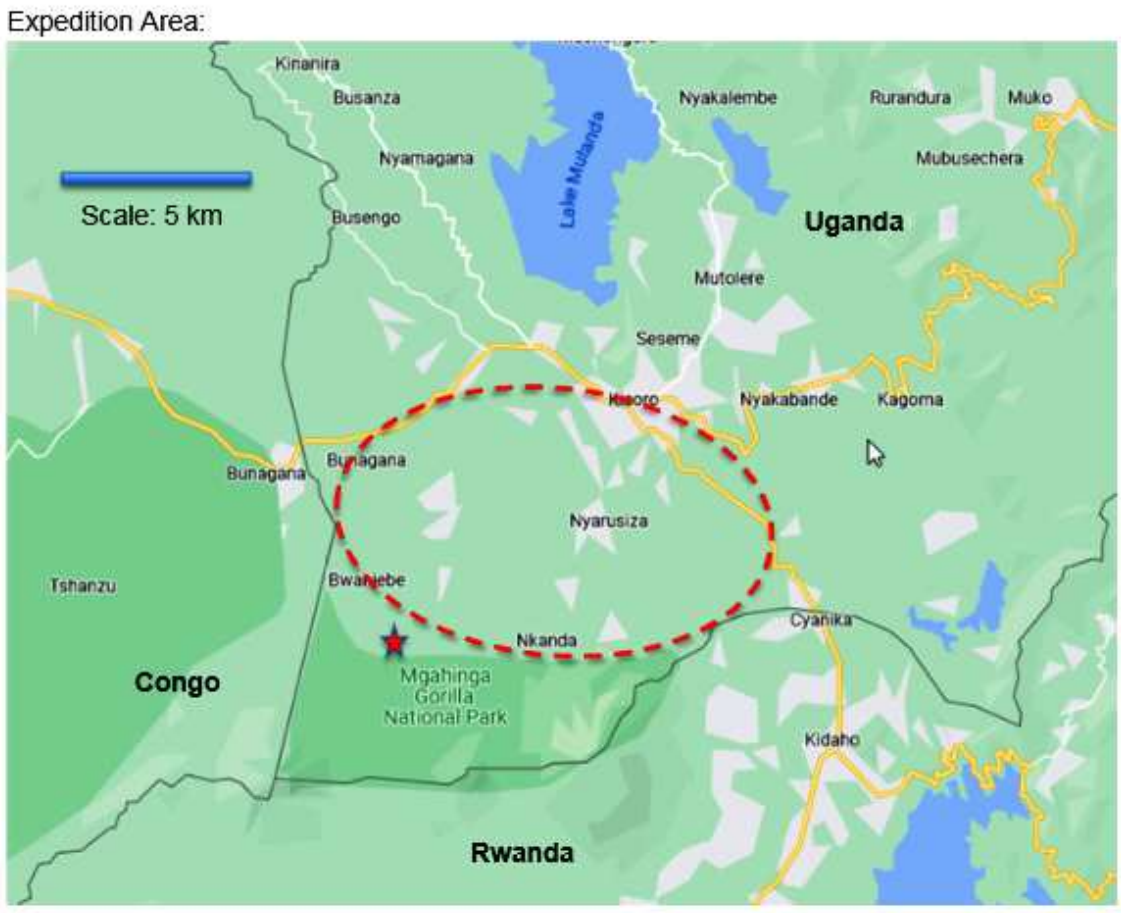


Fig 1: Overview of the expedition area. The base camp is indicated by the star. The dashed circle shows the area with surveyed lava caves.

about Uganda. A quick check confirmed that few caves were known and never any expedition was conducted. This seemed strange since the longest described cave was within the Mgahinga National Park in Uganda. The volcanoes are the same and the potential for lava caves should therefore be similar as in Rwanda The reputation of Uganda is being much more relaxed than in autocratic Rwanda and less formal. We therefore decided to obtain permission on-site and quickly booked flights and a 4x4. We arrived in Kigali in the beginning of December 2022. Since the Virunga Volcanoes are located in the very south of Uganda, it is faster to travel from Rwanda. . A full long day of driving is required from Kampala to the district town Kisoro, while it is only a half day from KIgali. The reasons are good tarred roads in Rwanda and a hassle free to cross border post, which is regularly used by tourist groups. We stopped a few days in the Musanze district, the gateway city where the former expeditions stayed. Here we took two days to make personal contacts with our local partners from a bat and ecotourism project. We visited also a five of the longer caves surveyed by the former expeditions and were surprised about the passage dimension of 10 m width and 8 m height going for kilometres. Afterwards we crossed the nearby border at Cyanika to Uganda and took our base near the main entrance gate of the Mgahinga National Park.

Expedition Team - D.Froehlich

Overview of the expedition area

The Virunga mountain range is in the very south-west of Uganda. It stretches 80 km from the Cyanica border to the Kivu lake with 8 volcano mounts. The border runs along the main ridge. The part of Uganda is with a ridge length of 20 km relatively small compared to the ones in Rwanda and the DRC. The three volcanoes on the Uganda/Rwanda border are Muhabura (4127m), Sabyinyo (3611 m) and Gahinga (3470 m). All are climbable as part of the National Park activities. Gahinga, located in a saddle between the two others, it is in some literature described as a side volcano to Muhabura. They are all extinct stratovolcanoes with Sabinyo being the oldest mount formed in the Pliocene to Pleistocene. The Virunga mountain range is geologically the western branch of the East African Rift System and connects to the Albertine Rift valley. The name "Virunga" is an English version of the Kinyarwanda word *ibirunga*, which means "volcanoes". The area is above around 2300 m sea level and a protected area with the Volcanoes NP on the Rwanda side and the Mgahinga National Park in Uganda. They are famous for one of the few remaining populations of mountain gorillas which is the main reason tourists visit. The only known cave is the Garama cave located within the National Park border. It can be visited as part of a Batwa cultural trail since the cave possesses cultural significance for the local pygmy tribe. It served before the National Park (NP) was designated as a hiding place and for ceremonies. It was surveyed in 1995 by the British expat B. Randall to a length of 324 m and until then the longest cave of Uganda. The area outside the park boundaries is densely populated and used for agriculture. The major staple is corn, but directly to the NP border Irish potatoes are planted. These were introduced by a development project and act as a natural border being less favoured than the corn by wild animals. There are few streams from the mountain tops which discharge into the Mutanda lake in 20 km distance at 1800 m asl. The landscape is very scenic with the lush fields dotted with side volcanoes and a lake view while the

Entrance to Karamara Cave
K. Koeble

high volcano mounts tower behind often in mist. We focused our search on lava caves outside the NP between the Cynanica border post, the nearby border to DRC and towards the district town of Kisoro. An area of around 16 km x 8 km which is drivable in less than one hour in all directions.

Exploration of lava caves

We took our base at the Amajambere Iwacu Community Camp which offers huts, camping facilities and a restaurant with a half board option. They offer cultural walks and even have a cave called Ruhengo as a visitor experience. We could therefore easily hire a guide to search for lava caves in the nearby villages for one week. The afternoon orientation walk on the same day already confirmed three more cave entrances. The next day, we started walking from the camp and surveyed five shorter caves of 25m -100m length and until we found Urutare rwa Sooko. The cave has a 5 m high and 8 m wide entrance portal in a field collapse. The major passage is oriented in north northeast to south southwest direction and on average 10 m wide and 5 m high. The entrance area is full of broken pottery. There are few side extrusions in the main direction. One has a red coloured pahoehoe lava flow. The passage becomes too narrow to continue at the end. There are several higher side passages at 4-5 m height which need a ladder to climb and were therefore not mapped. The total length is 1025 m making it the new longest cave of Uganda. The next six days we extended our range and surveyed in total 23 lava caves of 3 km length. They are listed with coordinates in table 1. Most of them are located at an altitude between 2100 and 2300 m. We assume at this altitude the slope angle provides good conditions to develop lava tubes (pyroducts). We also checked several off small side volcanoes, but found only short fissure oriented cracks.

Entrance to Karamara Cave
D. Froehloch

The entrances of the lava caves were often round collapses of

10-20 m diameter in the field, but occasionally also small holes in the middle of the field of less than 1 m diameter. Urutate rwa Karamara is such a cave with a 280 m long single passage in northeast to southwest orientation.

The passage is relatively small with 3 m width and 2 m height. The lava at the bottom is changing from pahoehoe to aa and again to pahoehoe type. The ceiling gets very low in a few places with crawling until it widens again and stops at the end. The passage is close to the surface with roots hanging from the ceiling everywhere. There are also many bats. The experience is sometimes cruel since many bones are scattered near the entrance, most of them from humans with several intact skulls. We assume from the civil war times between Uganda and Rwanda.

The villagers were always welcoming and guided us to the caves. We paid attention to provide them with headlights and invited them to join. It was for them a new experience in seeing the passages since they usually used mobile phone as lights. One village even insisted on having the information about the length and an instant map while walking back to the car. Our photos with scenic passages quickly spread from our guide to the local Whatsapp communities and we became known. More information about other entrances arrived by calls and posts to our guide Emma. It developed almost into a kind of armchair caving discussing in the evening after a three course dinner at the fire pit which of the reported entrances had the highest potential while serving ourselves drinks from the bar.

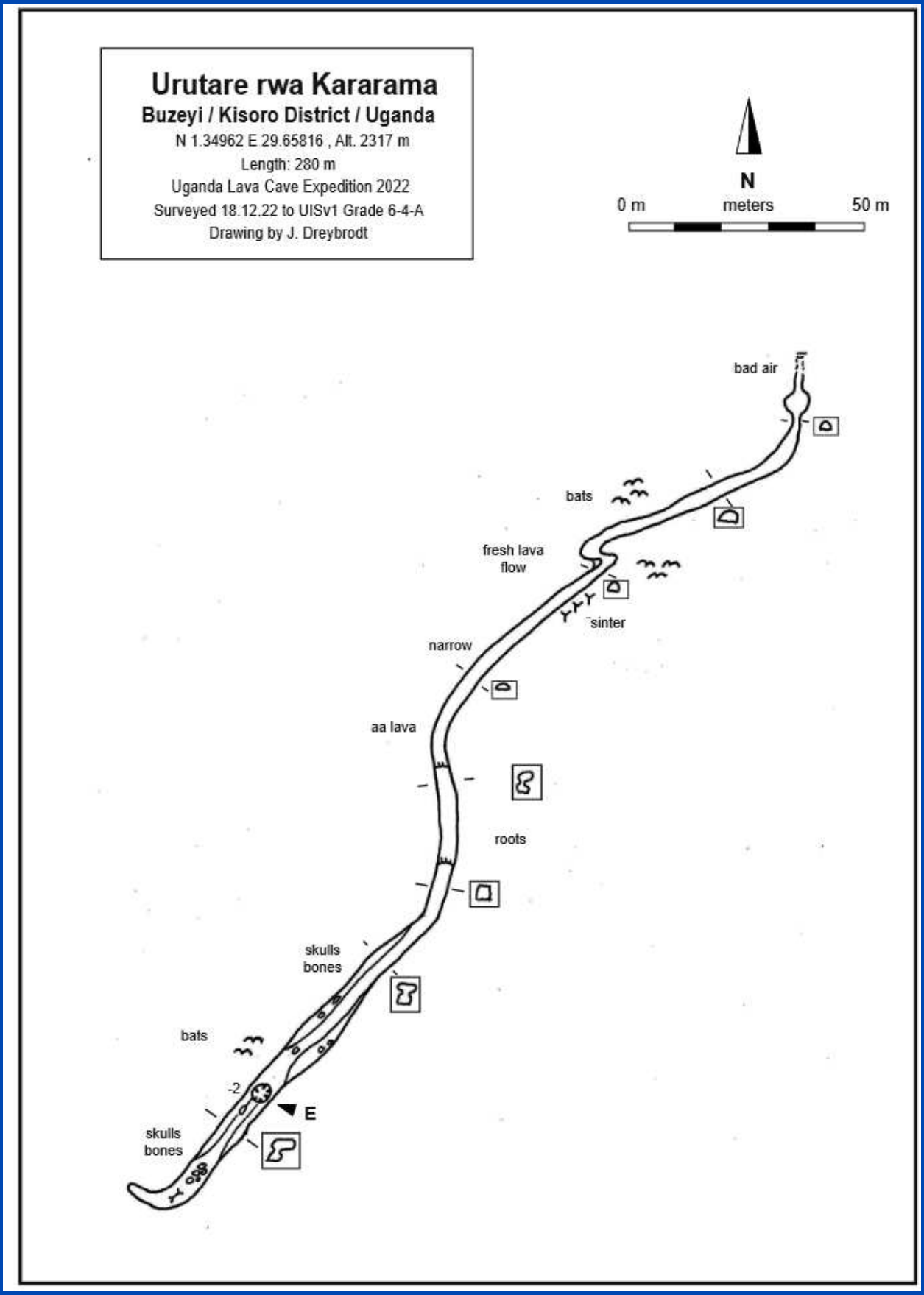
Lava Pillar — D. Froehlich

Biospeleology


Beetle. H. Koeble

The assessment for the biodiversity in lava caves is a relatively new field. Most studies with the discovery of many new species originate from limestone caves in the Dinaric karst. Biospeleological surveys in lava caves are relatively new and were first performed in Hawaii, later in the Canary islands and Azores and recently in Vietnam. There were occasional visits to Sub Saharan Africa mostly on bats. There have been no systematic surveys of subterranean fauna. The expedition conducted an initial assessment on the potential with the expedition member Hannes being an expert in this field. Each cave was carefully investigated and findings recorded in the Cave Life App on Mobile phone which connects to a database in the cloud. In addition pictures were taken with the focus on invertebrates and bats. A sampling was not performed since an official export permission of fauna has not been obtained. This is mandatory to enable research and taxonomy by international experts in museums and universities. The fauna is rich in the visited caves with spiders, beetles and other invertebrates. The presence of organic matter is high with the caves being close to the surface and roots hanging into the passages. Also material is transported into the entrances from streams during the rainy season. Several of the caves have ponds or the passage is partially filled by a lake. These pools are interesting for aquatic fauna, but were not investigated. Many of the caves have bats, some even larger colonies, with three different species identified. A summary of documented fauna is shown in table 2.


