The 13th International Symposium on Vulcanospeleology

September 1-5, 2008

Sunshine Hotel, Jeju Island, Republic of Korea

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Organized by

Jeju Island Cave Research Institute
Cave Research Institute of Korea
Korean Society of Cave Environmental Science.

SCHEDULE

Sunday, Aug. 31

Afternoon:

Registration **From 11:00am** at the Sunshine Hotel Lobby

The registration desk will be open as below:

August 31, 2008 (Sunday)	14:00-20:00
September 1, 2008 (Monday)	09:00-18:00
September 3, 2008 (Wednesday)	09:00-18:00
September 5, 2008 (Friday)	09:00-14:00
September 6, 2008 (Saturday)	09:00-12:00

Evening:

19:00-21:00 Icebreaker at the Sunshine Hotel

Monday, Sep. 1

10:00-10:30

Opening Ceremony *Presided by Kyung Sik Woo*

Opening Remark by In Seok Son, Director of Jeju Island Cave Research Institute

Welcoming Address by Tae Hwan Kim, Governor of Jeju Special Self-Governing Province

Congratulatory Address by Jan Paul van der PAS, President, Volcanic Caves Commission of the UIS

10:50-12:10	SESSION 1
12:10-13:20	Lunch break
13:20-15:20	SESSION 2
15:20-15:40	Coffee break
15:40-17:20	SESSION 3

Evening:

Invited Banquet From 18:30 at the Sunshine Hotel

Tuesday, Sep. 2

Mid-Conference Field Trip No. 1

09:00	Departure from the Sunshine Hotel
18:00	Arrival

Wednesday, Sep. 3

09:00-10:40	SESSION 4
10:40-11:00	Coffee break
11:00-12:40	SESSION 5
12:40-14:00	LUNCH Break
14:00-15:40	SESSION 6
15:40-16:00	Coffee break
16:00-17:20	SESSION 7

Thursday, Sep. 4

Mid-conference Field Trip No. 2

09:00	Departure from the Sunshine Hotel
18:00	Arrival

Friday, Sep. 5

09:00-10:40	SESSION 8
10:40-11:00	Coffee Break
11:00-12:20	SESSION 9
12:20-13:40	Lunch Break
13:40-14:40	Informal Meeting I (organized by Dr. Chris Wood)
14:40-15:40	Informal Meeting II (WoMoVoc)
15:40-16:00	Coffee break
16:00-17:40	Official Meeting of the Volcanic Caves Commission

Evening:

18:30-19:00

Closing Ceremony *presided by Kyung Sik Woo*
Congratulatory Address by Andy Eavis (President, UIS)
Congratulatory Address by Jaul Paul van der PAS
Closing Remarks by Kwang Choon Lee, President, Korean Society of Cave Environmental Science

19:00-

Farewell Banquet at the Sunshine Hotel

PRESENTATION SCHEDULE

MONDAY, SEPTEMBER 1

SESSION 1 ***Chaired by Julia James***

10:50-11:30	Kyung Sik Woo	Jeju volcanic landforms and lava tubes : A road to the World Heritage Inscription
11:30-12:10	Derek Ford	UNESCO: the World Heritage natural site requirements compared to the new "Global Geopark Network" concept and its requirements.
12:10-13:20	LUNCH BREAK	

SESSION 2 ***Chaired by Chris Wood & Andy Spate***

13:20-14:00	Young Kwan Sohn	Geology of Jeju Island, Korea: Growth of a shield volcano on a continental shelf
14:00-14:20	Amos Frumkin	Basalt cave types and paleoclimate of Harrat Ash Shaam, Middle East
14:20-14:40	Peter Gadanyi	Hornito caves on the Aðaldalshraun lava field, Iceland
14:40-15:00	Tsutomu Honda	Study on the structure of Hornito Cave of Mihara-yama in Izu-Ohshima Island, Tokyo, Japan
15:00-15:20	Tsutomu Honda	Under ground cavity of Mt-Fuji -Volcanic cave and Lava tree mold
15:20-15:40	COFFEE BREAK	

SESSION 3 ***Chaired by Chris Wood & Andy Spate***

15:40-16:20	Chris Wood	The Geomorphology of Cavernous Lava Terrains
16:20-16:40	Ed Waters	Lave Tube Caves of the Odaðahraun; Iceland
16:40-17:00	Isao SAWA	Studies of XRF Analysis, X-ray Analysis, K-Ar Age Determination and Polarization-Microscope for Lava, Jeju Lava Caves, Korea
17:00-17:20	Isao SAWA	Many Forms of Secondary Feature in Lava Cave