Spider — H. Koeble

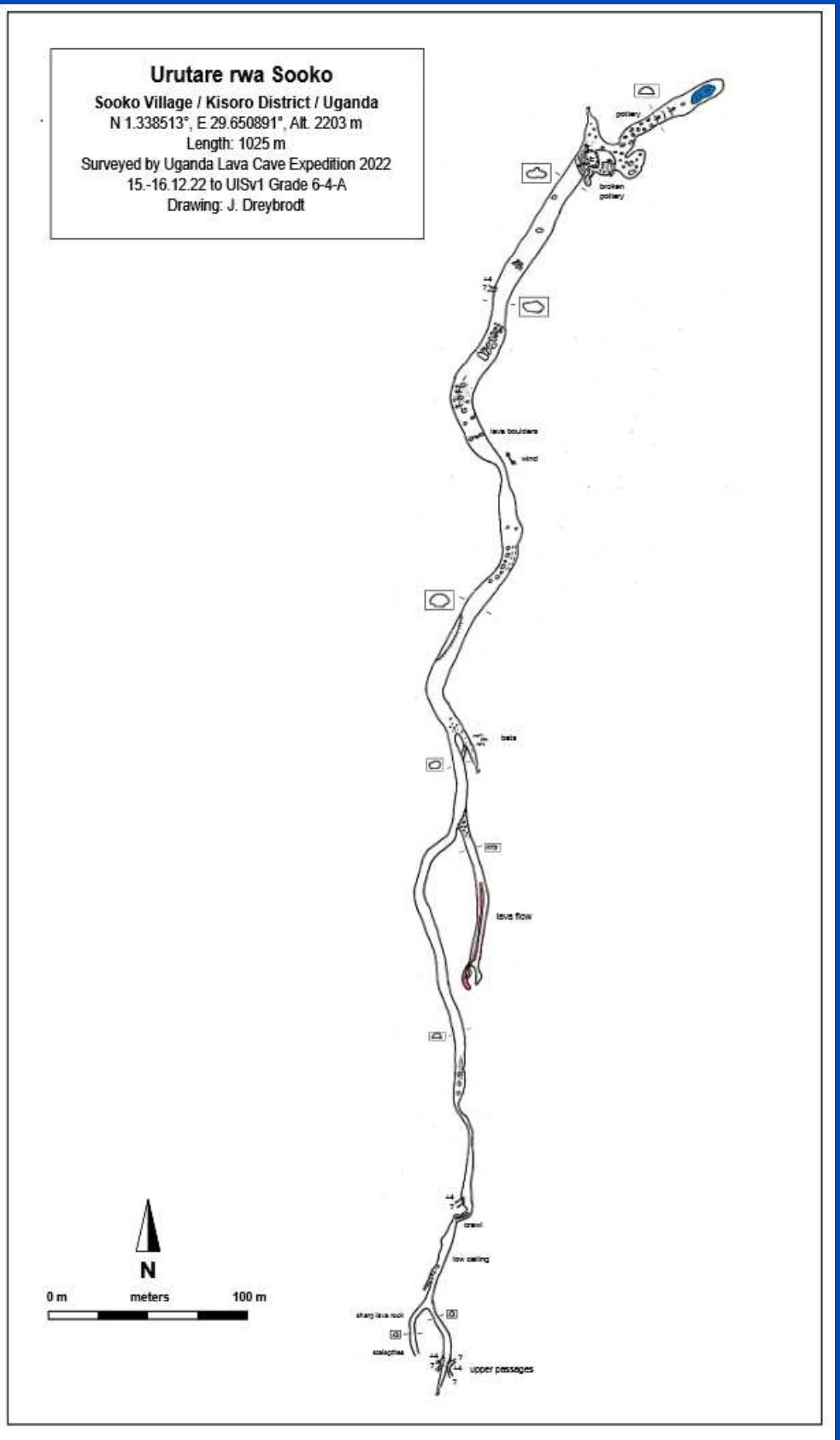

Urutare rwa Kararama
Buzeyi / Kisoro District / Uganda
N 1.34962 E 29.65816 , Alt. 2317 m
Length: 280 m
Uganda Lava Cave Expedition 2022
Surveyed 18.12.22 to UISv1 Grade 6-4-A
Drawing by J. Dreybrodt
N
0 m
meters
50 m
bad air
bats
fresh lava flow
sinter
narrow
aa lava
roots
skulls bones
bats
-2
E
skulls bones

Potential of caves

The last days of the expedition the contact to the director of the Mgahinga NP and the district authorities was established. The NP director quickly understood the potential of our research and was very supportive when seeing our pictures and maps from the last days.

Unfortunately the decision for documenting the caves inside the NP was not within his authority and we sent an application letter to the General director of the Uganda Wildlife Authority in Kampala. By coincidence a German educated tour operator learned from our project and called the personal secretary for a fast decision. Pictures tell more than thousands words applied also here, being quickly posted by Whatsapp. Unfortunately the General Director was in the field and permission was not granted during our stay.

We were in the communication to the district authorities more careful on the advice of our guide.



The forest department was not interested in receiving us, but the head of tourism was available. He praised us for coming to him since the presence of white people “Muzungu” in villages without pre-announcement would have created chaos and confusion within the communities. It is interesting how perspectives can differ! The good things was that he knew the area well and mentioned several of the caves we had already surveyed, but none beyond. This confirmed our observation that most caves are found above 2100 m sea level and the potential to areas beyond is very low. He offered us to inform the villages, arrange guides and to issue an official permit paper for the next day. We called afterwards and said we were short in time with few days left and would return next year.

Sooko Cave Main Passage
H. Koeble

Karamara Cave, passage with roots
H. Koeble

Table 1

Table of surveyed caves:

No	Name	Coordinates (WGS 84)		Altitude	Village	District	Region	Length	Depth
		S	E	(m)				(m)	(m)
1	Urutare Rwa Gasizi South	1.3486534	29.635002	2353	Gisozi	Kisoro	Western	35	
2	Urutare Rwa Gasizi North	1.3484085	29.6350354	2321	Gisozi	Kisoro	Western	25	
3	Urutare Rwisangane South	1.3479862	29.6347977	2326	Gisozi	Kisoro	Western	32	
4	Urutare Rwisangane North	1.3476959	29.634638	2321	Gisozi	Kisoro	Western	125	
5	Urutare rwa Kanyapindu	1.35354	29.64088	2428	Gisozi	Kisoro	Western	50	
6	Urutare rwa Sooko	1.337652	29.652017	2185	Kasuri	Kisoro	Western	1025	
7	Urutare rwa Cugyi	1.33592	29.65228	2185	Kasuri	Kisoro	Western	287	
8	Urutare rwa Chegyezi	1.33144	29.654145	2105	Kasuri	Kisoro	Western	80	
9	Urutare rwa Nyabyondo	1.309758	29.670489	1980	Sooko	Kisoro	Western	236	
10	Urutare rwa Nyamiseke	1.31003	29.6702847	1980	Sooko	Kisoro	Western	65	
11	Urutare rwa Muvubiro	1.31917	29.71419	2062	Rutare	Kisoro	Western	80	
12		1.3206	29.71416	2072	Rutare	Kisoro	Western		-15
13	Urutare rwa Nyamigogo	1.31799	29.714146	2032	Rutare	Kisoro	Western	35	
14	Urutare rwa Chegyezi (Nzongera)	1.34851	29.70212	2337	Nzogyera	Kisoro	Western	20	
15	Urutare rwa Muremure	1.35096	29.70334	2360	Nzogyera	Kisoro	Western		
16	Urutare rwa Kararama	1.34962	29.65816	2317	Buzeyi	Kisoro	Western	280	
17	Urutare rwa Busamba	1.29625	29.70521	2094		Kisoro	Western	10	-5
18	Lava Flow Roof Collapse	1.3504	29.68641	2349	Kabande	Kisoro	Western		
19	Urutare rwa Gakondogoro	1.35231	29.69249	2422	Kabande	Kisoro	Western	77	
20	Urutare rwa Kivumu	1.3515465	29.6846861	2374	Kabande	Kisoro	Western	20	
21	Urutare rwa Chugyi	1.31478	29.63164	2077	Muramba	Kisoro	Western		
22	Urutare rwa Mwambikye	1.26373	29.72663	1876	Gakoro	Kisoro	Western	223	
23	Urutare rwa Ruhengo	1.343003	29.61418	2250	Nyagakenke	Kisoro	Western	312	

Table 2

Table of Biodiversity:

No	Date	Name	Village	Length (m)	Fauna
1	12/13/22	Urutare rwa Maya	Kamaya	270	Rhinolophus clivosus, Small white insects (Hemiptera?) Isopoda, Acari (on bats), Lepidoptera (empty pupas), Gastropoda
2	12/15/22	Urutare Rwa Gasizi South	Gisozi	35	Araneae>Pholcidae
3	12/15/22	Urutare Rwa Gasizi North	Gisozi	25	Araneae>Pholcidae
4	12/15/22	Urutare Rwisangane South	Gisozi	32	-
5	12/15/22	Urutare Rwisangane North	Gisozi	125	Microchiroptera (bones, guano), Araneae>Ctenidae, Isopoda
6	12/15/22	Urutare rwa Kanyapindu	Gisozi	50	Rhinolophus clivosus, Heteroptera>Coreidae Isopoda, Araneae>Pholcidae
7	12/15/22	Urutare rwa Sooko	Kasuri	1025	Rhinolophus clivosus, Araneae>Ctenidae, Araneae>Pholcidae, Brachycera+Nematocera, Aves>Hirundinidae, Collembola, Blattodea (white, small), Isopoda>Armadillidiidae, Coleoptera
8	12/16/22	Urutare rwa Cugyi	Kasuri	287	Miniopterus sp., Rhinolophus clivosus, Rhinolophus cf. Landeri, Araneae>Ctenidae, Brachycera+Nematocera, Myriapoda>Polydesmidae, Myriapoda>Julidae, Ensifera, Blattodea (white), Coleoptera
9	12/17/22	Urutare rwa Chegyezi	Kasuri	80	Rhinolophus clivosus, Araneae>Ctenidae, Collembola, Coleoptera
10	12/17/22	Urutare rwa Nyabyondo	Sooko	236	Opiliones, Nematocera, Isopoda, Myriapoda>Julidae, Collembola
11	12/17/22	Urutare rwa Nyamiseke	Sooko	65	Araneae>Ctenidae
12	12/18/22	Urutare rwa Muvubiro	Rutare	80	Rousettus cf. aegyptiacus, Rhinolophus clivosus, Aves>Hirundinidae
13	12/18/22		Rutare		shaft of ~15m, bee nest at entrance
14	12/18/22	Urutare rwa Nyamigogo	Rutare	35	-
15	12/18/22	Urutare rwa Chegyezi (Nzongera)	Nzogyera	20	-
16	12/18/22	Urutare rwa Muremure	Nzogyera		-

17	12/18/22	Urutare rwa Kararama	Buzeyi	280	Microchiroptera (very long ears, very silent), Coleoptera, Auchenorrhyncha (white), Lepidoptera (Erebidae/Nolidae)
18	12/19/22	Urutare rwa Busamba		10	Araneae
19	12/19/22	Lava Flow Roof Collapse	Kabande		-
20	12/19/22	Urutare rwa Gakondogoro	Kabande	77	Rhinolophus clivosus, Araneae>Ctenidae, Myriapoda>Polydesmidae, Isopoda, Ensifera (cave adapted), Blattodea (white)
21	12/19/22	Urutare rwa Kivumu	Kabande	20	-
22	12/19/22	Urutare rwa Chugyi	Muramba		-
23	12/20/22	Urutare rwa Mwambikye	Gakoro	223	Rhinolophus clivosus, Araneae>Ctenidae, Coleoptera>Staphylinidae, Myriapoda>Polydesmidae, Collembola, Ensifera (cave adapted)
24	12/21/22	Urutare rwa Ruhengo	Nyagakenke	312	Rhinolophus clivosus, Araneae>Ctenidae, Nematocera>Psychodidae, Coleoptera, Coleoptera>Staphylinidae, Collembola, Aves>Hirundinidae

Summary and Outlook

The first systematic speleological expedition was conducted in December 2022 for 10 days to the Virunga Volcanoes Mountains at the very southwestern part of Uganda in Kisoro district. The presence of lava caves was confirmed with most of them located between 2100 m and 2300 m at the foot of the Gahinga mount. In total 23 caves were visited and surveyed with a total length of 3 km. The new longest cave is Urutare rwa Sooko with 1020 m. The caves are north-south oriented and mostly single passages with minor extrusions in the same orientation. An biospeleological survey found a rich subterranean fauna and made an initial assessment by using the cloud based Cave Life App in combination with high resolution photo documentation. A sampling was not performed since an export permit has not been obtained. The potential for other lava caves in Uganda is low with Virunga being the dominant chain and only few small lava fields are more north present.

Logistics & Security


View to Mutanda lake.
J. Dreybrodt

An East Africa Visa allows to enter Rwanda, Uganda and Kenya and can be applied as eVisa for 100 USD. Accommodation is easily found from luxury lodges to camp grounds. Most camps have a restaurant and offer meals and half board. A 4x4 is a must in Uganda with main roads tarred, but the side roads being dirt tracks with a continuous chain of potholes. The ground is of volcanic rock and remains solid after rain falls, which allows visiting during the small rainy season in November-December.

The border to DRC is only a few km away with the M21 resistance army camps behind. It was closed, but insurgencies can occur any time. It is mandatory to inquire before a visit on the situation and a local guide is mandatory.

An Ebola outbreak was present during our visit near Kampala and districts were sealed off to contain the virus. The health situation should be checked before arrival.

The Marbach virus was confirmed in bats in a cave in central Uganda which caused the death of a tourist. The cave was afterwards closed. The bats in Garamba cave were checked by the NP authorities and confirmed as being virus free. Masks are highly recommended in caves with bat roosts.

Expeditions members: Joerg Dreybrodt (Swiss Society of Speleology), Dominik Froehlich and Hannes Koebele (both German Speleological Federation), Emma Mungeri (Uganda)

Acknowledgement

We are grateful to the staff of Amajambere Iwacu Community Camp with the manager Josephine making our stay as pleasant as possible.

The local knowledge and curiosity of our guide Emma was essential to find the caves and establish a good relationship with the villages.

Fred for connecting us to the Uganda Wildlife Authority and helping pragmatically with gorilla permits from his contingent.

Paul Nziza for the identification of bat species

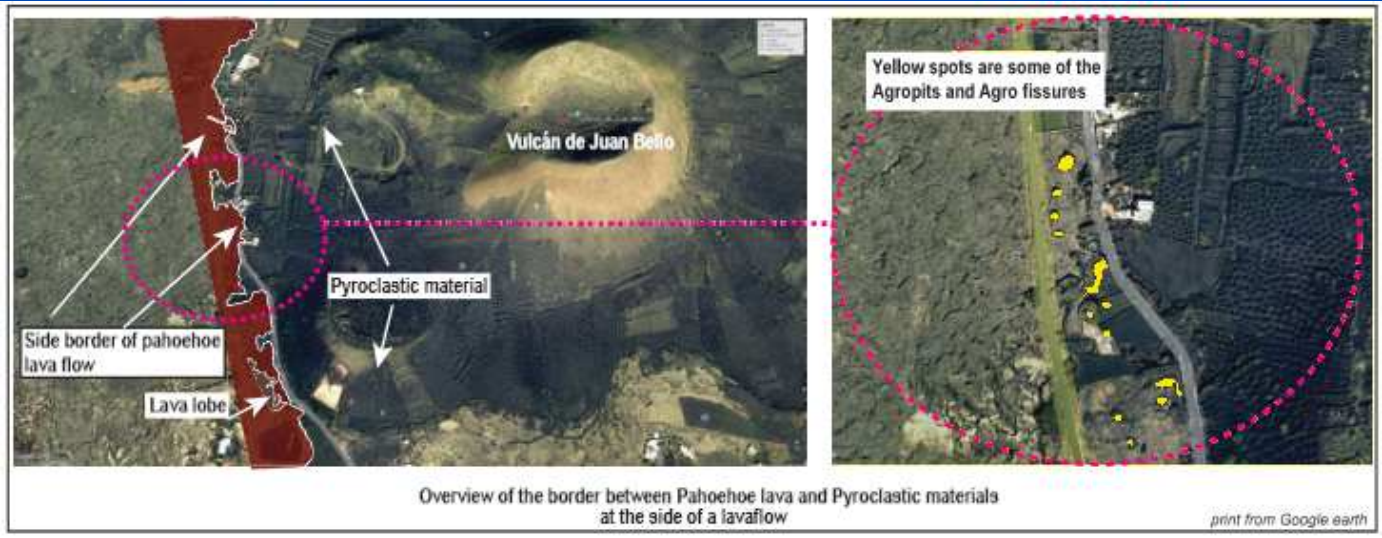
Webpages: https://www.mgahinganationalpark.org/ - https://www.amajambere.com/

Sooko Cave Lava Flow
H. Koeble

The support of the International Union for Speleology (UIS) is greatly appreciated.

The agropits (shafts) in Masdache, Lanzarote . A possible natural occurrence in a Pahoehoe lavaflow

By Laurens Smets
With help of Albert Neumann and Carmen Smith.



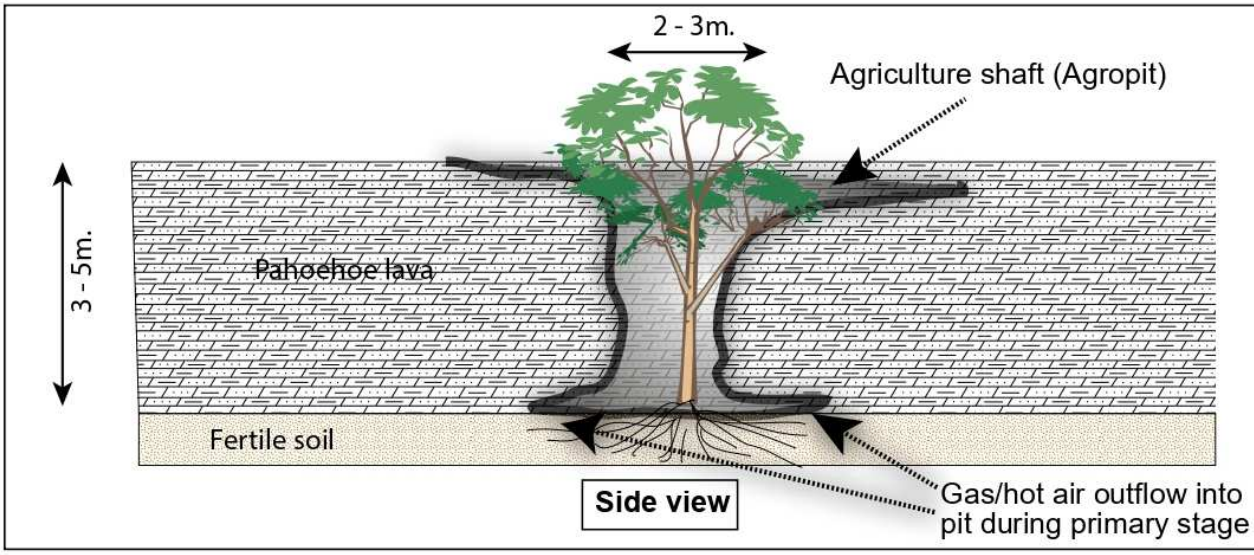
Overview of the border between Pahoehoe lava and Pyroclastic materials at the side of a lavaflow

Almost opposite the famous Cueva de Los Naturalistas or de las Palomas in the centre of the Island of Lanzarote a very peculiar phenomenon can be found. While driving on the road towards the village of Masdache at the side of a Pahoehoe lava flow just at the base of the Vólcan de Juan Bello, several nearly circular spots can be observed.

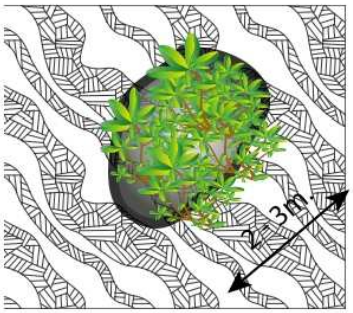
Normally these spots would be low bushes sometimes of figs or just a kind of weed vegetation. Due to the dryness and also due to the high often turbulent winds, plants do not get the chance to become a well formed tree but just stay low to the ground forming a kind of bush or small bush-tree.

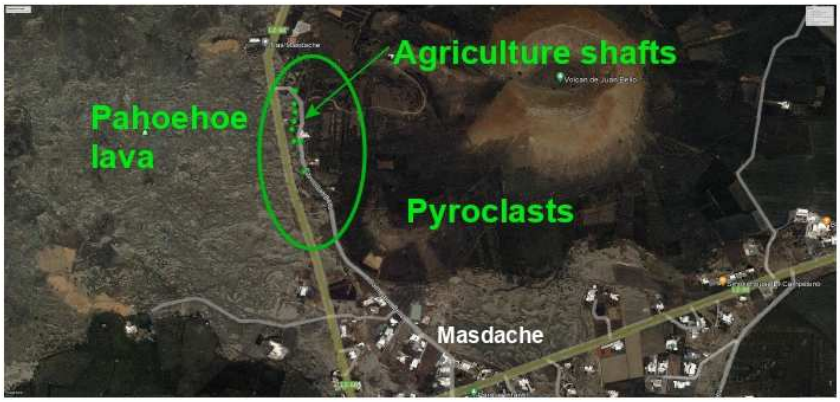
As there was somewhere a small cave mentioned in historic documents in this area we had to check this out and we were surprised what we found.

On a small distance un-deep shafts where situated near the borderline where the Pahoehoe lava meets the Pyroclastic small grained rocks/ash (Tephra , in Lanzarote called Picon). Inside the shafts thick fig trees can be found sometimes with trunks of nearly 30cm across. Near to the area some houses are situated , so the first thought is farming and mined pits. Similar to the once in the La Geria area where the famous grape plants are dug into the Pyroclastic underground.



Primary shafts in Pahoehoe lava as shelter for fig trees in Masdache, Lanzarote. *Drawing: L. Smets, 07-2023*





A talk to an old villager confirmed that there had been done some mining in the area. The mystery kept teasing me in my mind. Why would farmers dig down 3 till 5m. into the hard Pahoehoe lava layer when there is 30m. further uphill soft pyroclastic grain where you easily can dig into like they did all over the Canarian islands. The fig trees in the pits are indeed really big but they are in volume not bigger than the fig-bushes in other parts of the island. And it was not obvious they have more grape than others. It only could be that the holes collect moister during the night , and that the bottom of the pits are more fertile as there is a certain muddy soil on that level under the Pahoehoe lavaflow.

So investigation went on.

It appeared that these kind of pits can be found just near the side or at the tongue of a lava flow. We also found out that at the bottom of such a shaft , just above the fertile soil , mostly a small horizontal fissure went off, as shown in the drawing enclosed. Also primary cracks can be found in the walls. And up and then horizontal layer beds can be seen.

In the Masdache area almost all shafts contain agriculture plants.

In another Pahoehoe lava area near to La Geria we found almost the same kind of phenomenon just in the wild. No adjacent farming, no plants inside the shafts, and indeed at the side or at the tongue of a Pahoehoe lava flow. We also found that a lot of these shafts have been manipulated meaning that some have been widened a bit or cleaned out on the floor. Even the empty one in la Geria has signs of mining at one or 2 sides of the shaft.


A palm tree in a natural depression Montana Diama la Geria

Agropits seem to be quite common in Hawaii as Stephan Kempe told me. Sometimes used to grow crops or in another example just opened during the hunt for eggs of ground-nesting birds.

John Brush told me about cave entrances on Easter Island that were used for gardens probably to give plants more protection from wind, sun and salt spray and more moisture. Claude Mouret confirmed indeed what John Brush had told me.


Agropit with figtree at Masdache

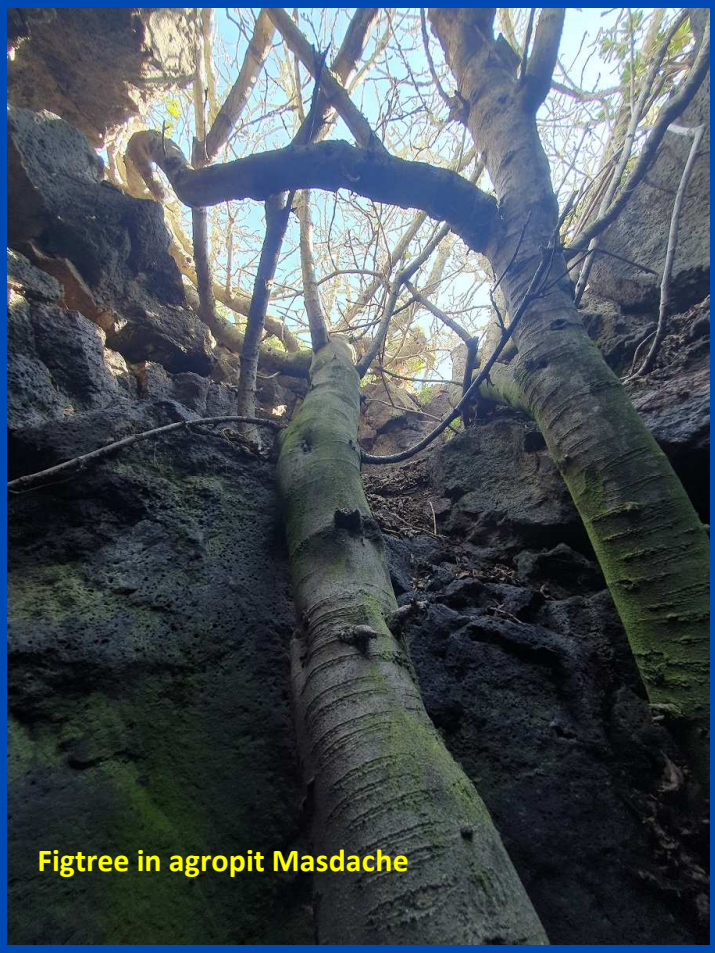
Bill Frantz compared the method of growing crops with the "Forestiere Underground Gardens in Fresno California" but that was under a "Hardpan soil" not volcanic.

Paoli Forti stated that the same type of farming is utilised in Azorean Islands (specifically in Pico

and Terceira) and it was told that this technic was used to protect vineyards from strong winds. To allow accumulation of the scarce soil preserving it inside these large holes drilled or dug in basaltic soil surrounded by boulders.

Paoli Forti also stated that he had seen banana trees (cultivated or wild?) on Easter Island surely growing inside natural collapses above the lava tubes.

Nicola Barone compares the phenomenon to the Pantelleria gardens in Sicilia.


Figtree in agropit Masdache

<u>Hypothetical development of the Agropits near Masdache Lanzarote</u>.

The difference with all the other so called agropits like in Hawaii, the Azorean Islands and Easter Island is that these pits are vertical, mostly circular or oval shaped, mostly natural of origin, relatively deep 3-5m. , situated in Pahoehoe lava, and are always situated at the side or a tongue from a lavatube. The area around is created by typical lobes and toes of lavaflows. The depth of a shaft is exactly the height of the lavaflow lobe untill the fertile soil underneath, Probably some pits have been widened and in some cases rocks have been piled up at the top or inside in some crevises. In some pits the bottom probably has been cleaned out from the rocks or ash which has been fallen in.


Figtree in front and background in a agropit Masdache

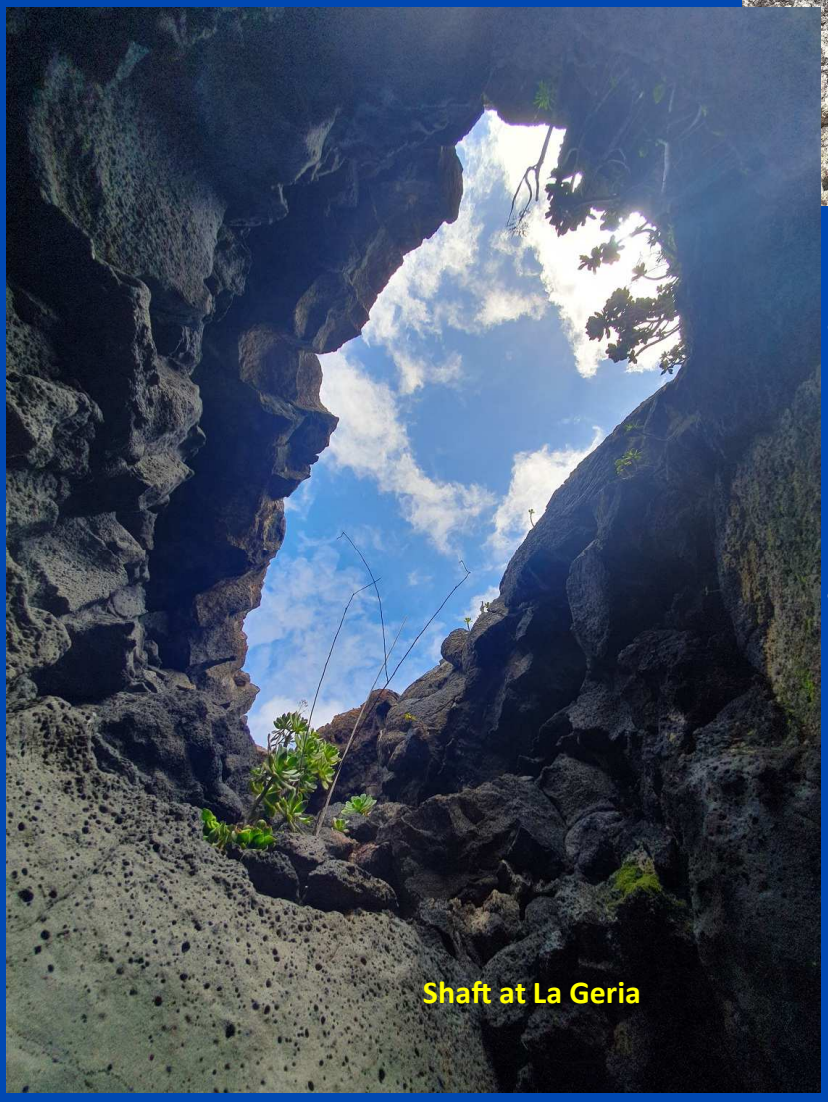
The agropits near Masdache contain figplants, some deep agro crevasses are used for growing vines.

There are so far we know no lavatubes or other cavities below the Pahoehoe lava. So these are certainly no collapses

The origin and development of the agropits can be compared to the lavaflow toe holes and lava lobe holes and fissures in the Pahoehoe lava area of la Geria Lanzarote. Due to several adjacent lobes flowing into or on top of each other, the lava flowing in a kind of toes , the burning soil, hot air and gasses underneath the lavaflow escaping at the toes or at the side of the lavaflow- cavities and crevises can be created between the lobes.

In conclusion these agropits or pits “with or without agricultural use” are a result of certain movements between several multilateral or multilevel lava lobes in conjunction with escaping gasses and hot air escaping (and perhaps also water) from under the Lava flow. Probably as week spots between lava lobes or fissures the shafts in some cases have been widened and/or cleaned up by humans.

Natural pit with constructed wall La Geria



Shaft at La Geria

The phenomenon is probably quite unique at least the combination “pahoehoe lava shaft” and “agriculture” making it into a true unique Agropit of its kind.

Lavaflow toes forming cavities. Ref USGS.gov

Lateral flow lobes forming crevi-ses and cavities. Ref nsf.gov

New lava tubes data of Cumbre Vieja (La Palma-Canary Islands)

Alfred Montserrat-Nebot
Equip de Recerques Espeleològiques (CEC)
Member of the Commission on Volcanic Caves (UIS)

Photo: Alfred Montserrat-Nebot

Now, almost two years after the eruption of Cumbre Vieja (Tajogaite or Cabeza de Vaca, as it is also known), on the island of La Palma, speleologists and members of the IGME-CSIC (Instituto Geológico y MInero de España-Consejo Superior de Investigaciones Científicas) and other entities, have begun to penetrate some of the tunnels formed during the last months of 2021. Even at that time it was observed how large masses of lava penetrated into the flow losing any reference on the surface.

Although some openings had been located by drone sighting months ago, speleologists and scientists have not been able to approach them until a few days ago. Thermal images from drone flights have begun to show temperatures relatively low enough to allow access to the lava tubes.

Temperatures of 50-60 degrees Celsius have not allowed it to go any further than a few tens of meters in some of the most superficial ducts, where cooling has been faster due to air circulation.

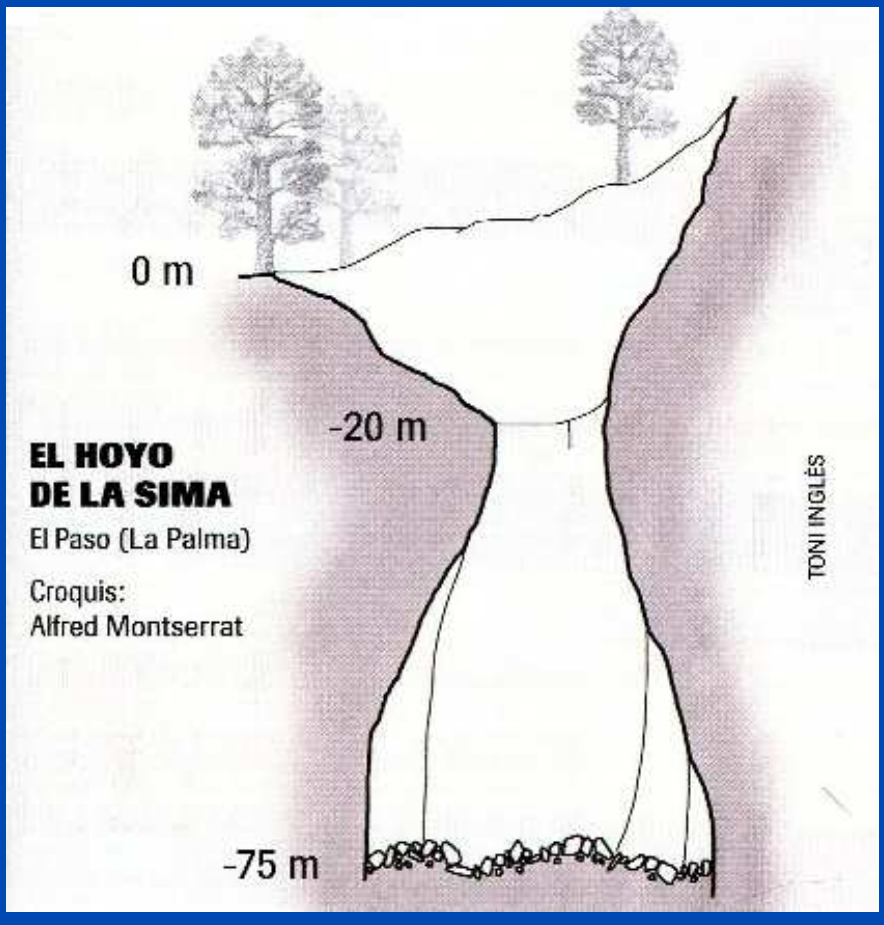
The thermal images obtained in some galleries show that the temperature of the surrounding rock is still above 200 degrees Celsius. This leads to suspicion that in the most important system of lava tubes, which is believed to be deeper, the temperature would exceed 400-500 degrees Celsius.

Expectations are set in the so-called "Tubo Rojo" (Red Tube), due to the color of the solidified lava. This is located in the flow that buried the population of Todoque, and it is believed that it could be the largest lava tube ever formed in the Canary archipelago.

Another conduit that has been visited for a few meters has been the "Austral Tube", one of the surface drainages of the emitting points of the Cogote Mountain.

Until now they have been almost anecdotal explorations but with the continued cooling of the lava tubes they can represent a job for years considering that the eruption of Cumbre Vieja contributed to the surface of the island more than 200 million cubic meters of lava during the 85 days that the 2021 eruption lasted.

From a petrological point of view, the products of this eruption are characterized as basanites, tephrites and phonolites. This gave rise to a flow of basic-alkaline composition, with a low content of Si and moderately high rates of Na and K. A fact to highlight is the low viscosity of the lava (Castro i Feisel 2022), which has been estimated to be ten times lower than lava from the 2018 Pu'u O'o eruption in Hawaii. The viscosity determines the flow regime, which in most castings is laminar. The data obtained show that in Cumbre Vieja the flows could have fluid in a turbulent regime. It will be necessary to study the effect that this low viscosity can represent in the formation of these new lava tubes.



The ridge of Cumbre Vieja or the Southern sector is the volcanically active area of the island of La Palma. Reactivated about 125.000 years ago, it has had seven historical eruptions during the last 500 years (Carracedo et al. 2022). The one in 1646 gave rise to one of the few vertical cavities on the island, the Bucaro San Martin. It is a 57 meter deep well. The other, Hoyo de la Sima, is located in El Paso and is 72 meters deep. Both have morphological features of having acted as eruptive

centers.
The eruption of 1949 gave rise to the Cueva de las Palomas or Tubo Volcánico de Todoque, more than 500 meters long, which was not affected by the flows of 2021. The last of the eruptions of the ridge of Cumbre Vieja, in 1971, gave rise to the Teneguia volcano.

Bibliography

Carracedo, J.C. et alt. (2022).- The 2021 eruption of the Cumbre Vieja volcanic ridge on La Palma, Canary Islands. Geology Today 38(3):94-107 DOI:10.1111/gto.12388
Castro, J.M., Feisel, Y. (2022).- Eruption of ultralow-viscosity basanite magma at Cumbre Vieja, La Palma, Canary Islands. Nat Commun 13, 3174. https://doi.org/10.1038/s41467-022-30905-4

Photo: David Sanz (IGME-CSIC)

This review was first published in *Hawai'i Underground*, Fall 2022 issue.

An appreciation of the second edition of *Volcanoes: Global Perspectives*

by Annie Bosted

The long-awaited second edition of the *Volcanoes* book has, at last, been published. Once again, HSS members Jack Lockwood and Rick Hazlett have drawn on their extensive experience of volcanoes, to produce an impressive tome. That experience includes decades of field work, research, lecturing and consulting. They are joined by a third co-author, Servando de la Cruz-Reyna in Mexico.

Although the blurb on the dust cover recommends the text book to teachers and students as well as "emergency planners, land use planners and civic officials", I would heartily recommend this to active lava cave explorers (and their arm chair counterparts) as a reference book. It is so crammed full of facts, photos, ideas, illustrations, concepts and explanations that I had difficulty reading more than a few pages at a stretch. Since the book has over 400 pages, that's a lot to digest. For this reason, I won't recommend it as "easy reading" for the average caver.

Global Perspectives is a key part of the book's title. I'm sure that this "global perspective" will keep the voracious reader coming back for more. Like many HSS Cavers, I count the thrill of seeing a volcano erupt among my more unforgettable experiences. This book relives those memories, embellishes them and then adds layers of volcanic knowledge from all over the world - and beyond.

The wide scope of this scholarly book is readily appreciated by perusing the 15 chapters comprising five parts. The first part, *Introduction*, covers eruptions, jargon and history. Part Two is entitled *The Big Picture* and explains plate tectonics, volcanism, the nature of magma, its physical properties and why it erupts. The third part is likely to interest the explorers of lava caves. It is entitled *Volcanic Eruptions and Their Products*. The fourth part delves into volcanic landforms, both positive and negative, and also discusses "mass-wasting". Here we read about volcanoes under the ocean and on the moon and other planets, among other topics. The final part, *Humanistic Volcanology* discusses life, climate, human history, risk, mitigation and the economics of volcanology.

As one would expect from a book of this caliber, it is rounded out with an extensive bibliography, appendices, and an index. The final two pages shows 186 volcanoes located on a world map. This map corresponds to numbers used throughout the text and a list of the

volcanoes with more info. about each - including the last time each one erupted.

At the end of each chapter is a list of questions for "thought, study and discussion". I found that reading these questions offered a good short cut to discover what that chapter covered. For example, when I read a question that ran "Why is the presence of datable charcoal so much more widespread beneath pahoehoe flows than it is beneath 'a'a and blocky flows?" my reaction was:

"OK, why? I gotta read this!"

Since this appreciation is written for HSS members, it seems logical to focus on the four chapters in Part Three, where lava caves are discussed. I would guess that there are few books on vulcan speleology that delve into even a small fraction of what these authors manage to cover in this part of their book, so I would advise readers to prepare to be overwhelmed.

Chapter Five has a rather dry title, *Classifying Volcanic Eruptions*, but unless you already know terms like Plinian, Peleean, Surtseyan, Vulcanian and Phreatomagmatic, you have much to discover. Classification systems entitled Lacroix, Rittman, Geze and Walker are all explained and illustrated. This level of detail is apparent throughout the book.

Let me be clear - this is not light reading. It is so much more. It is a scholarly and comprehensive reference book that no vulcan speleologist should go without.

Chapter Six delivers on its promising title, *Effusive Volcanic Eruptions and Their Products* by describing and explaining all that we see around us - above and below the surface. Again, just a sample of the bold-face terms used (spatter ramparts, agglutinate, clastogenic) hint at this book's depth.

For the past 30 years, I have been intrigued by the many iterations of Halema'uma'u (the lava lake on Kilauea). I have read news reports, I have written about it, and even given talks about it, yet the section on lava lakes plugged holes in my knowledge that I did not know existed. Who would have guessed that the movement of sections of crust on the surface of a lava lake mimic the movements of tectonic plates on our planet? And lava lakes also have parallels to "sea floor spreading", "transform faulting" and "subduction". This is not the sort of information one would get from a magazine or a newspaper. Now that the proverbial scales have fallen from my eyes, I see Halema'uma'u quite differently.

The sub-chapter on *Pyroducts, Conduits and Caves*, beginning on page 129, will no doubt interest vulcan speleologists. Those readers who were fortunate to attend the 17th Interna-

tional Vulcanology Symposium held in Ocean View, on Hawai'i, back in 2016 will remember that this book's first author, Jack Lockwood, delivered the key note address. Jack held the attention of his audience as he berated the use of the term "lava tube" and advocated using the term "pyroduct" instead. Here, he again climbs on his metaphoric soap box and again enthralls his readers with the linguistic cause that has been close to his heart for decades. Go, Jack!!

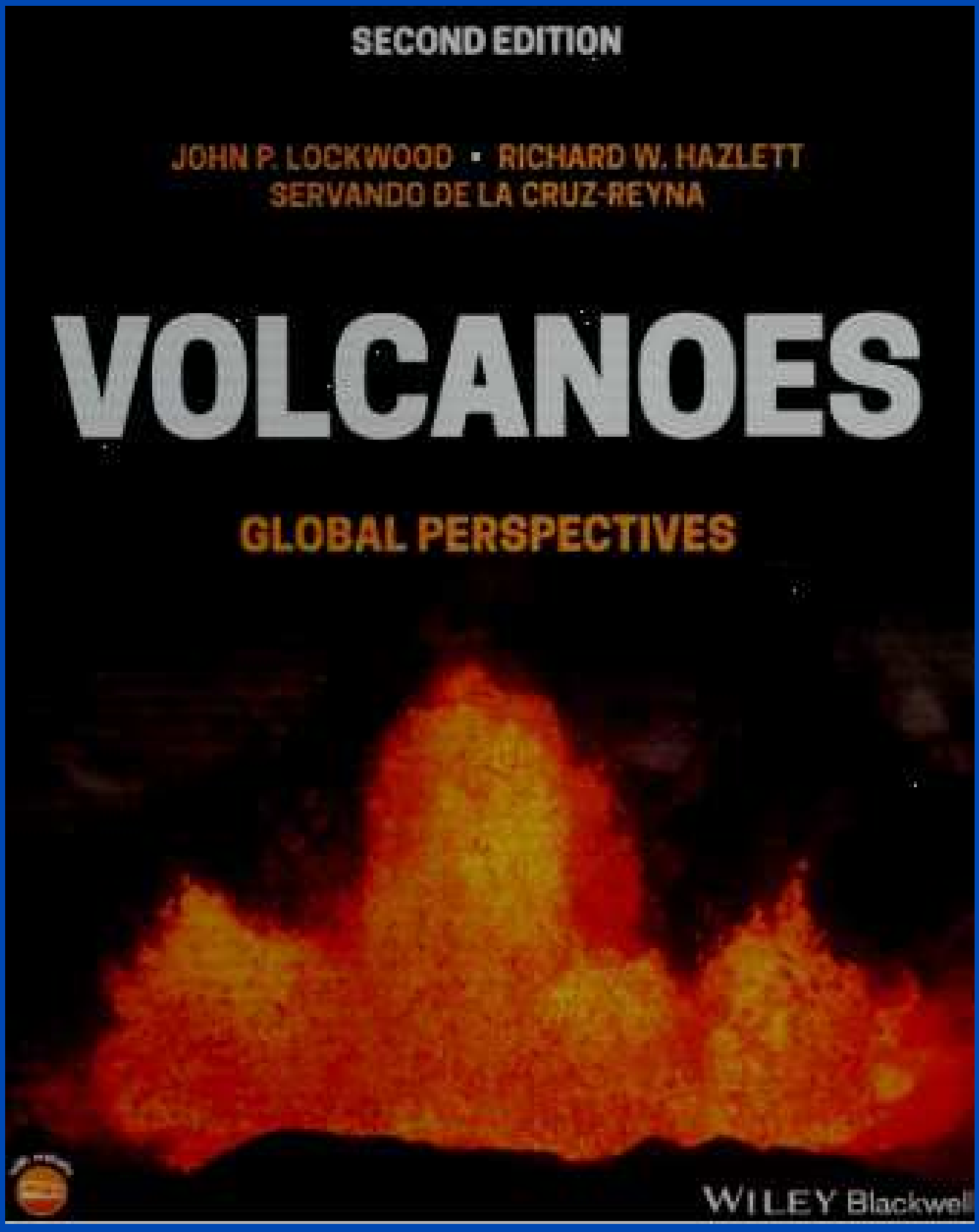
With that out of the way, the authors describe "Pyroduct Formation", explaining shatter rings, hornitos, skylights, thermal erosion, secondary ceilings, and lava falls. They also write about surface structures in pahoehoe and 'a'a.

An interesting factoid caught my attention as I was reading this chapter. Who knew that the world's most fluid pahoehoe was documented erupting from Nyiragongo volcano in the East African Rift Valley? It follows that this super-fluid pahoehoe is also very fast flowing and leaves very thin residual flows only a few centimeters thick - even when the "high lava marks" on burned trees evidence the fact that the initial flow had been about two meters thick as it flowed. Wow! Flowing lava that is six feet deep leaves behind a flow of less than an inch! I feel grateful that the book's authors were able to mine nuggets like these to explain why this mountain's lava has such low viscosity. Much as I love Hawaiian volcanoes, I also like to be awed by stories of volcanoes on the other side of the world. This book does that.

The pages on lava trees and tree molds and tree casts are obviously interesting and remind me of crawling through tree molds left by huge fallen trees on the slopes of Mt. Fuji in Japan. However, my interest level shot up as I turned the page and discovered a photo of . . . an elephant cast! Huh? It seems that thin, fast moving lava flowing from Nyirangongo (again) flowed around the body of a pygmy elephant creating a mold about two meters long. The unfortunate creature's fleshy parts are long gone, but its bones are still lying there in a cast - a cast that even shows where its muscular trunk once lay. How cool is that? Sad, but also cool.

In concluding, I would emphasize that for cavers interested in anything to do with volcanoes, this book is an invaluable learning tool and reference book that will delight and educate in many unexpected ways.

VOLCANOES: GLOBAL PERSPECTIVES. Second edition. By John P. Lockwood, Richard W. Hazlett and Servando de la Cruz-Reyna Copyright 2022 John Wiley and Sons Ltd.


SECOND EDITION
JOHN P. LOCKWOOD • RICHARD W. HAZLETT
SERVANDO DE LA CRUZ-REYNA
VOLCANOES
GLOBAL PERSPECTIVES
WILEY Blackwell

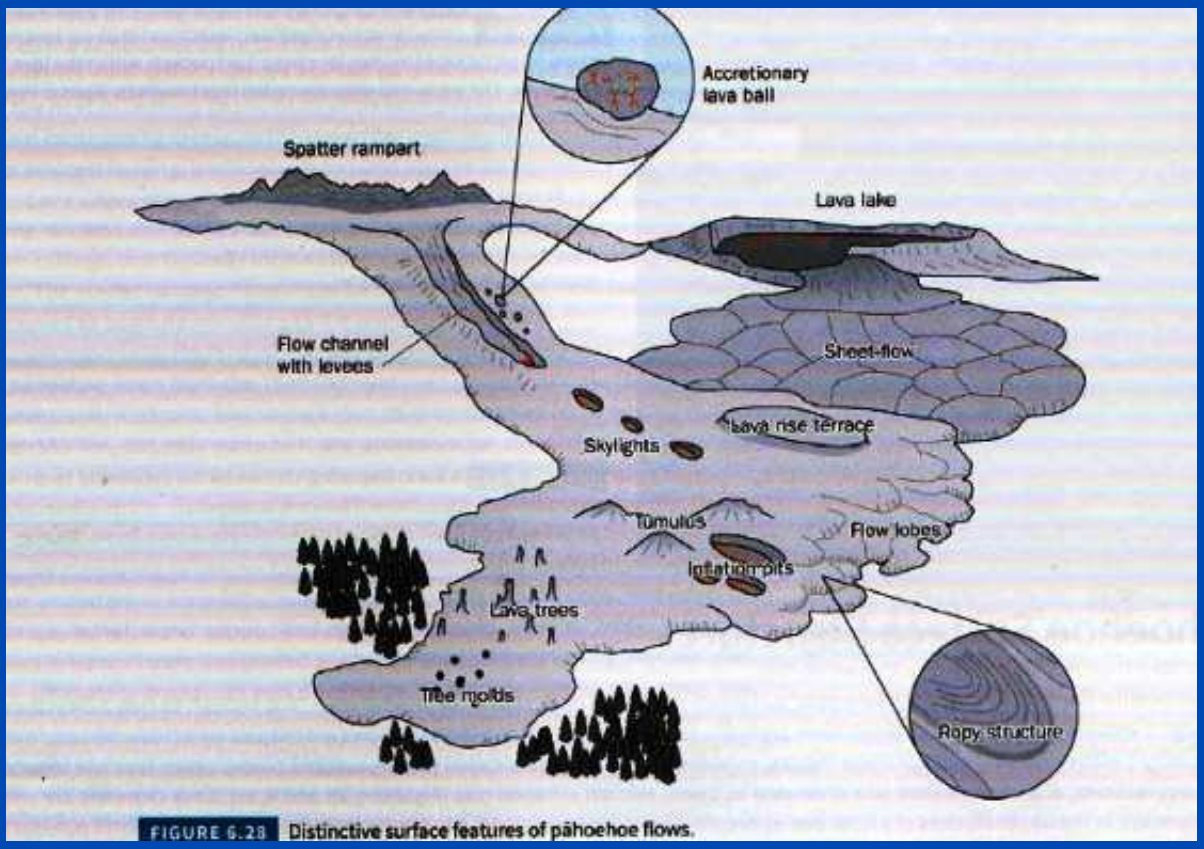
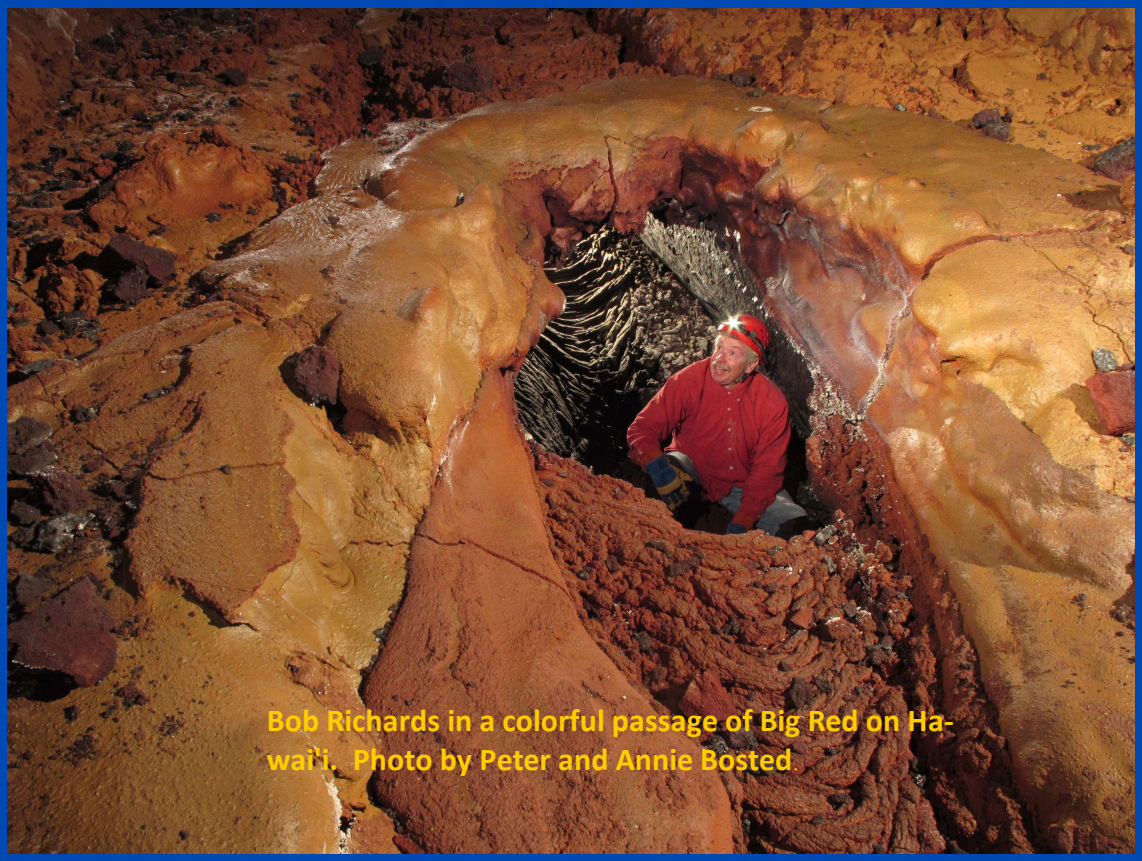


FIGURE 6.28 Distinctive surface features of pāhoehoe flows.



Bob Richards in a colorful passage of Big Red on Hawai'i. Photo by Peter and Annie Bosted.

4th International Planetary Caves Conference
May 4–7, 2023, Haría, Lanzarote, Spain

Stephan Kempe

Lancelot, a knight of King Arthurs's Table and one of those looking for the Holy Grail, gave -indirectly- his name to this mostly bare island, the northern-most of the volcanic Canary Archipelago. The name derives from Lancelotto Malocello, who is said to have established a trading station on the island at the beginning of the 14th century, a millennium after the legendary quest for the cup that once contained the blood of the savior. In a sense the name is appropriate since Lanzarote sports numerous containers that once were filled with the red-hot blood of Earth: lava. Or, as American missionary Titus Coan named such conduits in 1844, "pyroducts": Underground channels that conduct molten rock, in the same way as

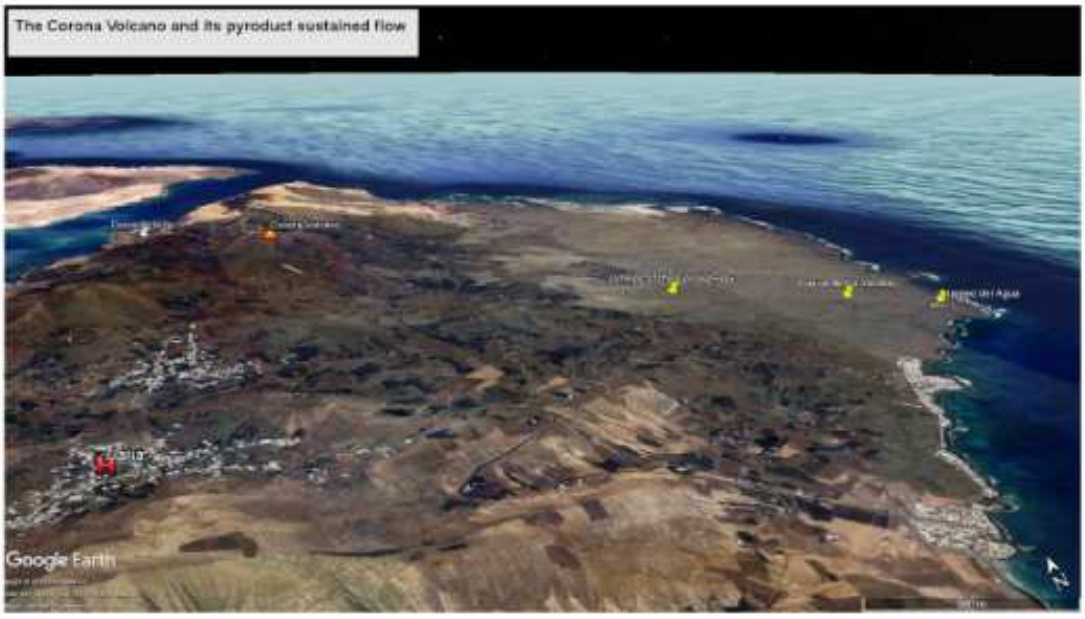


Figure 1: Slanted Google Earth view of the Corona Volcano and its major flow; view from SE.

Roman aqueducts conveyed water gravitationally in covered channels from sources to wells.

Furthermore, Lanzarote (Fig. 1) contains one of the most spectacular and famous of such pyroducts: The Corona System (Fig. 2), a series of caves belonging to the same lava flow. It funneled lava from a prominent cinder cone up to 600 m high, in the north of the Island, eastwards to the Atlantic Ocean. The eruption occurred during the last Glacial (about 22,000 years ago), when sea-level stood about 120 m below present. Thus, the pyroduct extended further seaward and flooded during the Holocene transgression, forming what is now the longest submarine lava cave known, the Túnel de la Atlántida. It is 1700 m long (total length about 2000 m if upper levels are included) and reaches 64 m below present sea-level. The cave's name alludes to another famous story, that of Plato's lost city of "Atlantis". Uphill, the cave becomes the Jameos del Agua, a voluminous cavity transformed into a hip restaurant, bar and

Figure 2: Overview of Corona System pyroducts (courtesy L. Smets).

concert hall. Conceived in 1966 by Lanzarote's foremost artist, César Manrique Cabrera, it has also the aura of a mythical place with its lava-set seawater pond housing the white endemic crayfish (*Munidopsis polymorpha*) and its blue lagoon set in white concrete and surrounded by palms, opening in the Jameo (collapse hole) to the lush night sky. Next, connected by a long siphon, is the Cueva de los Siete Lagos (730 m long) not open to the public (Fig. 3), making the lower part of the Corona Cave System 3364 m long.

Figure 3: The lake in the Cueva de los Siete Lagos (Photo courtesy L. Smets).

Unconnected, further uphill and accessible through another Jameo (at 55 m a.s.l.), we find the show cave Cueva de los Verdes. Unlike

what the name may suggest, there are just a few plants in the Jameo, artificially watered, and the cave's name is simply that of the owner's family. This cave has passages 6.6 km long. The cave itself is best described as an underground canyon, up to 40 m deep, incised and separated into an irregular number of levels by secondary ceilings, originally frozen on top of the flowing lava during downcutting. The cave may easily be the most voluminous pyroduct show-cave world-wide.

The entire system of the Túnel de la Corona starts at the Jameo de Prendes, 209 m a.s.l. and ends at 64 m below sea-level in the Túnel de la Atlántida, resulting in a vertical extent of 273 m and a total cave length of nearly 10 km. Towards the Corona Cone additional caves are situated intersected by collapses, totaling 125 m in length.

This was the setting for the 4th International Planetary Caves congress sponsored by ESA (European Space Administration) and NASA (National Aeronautics and Space Administration) to be conducted at the small neighboring community of Haría and its Tegala Community Center (Fig. 1). The organizers on behalf of ESA were Francesco Sauro and Jo de Waele. The listed topics were:

- Genesis and significance of cave-like features across the solar system planetary bodies
- Mars subsurface exploration and science potential through cave entrances
- Lunar subsurface exploration and science potential through cave entrances
- The possibility to search for subterranean volatiles and determine subsurface habitability
- Space mission concepts, remote sensing, robotic access, and exploration
- The astrobiology potential of planetary subsurface environments
- Technologies and architectures required for human exploration and habitation.

The program ran from Wednesday to Sunday:

Wednesday, May 3, 2023

4:00 pm	Centro La Tegala Hall	Registration desk opening
6:00 pm	El Aljibe Room	Inauguration of exhibition and welcome drink

Thursday, May 4, 2023

8:30 am	Centro La Tegala Hall	Registration desk opening
9.00 am	Centro la Tegala Theater	The state of extraterrestrial cave science and exploration
10.30 am	Centro la Tegala Theater	Lunar subsurface exploration and science potential through cave entrances
11.30	Centro la Tegala Theater	Mars subsurface exploration and science potential through cave entrances
3:00 pm	Centro la Tegala Theater	Genesis and significance of cave-like features across the Solar System: from Earth to planets
5:30 pm	Centro La Tegala Hall	Poster session: cave and pit crater science and exploration

Friday, May 5, 2023

9.00 am	Centro la Tegala Theater	Space mission concepts, robotic access and exploration
12.00 pm	Centro la Tegala Theater	Remote sensing, geophysics and scientific instruments for caves research - part 1

3:00 pm	Centro la Tegala Theater	Remote sensing geophysics and scientific instruments for cave research - part 2
4:00 pm	Centro la Tegala Theater	Astrobiology: subsurface microbial ecosystems
5:30 pm	Centro la Tegala Theater	Special session on Lanzarote and Canary Islands
7.15 pm	Jameo del Agua	Social dinner and special talks at the lava tube of Jameo del Agua
Saturday, May 6, 2023		
8.00 pm	Lanzarote	Field trip to Cueva de Los Verdes, Mirador del Rio, Timanfaya National Park and Los Clicos Lake
9:15 pm	Centro la Tegala Theater	Cave mysteries from Earth to planets
Sunday, May 7, 2023		
9:00 am	Centro la Tegala Theater	Astrobiology: secondary mineral deposits and biosignatures
12:15 am	Centro la Tegala Theater	Discussion - joint statement addressed to space agencies supporting a mission to a lunar or Martian cave in the next decade
2:30 pm	Centro la Tegala Theater	Technologies and architectures required for human exploration and habitation

---

The inauguration of the conference was held in a former cistern, situated below the square of Haria in front of the major hall. Above, the square was rimed by lush red bougainvillea and below, wine and cheese promised a good evening. The exhibition offered two topics: an architectural fantasy of a futuristic city in an unimaginable, large Martian cave and the maps of the real (some of them very large for terrestrial lava conduits) cavities of Lanzarote. The first, named *"Mars Underground: A Landscape Strategy for Long Term Human Colonies on the Red Planet"* was the product of an impressive Master Thesis by *Francesco Axel Pio Romio, University of Ferrara,* and needed a lot of the wine to comprehend, while the second, the bread and cheese part of the evening was simply announced as: *"Volcanic Caves of Lanzarote",* curated by *Gustavo David Santana Gomez, Vulcan Vertical Club, Lanzarote* and featuring mostly graphs by Laurens Smets (who could unfortunately not make it to the conference).

May 4, 2023: THE STATE OF EXTRATERRESTRIAL CAVE SCIENCE AND EXPLORATION

An overview on the potential of cave exploration and research on Earth and beyond.

Chairs: **Francesco Sauro and Penny Boston**

9:00 a.m. *Welcome and Introduction*

9:15 a.m. Boston P. J. *

Bubbles in the Rocks: Human Use of Caves on the Moon and Mars, 25 Years On **[#1082]**

In the 25 years since I first published a paper suggesting the use of caves on the moon and Mars for human habitat, all facets of our relevant understanding have advanced. Are we now ready to tackle the feasibility of this idea?

9:40 a.m. De Waele J. * Sauro F.

Conservative Cave Environment (CCE): an Exclusive Scientific Playground on Earth and Beyond **[#1003]**

Caves on Earth are exceptional conservative repositories of traces and evidences of past processes and life, and as on Earth, extraterrestrial caves will probably reveal a lot of data unique to these exceptional environments.

10:05 a.m. Lee P. *

Planetary Caves: A Rationale for Their Top Priority in Astrobiology, Mars, and "Moon To Mars" Science and Exploration **[#1076]**

Finding extant alien life is the topmost priority for astrobiology and planetary exploration, but due to extreme surface conditions for life on most planetary bodies, accessing their subsurface is critical to pursuing the search.

LUNAR SUBSURFACE EXPLORATION AND SCIENCE POTENTIAL THROUGH CAVE ENTRANCES

This session presented recent advances in the study of lunar cave entrances and their formation mechanisms.

Chairs: Laura Kerber

10:30 a.m. Wagner R. V. * Robinson M. S.

Unwrapping Lunar Pits: Horizontal Views From Orbit **[#1031]**

We developed a technique for reprojecting oblique orbital images into a horizontal viewing plane, using 3D models of lunar pits, and used those images to revisit previous studies of layering in pit walls.

10:50 a.m. Rodeghiero G. * Pernechele C. Massironi M. Pajola M. Simioni E.

Radiance Values Inside Marius Hill and other Lunar Caves **[#1034]**

This paper shows a developed ray tracing code to calculate radiance inside lunar cave pits as illuminated uniquely by the sunlight. This will be used in future camera SNR calculation. The simulations are carried out using optical ray tracing.

11:10 a.m. Horvath T. * Wilcoski A. X. Hayne P. O. Paige D. A.

Thermal Environment of Lunar Pits and Caves: Implication for Future Lunar Missions and Volatiles **[#1078]**

We studied the thermal environment and volatile stability of lunar pits and caves, determining that they have very stable and favorable thermal environments and low to mid latitudes and are unlikely to be significant reservoirs for water ice.

MARS SUBSURFACE EXPLORATION AND SCIENCE POTENTIAL THROUGH CAVE ENTRANCES

This session focuses on exploration and studies of planetary caves genetic mechanisms on Mars.

Chairs: Nadja Zupan Hajna, Tommaso Bontognali Maurizio Pajola

11:30 a.m. Catena S. De Waele J. Sauro F. *

Distribution and morphometric analysis of Candidate Cave Entrances on Arsia Mons, Mars **[#1012]**

This study revealed a differential distribution of APC and Skylight clusters in relation to the geographical location on Arsia Mons and the type of geological terrain.

11:50 a.m. Zupan Hajna N. * Baioni D.

The Potential for Evaporite Caves on Mars and Their Terrestrial Equivalents **[#1036]**

The potential for evaporite caves on Mars and their terrestrial equivalents. Wherever soluble rocks are present and flowing water is present, there is great potential for caves to develop. These processes can occur on Earth and Mars.

12:10 p.m. Bardabelias N. M. * Patterson C. J. S. Blank J. G.

Down-selecting Putative Martian Caves as Viable Targets for Future In-situ Exploration **[#1050]**On Mars, underground structures provide shelter from the harsh surface & are ideal places to search for signs of life. From a pre-compiled list of >1000 possible caves, we found 9 sites at low elevations suitable for future cave exploration missions.

GENESIS AND SIGNIFICANCE OF CAVE-LIKE FEATURES ACROSS THE SOLAR SYSTEM: FROM EARTH TO PLANETS

This session will provide an overview of the state of planetary cave science and speleogenetic studies from Earth to other planets

Chairs: Jo De Waele & Stephan Kempe

3:00 p.m. Kempe S. * Ketz-Kempe C.

Pyroducts, Genesis and Internal Development and their Possible Link to Lunar Rills **[#1006]**

Pyroducts (aka "lava tubes") are possible shelters on Moon or Mars. Genesis of roofs and internal development by erosion/collapse were studied in Hawaii, Jordan, Jeju, Galapagos and Australia (Undara). Discontinuous rills may be pyroduct collapses.

3:20 p.m. Calvari S. Dr. * Kauahikaua J. Dr. Morgavi D. Prof.

Lava Tube Caves on the Earth: A Review of Published Data Aimed at Defining their Field of Formation and Stability, Useful for Comparison with their Extra-Terrestrial Counterpart **[#1005]**

Lava tubes form in basaltic lava flows and lava flow fields, and are virtually absent within rhyolitic flows. We have been mining all available published papers to possibly define the range of parameters under which lava tubes can exist.

3:40 p.m. Tomasi I. * Massironi M. Meyzen C. M. Sauro F. Pozzobon R. et al.

Formation and Evolution of the La Corona Lava Tubes as Analogues for Lunar and Martian Lava Tubes **[#1021]**

Comparative geology of structures like lava tubes is very important when studying similar structures on other rocky bodies in the solar system.

4:00 p.m. Malaska M. J. * Schoenfeld A. Wynne J. J. Mitchell K. White O. et al.

Caves on Saturn's moon Titan **[#1055]**

There may be large number of karstic solution caves on Titan.

4:20 p.m. Fröhlich D. * Köble H. Haemers R. Dreybrodt J.

Discovery of new Lava Caves in Kenya and Uganda **[#1060]**

In 2022 two caving expeditions took place in Kenya and Uganda. In Uganda the new longest cave of the country was discovered and surveyed. In Kenya the 4th longest cave was discovered and surveyed, including a massive bat colony.

4:40 p.m. Sanz-Mangas D. Mr. * Galindo I. Ms. Fernández Lorenzo O. Mr. Vegas J. Ms. López-Gutiérrez J. Mr. et al.

Lava Tube and Skylights Formed During La Palma Volcanic Eruption in 2021: An Analog for Planetary Volcanoes and Ancient Flood Basaltic Eruptions. **[#1044]**

Lava tubes and channels in La Palma volcanic lava flow of 2021 provide an example of an interconnected lava tube system for planetary surfaces comparison like Moon and Mars.

5:00 p.m. Hutchinson K. J. * Pedersen G. B. M. Piispa E. J. Óskarsson B. V.

The Identification and Evolution of Lava Tubes during the 2021 Fagradalsfjall Eruption as a Potential Planetary Analogue **[#1035]**

The development of lava tubes during the course of an eruption in Iceland and a comparison to similar morphologies found on the Moon was done. The potential use of magnetometry to detect subsurface cavities for planetary exploration is investigated.

5:20 p.m. *Coffee Break*

5:30 p.m. POSTER SESSION: CAVE AND PIT CRATER SCIENCE AND EXPLORATION

Lemaire T. Morgavi D. Petrosino P. Calvari S. Di Martire D. et al.

Lava tubes formation at Vesuvius: insights from the 1858 eruption and its lava flow **[#1025]**

This work describes a detail survey carried out on the lava tube in the 1858 lava flow of Vesuvius based on historical documents and field observations. A complete morphological analysis of the tube was performed using 3D scanning.

Morgavi D. Calvari S. Barile C. Petrosino P. Di Martire D. et al.

TUBES: a research project for undersTanding lava tUBe formation and preservation **[#1027]**

The project TUBES focus on a volcanological, petrological, rheological and structural analysis and numerical modeling of the effusive phase of Vesuvius and Etna, aiming on understanding the mechanisms behind the formation of lava tubes.

Nodjoumi G. Lauro S. E. Pozzobon R. Rossi A. P.

From sharad observations to subsurface 3d modelling: the lava plains NW of Ascraeus Mons. **[#1061]**

In this work, we present an open-source tool to perform 2D and 3D analysis on subsurface data acquired by the SHARAD instrument. We present the preliminary results obtained from the subsurface reflectors under lava plains NW of Ascraeus Mons on Mars.

Aftabi P.

Salt-Tectonics, Ice-Tectonics, Plutonic-Volcanic diapirism, Crater-Tectonics and related caves on Mars: A key for future human explorations **[#1001]**

The salt-ice Tectonics is a key for future exploration on Mars. IN this paper used RS and models and nature examples.

Hong I. S. Yi Y.

Detection of Cave Network Beneath Impact Melt Pit Cluster by Using GRAIL **[#1004]**

We search the lunar cave network using gravimetry. A mass deficit signal appeared in the pit cluster. This result suggests that the possibility of the existence of a cave network can be added to the causes of the mass deficit in the cluster.

Parro L. M. López-Martínez G.

Selection of Lunar Caves Entrances as a Destination for Future Exploration **[#1056]**

Hundreds of possible caves have been identified on the Moon and our aim is starting to define a global classification of them in other to select the best complete candidates suitable for establishing a scientific exploration base.

Cambianica P. Cremonese G. Simioni E. Martellato E. Pozzobon R. et al.

ANTHELIA - ANalysis of illumination and THermal Environment of Lunar pIts and lavA tubes **[#1063]**

The human return to the Moon is a fundamental step to improve the knowledge about the evolution of our Solar System. We characterize the thermophysical properties of lava tubes since they are considered good candidates to provide astronauts shelter.

de Luis M. Parro L. M.

Which Asteroid to Prospect? Towards an Internal Fracturing Index Based on the Study of Pit Craters **[#1057]**

We propose the calculation of a simple index that would allow comparing the degree of fracturing of different objects. This a priori knowledge could be useful for decision making in the exploration and prospecting of the most suitable bodies to extract volatiles or minerals.

Espley J. R.

Magnetic Observations of Lava Tubes at Mars **[#1066]**

Local scale surface magnetic observations can detect and characterize lava tubes at Mars.

van Ruymbeke M. Karatekin Oz.

The Gravimeter "B-Grav" for in-situ gravity measurements adapted to the monitoring of lunar caves. **[#1030]**

We investigated a miniaturized 3D compact gravimeter as part of geophysical instrument package dedicated to small bodies of solar system. Principle of the sensor consists of to record the flexure of a flat spring rotating in the gravity field.

Turchi L. T. Pozzobon R. P. Martini P. M. Paoletti L. P. Pernechele C. P.

The OMNICAM: a Bifocal Panoramic Camera for Human and Robotic Space Exploration **[#1015]**

Modern technology can be used by mission operations to maximize the return of any operation. Spaceclick and INAF propose the OMNICAM, a novel camera system which can capture surroundings and an optically magnified portion of the panorama with a single lens and sensor.

Labia F. W. J. Bryce C. Hauert S.

Swarms for Sampling and Detection of Life in Caves on Earth and in Space **[#1062]**

A novel space mission proposal to use a swarm of robots to heterogeneously sample and detect life in caves. The swarm provides scaled up area coverage at a statistically significant sampling rate with greater confidence in possible detection of life.

Csuka J. M. Sanjabi A. Stockwell B. R.

Investigating Lipid Biosignatures in Lava Tubes **[#1074]**

Carotenoids and lipids are valuable for identifying life in extreme environments, particularly in astrobiological contexts. Using liquid chromatography-mass spectrometry, we identified carotenoids present in microbial mats colonizing lava tubes.

Osimiri K. Barry-Sosa A. Christner B. C.

Investigating N_2O cycling by rock hosted microbial biofilms in karstic aquifer cave systems of the UpperFloridan Aquifer. **[#1073]**

Aquifers are crucial reservoirs of freshwater that harbor diverse microbial communities but nitrogen cycling by rock-hosted biofilms is understudied. I focus on these biofilms and the potential for biosignatures reflective of their cycling of N_2O.

Phillips-Lander C. M. Lakrout C. Kulkarni H. Datta S.

Quantifying Background Microbial Biosignatures in Lava Tubes: Implications for Future Planetary Cave Exploration **[#1029]**

Visually identifiable microbial mats and speleothems may not be present in lava tube caves on other planetary bodies. Despite this, the invisible background microbial community may be present and active enough to be quantified.

Hollan S. Heathman I. Kulkarni H. V. Medley J. J. Hathaway J. J. M. et al.

Impacts of High Magnitude Wildfire on Volcanic (Lava Tube) Cave Water Chemistry **[#1067]**

This study examines the impact of wildfires on cave water chemistry in Lava Beds National Monument, California. Post-fire water samples showed lower pH and monovalent ions, and higher Ca2+ and NO3- concentrations.

Pérez-López R. Fernández-Lorenzo O. Palanco S. Galindo I. López-Gutierrez J. et al.

Radon and CO2 emission in lava tubes related to the Cumbre Vieja eruption (2021, La Palma, Canary Islands) **[#1068]**

The last eruption of La Palma (2021) shows a huge amount of lava tubes evolved at different stages from the early beginning to the end of the eruption. The monitoring of inner deep-rooted gas as CO2 and radon shows different models of gas outgassing.

Wagner R. V. Henriksen M. R. Manheim M. R. Miconi C. E. Robinson M. S.

3D Models of Lunar Analog Hawaiian Pit Craters and Measurement of a New Rockfall **[#1046]**

We produced high-resolution 3D models of pit craters in Hawai'i to create digital-form analogs for extraterrestrial pits. In doing so, we identified and quantified a rockfall that occurred in one of those pits, shedding light on erosional processes.

Gmöhling M. Köhl S. Zevering J. Borrmann D. Ferrari S. et al.

Non-invasive identification of lunar rocks with optical and LiDAR systems **[#1038]**

In this work we focus on generally using compact and non-invasive systems for spectral rock identification with emphasis on H2O detection in lunar caves. We use a LiDAR and an optical approach with multiple devices at different wavelengths.

Lee P. Quinn G. Rohrig J. Himmelmann A. Dalal S. et al.

First Terrestrial Analog Field Study of EVA Spacesuit Systems and Science Operations for the Human Exploration of Pits and Caves on the Moon and Mars. **[#1081]**

The human exploration of caves on the Moon and Mars presents challenges beyond those of surface exploration. The first field study of EVA caving requirements with an EVA systems manufacturer was carried out at NASA HMP-2021 at Skylight Cave, Oregon.

Turchi L. T. Varadharajan V. S. V. Beltrame G. B.

Space Missions Monitoring and Multispectral Prospecting with Lunar Autonomous Robotic Swarms (LUNARS) **[#1022]**

With LUNARS we propose application of autonomous recognition to swarm robotics, together with autonomous mapping and navigation. This could drastically improve the level of autonomous sci/ops, minimizing the overall need for operator supervision.

Bessone L. Sauro F. Bandecchi M.

The "Lunar Caves" Mission Study at the Concurrent Design Facility (CDF) of the European Space Agency **[#1010]**

The Lunar Caves CDF study has been performed by ESA to address technical and non-technical gaps for a potential mission to the Marius Hill Pit on the Moon.

Lario J. Martín-Pozas T. Sánchez-Moral S. Cañaveras J. C. Benavente D. et al.

The Sublantida Project (Lanzarote): Aquanauts Under the Volcano **[#1087]**

The Túnel de la Atlántida corresponds to the submerged part of the lava tube complex of the La Corona volcan. During the development of the Sublantida Project various forms associated with the formation of the volcanic tube have been catalogued.

Friday, May 5, 2023 : SPACE MISSION CONCEPTS, ROBOTIC ACCESS AND EXPLORATION

This session focuses on recent advances in mission concepts and technologies for exploration of planetary caves and pit craters on other worlds

Chairs: Laura Kerber & Maurizio Pajola

9:00 a.m. Kerber L. *

An Update on the Moon Diver Mission: Field Tests and Instrument Requirements **[#1083]**

This abstract is about updates on the Moon Diver mission concept.

9:15 a.m. Pozzobon R. * Sauro F. Rossi A. P. Pajola M. Massironi M.

Landing site characterization of Marius Hills pit (Moon): a feasibility evaluation for the ESA Lunar Caves CDF study **[#1009]**

In 2020 ESA issued a call for ideas through the SysNova Lunar Caves system studies framework to explore the lunar subsurface by accessing the Marius Hills Hole. A landing site characterization in support of the DAEDALUS mission concept is presented.

9:30 a.m. Arias M. Navarro-Medina F. * Leon G. Camanzo A. Suarez C. M. et al.

The Robocrane system for providing access, power, and communication to lunar caves **[#1008]**

RoboCrane addresses the challenges of exploring lava caves, proposing a solution for the lack of solar light inside them, the lack of direct sight line for communications with the surface, and the risks of robots to access the bottom of the skylight.

9:45 a.m. Simioni E. * Pernechele C. Pozzobon R. Massironi M. Della Corte V. et al.

The DAEDALUS-CAM: The immersive and stereoscopic way for lunar lava tubes exploration **[#1033]**

Daedalus is the winner of the the SysNova Lunar Caves system studies framework ESA. The CDF defines a mission for the exploration of the Marius Hills sky-light. DAEDALUS-CAM is the imaging payload for reach the primary objective of the mission .

10:00 a.m. Whittaker W. L. * Jones H. L. Ford J. S. Wagner R. V. Domingue D.

Pit-MAGIC: Lunar Pit Morphology & Geomechanics Investigation Via Circumnavigation **[#1071]**

MAGIC explores the Lacus Mortis Pit to determine its origin and history. MAGIC roves the pit rim, stopping often to view its interior using four high-resolution visible and IR cameras. MAGIC constructs 3D models of the pit and returns them to Earth.

10:15 a.m. Elliott L. * Wagner A.

Advancements In Exploratory Planning For A UAS **[#1049]**

Autonomous navigation of unexplored regions is crucial to navigation in on-world and off-world environments. Our system successfully demonstrated the feasibility of exploratory planning in complex and unknown environments.

10:30 a.m. *Coffee Break*

10:45 a.m. Wagner A. * Elliott L.

Mapping a Limestone Cave With an Autonomous Unmanned Aerial System **[#1048]**

In this research, we demonstrate the results of mapping Dinosaur Cave, a limestone cave located near San Antonio, Texas, with a UAS. The UAS explored and mapped the cave fully autonomously without any user input except a takeoff and explore command.

11:00 a.m. Domínguez R. MSc. * Vögele T. Dr. Ocón J. Dr. Germa T. Govindaraj S. et al.

Field Testing of Cooperative Multi-Robot Technology for Accessing and Exploring a Planetary Lava Tube **[#1026]**

Technology for a multi-robot cooperative exploration mission of a skylight and connecting lava tube has been developed in the EU research project Corob-X. The final field test performed in a skylight on Lanzarote island is described in the paper.

11:15 a.m. Siegel V. L. * Stone W. C. Richmond K.

Robotic Survey and 3-D Mapping of Underwater Caves using a SUNFISH® Autonomous Underwater Vehicle **[#1037]**

A highly maneuverable SUNFISH Autonomous Underwater Vehicle has been used to explore and map numerous water-filled caves. The behaviors developed can be applied to other cave-exploration robotic platforms.

11:30 a.m. Lichtenheldt R. * Schütt M. Franke D. Pignede A. F. X.

Towards Robotic Exploration of extraterrestrial Caves – The first in-cave Tests of the DLR Scout Rover. **[#1017]**

In this work we present a test campaign of the Scout rover in a cave on earth. Scout is focused to be as close to space qualifiable hardware as possible in this prototype stage. We summarize on planning, transport, obstacles and campaign results.

REMOTE SENSING, GEOPHYSICS AND SCIENTIFIC INSTRUMENTS FOR CAVES RESEARCH - PART 1

This session provides an overview of remote sensing technologies for the detection and study of terrestrial and planetary caves.

Chairs: Tomaso Bontognali & Riccardo Pozzobon

12:00 p.m. Carrer L. * Castelletti D. Pozzobon R. Sauro F. Bruzzone L.

Assessing Caves Characteristics and Accessibility from Orbital Very High-Resolution Radar Images **[#1023]**

We present a novel methodology with experimental validation based on very high-resolution orbital synthetic aperture radar (SAR) imaging systems, to estimate both caves geometric characteristics and accessibility information in the proximity of a skylight.

12:15 p.m. Richardson J. A. * Bell E. R. Jr. Scheidt S. P. Ng Y. Gallant L. et al.

Pit Crater Vertical Magnetic Surveys **[#1054]**

Vertical magnetic surveys are performed at a collapse pit in Hawaii to measure magnetic anomalies due to exposed volcanic strata. Magnetic signatures can be linked to the presence or absence of magnetic fields during deposition.

12:30 p.m. Cloutis E. A. *

Reflectance Spectroscopy of the Surfaces and Interiors of Basaltic Planetary Lava Tubes **[#1007]**

The spectral reflectance properties of the exterior surfaces of lava tubes differ from interior broken surfaces and can be used to understand conditions present at the time of their formation .

12:45 p.m. Santagata T. S. Mr * Sauro F. S. Dr Pozzobon R. P. Dr Massironi M. M. Dr

3D scanning of lava tubes on Earth as a tool to predict lava tube morphology and morphometry on other planets **[#1059]**

In recent years, 3D scanning techniques are being increasingly used to study lava tubes. Here we describe the techniques used and the scientific study realized through the analysis of wide dataset collected in four countries.

REMOTE SENSING GEOPHYSICS AND SCIENTIFIC INSTRUMENTS FOR CAVE RESEARCH – PART 2

This session provides an overview of remote sensing technologies for the detection and study of terrestrial and planetary caves.

Chairs: Elena Pettinelli & Alexander Braun

3:00 p.m. Martos Y. M. * Espley J. Bell E. Richardson J. Sheppard D.

Analyzing Magnetic Susceptibility and Magnetic Signals of Lava Tubes **[#1042]**

We measure magnetic susceptibility of lava tubes to characterize their magnetic signature. This can be used to understand the magnetic signal measured at the surface and assist in estimating the geometry of the observed lava tube from the surface.

3:15 p.m. van Ruymbeke M. *

ROB intruments set-up in the Cueva de los Verdes (Lanzarote) are adapted to the monitoring of lunar caves. **[#1011]**

The Royal Observatory of Belgium (ROB) was invited in 1987 to contribute to the geophysical monitoring in the Cueva de los Verdes lava tube (Lanzarote). A concept, named EDAS, was developed which is adapted to the monitoring of lunar dynamics.

3:30 p.m. King W. E. * Zanetti M. R. Hayward E. G. Miller K. A.

The Kinematic Navigation and Cartography Knapsack (KNaCK): Demonstrating SLAM (Simultaneous Localization and Mapping) LiDAR as a Tool for Exploration and Mapping of Lunar Pits and Caves. **[#1075]**

Mobile LiDAR has the potential to penetrate the darkness and rapidly characterize the topography of lunar pits and lava tubes. The KNaCK team is using planetary analogs to develop and refine mapping techniques for use on the Moon and other worlds.

3:45 p.m. Bell E. * Schmerr N. Young K. Espley J. Garry W. B. et al.

Relating Magnetic Anomalies of Terrestrial Lava Tubes to Tube Geometry as a Lunar Analog **[#1047]**

This study demonstrates the usefulness of magnetometry for determining the geometry and extent of lava tubes on the Earth, and by proxy the Moon, by relating the magnetic anomalies of the lava tube to the location, width, and height.

ASTROBIOLOGY: SUBSURFACE MICROBIAL ECOSYSTEMS

This session will focus on how the potential characterization of subsurface extraterrestrial life on other worlds.

Chairs: Charity Phillips-Lander & Penny Boston

4:00 p.m. Blank J. G. *

Highlights of the NASA BRAILLE Project: A Mars Analog Astrobiology Study Focused on Volcanic Caves at Lava Beds National Monument (N. California USA) **[#1072]**

This presentation will provide an overview of the NASA BRAILLE (Biologic and Resource Analog Investigations in Low Light Environments) Project, showcasing its most significant accomplishments.

4:15 p.m. Long S. Þorsteinsdóttir G. V. Blischke A. Jónsson S. S. Kopacz N. et al.

Cold, Dark and Lively: Psychrotrophic, Phosphate Mobilizing Bacteria Isolated from Ice and Wall Crust in Icelandic Lava Tubes **[#1024]**

Bacteria isolated from low-temperature, oligotrophic lava tubes were assayed for inorganic phosphate-solubilization. Representative strains were whole-genome-sequenced and their genomes analyzed for metabolic pathways and inorganic ion transport.

4:30 p.m. Miller A. Z. * Gonzalez-Pimentel J. L. Palma V. Jiménez-Morillo N. T. Gutierrez-Patricio S. et al.

Microbial inhabitants and biosignatures of volcanic caves from Macaronesia **[#1065]**

Microbial communities on speleothems from volcanic caves of Selvagens, La Palma and Lanzarote were investigated to understand which microbes grow in these ecosystems and recognize biosignatures valuable for astrobiology.

4:45 p.m. Barry-Sosa A. * Flint M. K. Martin J. B. Christner B. C.

Microbiology of Subsurface Aquatic Environments: Lessons from the Upper Floridan Aquifer **[#1013]**

Geomicrobiological research conducted in the oligotrophic Upper Floridan Aquifer facilitates understanding how life thrives under energy limited conditions, helping to evaluate the life hosting potential of subsurface environments beyond Earth.

5:00 p.m. Cappelletti M. * Ghezzi D. Firrincieli A. Lopo E. Vergara F. et al.

Microbiology of silica amorphization in terrestrial cave environments: potential biosignatures for astrobiology **[#1040]**

This study describes the biodiversity and metabolic activities of microorganisms retrieved from amorphous silica deposits in Imawarì Yeuta cave that are analogs of deposits characterizing the Martian underground.

SPECIAL SESSION ON LANZAROTE AND CANARY ISLANDS

Invited talks to introduce the geology and astrobiology significance of Lanzarote and volcanic islands.

Chairs: Francesco Sauro & Ana Z. Miller

5:30 p.m. Martínez-Frías J. * Miller A. Z. Mateo-Mederos M. E.

Earth Analogs in Astrobiology: Lanzarote, Mars and the Moon **[#1085]**

In this contribution, a general overview of the current knowledge and astrobiological relevance of earth analogs is provided. In addition, essential information about Lanzarote, particularly some selected sites (including lava tubes), will be given.

5:45 p.m. Martínez A. *

Caves, Islands, and...Planets? Eco-Evolutionary Tales from Volcanic Caves in Islands and the Importance of Boundaries to Understand Evolution of Life **[#1086]**

Caves are excellent models for eco-evolutionary research on Earth and, perhaps, beyond! I explore the possibilities they offer using cases of studies from the Canary Islands. I also introduce the unique subterranean aquatic fauna from Lanzarote.

May 5, 7:00 p.m: SOCIAL DINNER AND SPECIAL TALKS AT THE LAVA TUBE OF JAMEO DEL AGUA

7:15 p.m. Bus transfer from Haria to Jameo del Agua
7:30 p.m. Guided tour of Jameo del Agua
8:30 p.m. Social dinner with the invited talk of ESA astronaut Luca Parmitano and video images of Tunnel de la Atlantida (Javier Lario, Atlantida Project, Poster n. 1087)

May 6, 8:00 p.m.: FIELD TRIP TO CUEVA DE LOS VERDES, MIRADOR DEL RIO, TIMANFAYA NATIONAL PARK AND LOS CLICOS LAKE

9:15 p.m: Saturday, May 6, 2023 CAVE MYSTERIES FROM EARTH TO PLANETS

Moderators: Jennifer Blank:

In this informal meeting congress participants can show images of peculiar cave formations or unresolved questions about speleogenesis and microbial ecosystems. Each question will be discussed among the audience in an informal way to foster multidisciplinary discussion and engagement. All images and related topics of discussion should be sent in advance to Dr. Jene Blank (jen@bmsis.org) in order to organize the event.

May 7: ASTROBIOLOGY: SECONDARY MINERAL DEPOSITS AND BIOSIGNATURES

This session is focused on cave mineral research and the study of cave biosignatures with implications for astrobiology.

Chairs: Harshad Kulkarni, José Calaforra

9:00 a.m. Kopacz N. * Csuka J. Baqué M. Iakubivskyi I. Guðlaugardóttir H. et al.

Blue Copper-rich Speleothems in Icelandic Lava Tubes: Strongholds to Subsurface Life on Mars? **[#1043]**

Lava caves on Mars hold the potential of harboring traces of extant or extinct life. To support the development of future astrobiological mission concepts we investigated Icelandic lava tubes, host to a variety of microbes and speleothems.

9:15 a.m. Onac B. P. * Sauro F. Miller A. Z. Palma V. Gasparetto P. et al.

Mineralogy and Isotope Geochemistry Studies in Lava Tubes: Potential Applications in Planetary Exploration **[#1032]**

Mineralogical studies in combination with stable isotope analysis studies are increasingly important in providing a fingerprint for terrestrial sulfates, carbonates and ice accumulated in lava tube caves.

9:30 a.m. Gázquez-Sánchez F. * Sauro F. Miller A. Z. Fernández-Cortés A. Onac B. P. et al.

Stable isotopes of gypsum speleothems in lava tubes: a potential planetary analogue of extraterrestrial gypsum deposits. **[#1018]**

We analyze the oxygen and hydrogen stable isotopes of gypsum hydration water in speleothems from Lanzarote lava tubes to investigate their formation mechanisms.

9:45 a.m. Kulkarni H. V. * Ford J. Datta S. Blank J. G.

Geochemical Analyses and Modeling to Understand Secondary Mineral Formation in Volcanic (Lava Tube) Caves **[#1019]**

This study investigates terrestrial lava tubes as a planetary analog site for Mars and Earth's Moon using principles of aqueous biogeochemistry and advances our understanding about the processes of secondary minerals formation in lava tubes.

10:00 a.m. Bontognali T. R. R. * Tisato N. Lakrout C. A. Sauro F. De Waele J. et al.

Biogenic Speleothems: Defining Morphological Biosignatures for the Search for Extraterrestrial Life in Planetary Caves **[#1039]**

The study of biogenic speleothems, their cataloguing, and the definition of criteria allowing for differentiating abiotic from biogenic speleothems may be very helpful for the search for extraterrestrial life inside planetary caves.

10:15 a.m. Diering A. * Pozarycki C. Stockton A. Cicerone M.

High-resolution Discemment of Biosignatures in Gypsum with Broadband Coherent Anti-Stokes Raman Scattering (BCARS) Microscopy **[#1053]**

This abstract proposes that Broadband Coherent Anti-Stokes Raman Scattering (BCARS) microscopy imaging of samples within planetary caves will provide higher resolution, less fluorescent interference, and faster imaging of well-preserved samples.

10:30 a.m. Bower D. M. * McAdam A. C. Millan M. Knudson C. Graham H. V. et al.

Who Came First – Microbes or Minerals? A Case Study in a Hawaiian Lava Tube **[#1041]**

We characterized the interior of a Hawai'i lava tube using mission-relevant techniques to understand the potential to use secondary minerals as indicators of habitability and active life.

10:45 a.m. Jiménez-Morillo N. T. * González-Pérez J. A. De la Rosa J. M. San-Emeterio L. M. Palma V. et al.

Assessing the Biogenic Source of Organic Molecules Preserved in Subterranean Volcanic Ecosystems: a First Approach Using Ultra-High Resolution Analytical Pyrolysis (UH-Py-GC-TOF-MS) and Chemometrics **[#1064]**

The advantages of the combination of ultra-high resolution analytical pyrolysis with chemometrics will be showed as an innovative strategy for unsupervised classification and visual analysis of organic matrices preserved in siliceous speleothems .

11:00 a.m. *Coffee break*

11:15 a.m. Theiling B. P. * Stern J. C. Bates S. M.

Evaluating Biological Productivity of Hawaiian Lava Tubes with Atmospheric Gases and Surface ATP Measurements **[#1052]**

Here we present preliminary results from a pilot study in the Hi-Seas Lava Tube on Hawaii to characterize changes in biological productivity within the cave using CO_2 and CH_4 concentrations and carbon isotope ratios, and ATP measurements of surfaces.

11:30 a.m. McAdam A. C. * Bower D. M. Achilles C. N. Fishman C. B. Millan M. et al.

Organic-Mineral Associations and Trace Minerals in Materials from a Mars Analog Lava Tube Environment **[#1058]**

We discuss a geochemical and mineralogical study of Hawaiian lava tube materials to understand their alteration mineralogy and the mineral context of organic preservation in this basaltic Mars analog environment.

11:45 a.m. Northup D. E. * Boston P. J. Medley J. J. Spilde M. N. Hathaway J. J. M.

Cryptic Minerals and Microbial Deposits in Caves: Implications for Life Detection on Extraterrestrial Bodies **[#1079]**

Across lava caves on Earth we have found a range of cryptic secondary mineral deposits that contain a diversity of microbial communities that both overlap with and differ from microbial communities present in microbial mats, providing biosignatures.

12:00 p.m. Tng F. * Barua S.

Uncovering Extraterrestrial Life On Mars: Evaluating Potential Technologies to Detect Biosignatures on Planetary Cave Surfaces **[#1045]**

This review will identify and evaluate the potential of existing technologies for predicting astrobiological indicators on Martian cave surfaces and make recommendations to guide the design of future astrobiological missions to planetary caves.

Sunday, May 7, 2023: DISCUSSION - JOINT STATEMENT DIRECTED TO SPACE AGENCIES SUPPORTING A MISSION TO A LUNAR OR MARTIAN CAVE IN THE NEXT DECADE

In this panel the science organising committee of the 4th IPCC and the ESA Topical Team on Planetary Caves will propose and discuss with the conference participants the preparation of a joint statement directed to national space agencies supporting the development and approval of a space mission to a lunar or Martian cave in the next decade.

TECHNOLOGIES AND ARCHITECTURES REQUIRED FOR HUMAN EXPLORATION AND HABITATION

This session is focused on human exploration and potential technologies and programs that could help to prepare future human missions and habitation in planetary caves.

Chairs: Jen Blank & Riccardo Pozzobon

2:30 p.m. Romio F. A . P. Mr. *

Lava Tubes of Mars: Landscape Strategies for Long-Term Colonies on the Red Planet **[#1014]**

Future planetary missions might take advantage of underground caves such as lava tubes. To enable such scenarios, especially for long term living, it is important to design such spaces following principles that enhanced their habitability on Earth.

2:45 p.m. Turchi L. T. * Payler S. P. Sauro F. S. Drozdovskiy I. D. Pozzobon R. P. et al.

The Electronic FieldBook Tool Suite: innovative field science tools for astronaut training and underground exploration **[#1016]**

The Electronic FieldBook (EFB) tool suite is a deployable set of tools being developed for the ESA CAVES & PANGAEA Astronaut Training Campaigns, and designed to support field mission operations, scientific data gathering and transmission to ground.

3:00 p.m. González-Cinca R. *

Power Supply Technologies for Human and Robotic Activities in Lunar Caves **[#1051]**

An analysis of different power supply technologies for long duration human and robotic missions in lunar caves. The appropriate technology for each mission is determined by the type of mission and its corresponding power requirements.

3:15 p.m. Ding D. E. Xie Prof. * Guo Prof. Xiong D. E. Han M. E. et al.

Karst Cave as Terrestrial Simulation Platform to Test and Design Human Base in Lunar Lava Tube **[#1020]**

The structure, size and internal environment of the karst cave on Earth are comparable to those of the extraterrestrial lava tubes, which as a platform to study how to use lunar lava tubes to build a lunar base is promising.

3:30 p.m. Leon G. * Gómez-Sanjuan A. M. Loredo S. Arias M. Aguado F. et al.

Communications Channel Analysis of Lunar Caves **[#1028]**

To support the exploration of lava tube, a communications network shall be deployed. Two different models have been implemented to study the communication link for a roughness scenario and for a specular one, with different multipath effects.

3:45 p.m. Caffrey J. A. * Hayward E. G. Zanetti M. R. Godfroy T. J. Smith M. B.

Radiation and Nuclear Technology in Planetary Cave Environments **[#1077]**

Space nuclear technology enables unique scientific exploration opportunities both above and below planetary surfaces. Caves or pits may in turn enhance the application of these technologies and mitigate effects from all sources of radiation.

4:00 p.m. González F. G. Mr. Muñoz -Elorza I. M. E. Mr. Ceballos D. C. Mr. Leira M. L. Mr. * Guillén A. G. Dr.

ARES STATION: a unique permanent plug-and-play subsurface analog station FOR EXPLORING HABITABILITY AND OPERATIONAL CAPABILITIES ON MARS / MOON LAVA TUBES. **[#1070]**

Astroland is currently operating the first permanent plug-and-play subsurface analog in the environment of a cave in Cantabria, Spain. Isolated from external interferences, hosting a habitat to simulate Mars missions inside a Mars / Moon lava tube.

4:15 p.m. Schlosser K. K. *

Aquanauta CE's first cave diving mission - a high-fidelity analogue approach to space exploration **[#1080]**

Aquanauta CE is a cave diving space analog mission concept exploring the utility of cave diving as a high-fidelity analog concept to space exploration - with a particular interest in behavioral health. (www.aquanauta.space).

4:30 p.m. Heemskerk M. V. * Pouwels C. R. Stéfansson A. B. Sathe A. Konijnenberg E. M. et al.

Risks and Rewards: Extra-Terrestrial Subsurface Exploration and Scientific Potential of Lava Tubes by Analogue ICEE (Isolated, Confined Extreme Environments) Mission on Earth **[#1084]**

It is impossible to judge which of these presentations were the most advanced or interesting, but the author found the approach of Nadja Zupan to search for real karstic environs on Mars the most enlightening. These features may offer cavities at low elevation, while the volcanic caves are mostly associated with the high volcanoes that reach into such thin air, that human usage is excluded *a priori*. Also very interesting were different approaches to researching lunar pits from orbit. Temperature modelling by Horvath Tyler suggests that potential lava caves may have temperatures above 290 K (due

Figure 4: View downhill into the seawater pond of Cueva del Agua. The tables in the foreground seem to sit on a natural, flat floor (unless this is a very, very cleverly constructed floor), typical for lava lake surfaces. Below the black lava of the Corona flow sits on a more reddish lava, which the Corona has cut into. Note the vertical lining in the lower left on the red lava (Photo S. Kempe).

to the solar insulation during the long lunar day), i.e., ice, that may have been present once, should be gone from the caves, shattering hopes to find water there.

The visit to the Jameo del Agua during the evening reception was too short to analyze the morphology and genesis of this large pyroduct, but one feature was striking: The floor of the cave in its higher sections appears to be that of a flat lava lake (Fig. 4) Thus, the lava must have ponded at one stage in the

conduit's evolution before it attained its present cavity. Since much of the floor is artificially covered, and the evening progressed too quickly, there was no chance to verify this conclusion.

Figure 5: Cueva de los Verdes, view downhill onto the closing of the lowest secondary ceiling. Into the V-shaped gap in between accreting benches a large block of lining has become wedged. It had detached from the high canyon walls uphill and floated on the lava river before getting stuck in the constriction (Photo S. Kempe).

A little bit more time was available at the Cueva de los Verdes. It is an amazingly deeply incised canyon, divided into several levels. The secondary ceilings can be seen closing by accreting benches (Fig. 5). After the final day some of the participants were allowed to visit the geophysical laboratory for Earth tides. It is reached uphill of the concert hall of the touristic section at the final level. There the lower level of the cave is six to seven meters high (Fig. 6).

Stephan Kempe
Technical University Darmstadt, Germany,
email: kempe@geo.tu-darmstadt.de

Figure 6: View uphill along the lower level of Cueva de los Verdes towards the geophysical laboratory. Note the closure of a secondary ceiling in the foreground while in the background a much higher secondary ceiling forms the roof of the lower passage. To the left, an accretionary ledge has partly collapsed allowing inspection of the accretionary process (Photo S. Kempe).

The author is grateful to Carlos Benedetto, John Brush, Greg Middleton and Laurens Smets for their editorial help.

ISV21 Symposium
(Galápagos – Ecuador - April 15th-20th, 2024)

Pre-Symposium (April 10-13th, 2024)

Notes:

Those wishing to participate in the full list of opportunities should plan on arrival on or before April 9th. Arrivals April 10th or later will miss a portion of the pre-event trips.

All trips will be for one of the following purposes:
- **Exploration\Survey**
- **Photographic documentation**
- **Science**

Hotel accommodations are on your own. The conference hotel will be "Hotel Flamingo". Two additional hotels will be available across the street, Hostal Gardner and Espana. We are negotiating rates for each hotel.
- **Hotel Flamingo (https://www.hotelflamingo.com.ec/)**
- **Hostal Gardner (hostalgardnergps@gmail.com)**
- **España (Hotel España – Galápagos – Ecuador (hotelespanagalapagos.com)**

All food and beverage is on your own during the days before the official beginning to the ISV.

The conference venue is approximately 200m from the hotels.

ALL persons landing in Galapagos are required to pay a $100USD National Park fee for entry to the islands.

There are two airports in Galapagos. Please make arrangements for arrival at Baltra airport (code GPS). Transfers from the airport to Puerto Ayora include:
- **Bus from airport to channel ferry - free**
- **Ferry to Santa Cruz island - $1-$2USD**
- **Taxi from dock to Puerto Ayora - $40 (4 person max.)**

Please feel free to contact Aaron Addison (aaddison67@gmail.com) with any questions.

Schedule at a Glance:

Wednesday April 10, 2024	Day trips leaving hotel 8am. Returning no later than 6pm daily.
Thursday April 11, 2024	Day trips
Friday April 12, 2024	Day trips
Saturday April 13, 2024	Day trips
Sunday April 14, 2024	Free day on your own

ISV21 Symposium (April 15th-20th, 2024)

Notes:

Registration for this event must be limited to no more than 100 persons

Arrivals are expected on April 14th or earlier

Meals on your own should be budgeted at approximately $20, though more frugal meals are available with some exploring of town.

Hotel rates will be negotiated, but attendees are responsible for booking their own rooms. Estimated rates $40-100 night (depending on occupancy & amenities) incl. breakfast

Schedule at a Glance:

Monday April 15, 2024	Sessions all day, lunch provided. Evening social reception and dinner
Tuesday April 16, 2024	Sessions until 3pm, lunch provided Meeting of Commission on Volcanic Caves, 3-4:30pm Dinner on your own
Wednesday April 17, 2024	Field trips: Floreana and return - Caves of Post Office Bay* (20 person max limit). Additional boat charter fee (Approx $50 for round trip). Santa Cruz caves* - multiple caves offered, many newly discovered in just past few years**. Bag lunches provided, dinner on your own
Thursday April 18, 2024	Field trips: Isabela departure: Caves of Isabela* (20 person max limit). Additional boat charter fee (Approx $60 for round trip) Santa Cruz caves* - multiple caves offered many newly discovered in just past few years**. Bag lunches provided, dinner on your own
Friday April 19, 2024	Field trips: Isabela caves* (afternoon return to Santa Cruz) Santa Cruz caves - multiple caves offered,, many newly discovered in just past few years**. Bag lunches provided. Evening closing dinner for ISV21
Saturday April 20, 2024	Departures on your own, (transportation can be arranged to airport).

*Short descriptions of the field trip caves will be made available at a later date.

**Including the longest known volcanic cave system in South America.