WEDNESDAY, SEPTEMBER 3

SESSION 4		***Chaired by J. P. van der Pas & John Pint***
09:00-09:40	Paolo Forti	Speleology : a powerful tool in scientific research
09:40-10:00	Stephan Kempe	Immanuel Kant's remark on lava cave formation in 1803 and his possible sources
10:00-10:20	Stephan Kempe	Kempe Cave: an unusual, meandering lava tunnel cave in NE-Jordan
10:20-10:40	Árni B. Stefánsson	Skrúðshellir and two other littoral caves in Iceland
10:40-11:00	COFFEE BREAK	
SESSION 5		***Chaired by J. P. van der Pas & John Pint***
11:00-11:40	Young Woo Kil,	Petrology and Geochemistry of Jeju Volcanic Island, Korea
11:40-12:00	Paolo Forti	Lava tubes of the Rohio lava field (Rapa Nui, Chile): exploration and scientific interests
12:00-12:20	Árni B. Stefánsson	The preservation of Þríhnúkagígur and the status of the feasibility studies of its access.
12:20-12:40	Árni B. Stefánsson	About the preservation and conservation of sensitive formations in Icelandic lava caves
12:40-14:00	LUNCH BREAK	
SESSION 6		***Chaired by George Veni & Fadi Nader***
14:00-14:20	Fadi H. Nader	Exploration, surveying and photo-documentation of the Aariqa Lava Tube (Quaternary − Es Suwaida, southern Syria)
14:20-14:40	Greg Middleton	The unexpected discovery of a Dodo Raphus cucullatus Linn. (Aves, Columbiformes) in a highland Mauritian lava cave
14:40-15:00	Chris Wood	A new survey of the lava caves of Mount Suswa, Kenya
15:00-15:20	Tim Francis	Introduction to the lava caves of Payunia, Argentina
15:20-15:40	John J. Pint	Umm Jirsan: Arabia's longest lava-tube System
15:40-16:00	COFFEE BREAK	
SESSION 7		***Chaired by George Veni & Fadi Nader***
16:00-16:20	George Veni	The Karst Information Portal: A Vital Resource for Non-Karst Caves and Related Phenomena
16:20-16:40	Andy Spate	Lava caves with calcite speleothems: some international comparisons and a plea for more information
16:40-17:00	Kenneth Ingham & Diana E. Northup	Discovering New Diversity in New Mexico, Hawaiian, and Azorean Lava Tube Microbial Mats
17:00-17:20	Young Bok Cho	Cavernicolous Animal Diversity of Lava Tubes in Jeju Island, Korea

FRIDAY, SEPTEMBER 5

SESSION 8 ***Chaired by Greg Middleton & Paul Williams***

09:00-09:40	Paul W Williams	Management requirements that apply to World Heritage karst and volcano-karst properties
09:40-10:00	George Veni	Preview of the 15th International Congress of Speleology
10:00-10:20	João C. Nunes	New Geological Insights for the Azores Islands (Portugal) Lava Caves
10:20-10:40	Jong-Deock Lim	Korean Cretaceous Dinosaur Tracksites for the UNESCO World Heritage Inscription
10:40-11:00	COFFEE BREAK	

SESSION 9 ***Chaired by Greg Middleton & Paul Williams***

11:00-11:20	M. P. Costa	Most Outstanding Volcanic Caves Of Azores Islands as Potential Geosites of the "Azores Geopark"
11:20-11:40	J. P. Constancia	WoMOVoC: Online Database for the WorldMos Outstanding Volcanic Caves
11:40-12:20	Jose Ayrton Labegalini	UIS - International Union of Speleology: Short history and current situation
12:20-13:40	LUNCH BREAK	

POSTER SESSION

Yong-Gun Choi	The volcanic cave of erosion in origin near Hantan River, Gyeonggi Province, Republic of Korea
Won-Rok Kim	The Environmental Characteristics and Species composition of Manjang-gul Cave, Jeju Island, Korea
Isao SAWA	Cave Photograph of Jeju Island
Peter Gadanyi	Research work into lava caves of the Hungarian geographer Dénes Balázs

CONTENTS

Jeju volcanic landforms and lava tubes : A road to the World Heritage Inscription

Kyung Sik Woo

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Mt. Hallasan, Seongsan Ilchulbong Tuff Cone and Geomunorem Lava Tube System were proposed to be included in the World Heritage Sites by Korean government in February 2006 and were inscribed in July 2007. The Jeju Island contains a variety of volcanic landforms and more than 120 lava tubes of geological and speleological significance. It essentially consists of one major shield volcano, Mt. Hallasan, with satellite cones around itsAlso notable feature includes the parasitic cone (Seongsan Ilchubong Tuff Cone), which shows Surtseyan-type underwater volcanic eruption. Most notable is a variety of lava tubes (Bengdwi Cave, Manjang Cave, Gimnyeonsa Cave, Yongcheon Cave and Dangcheomul), which show a complete flow system and display perfectly preserved internal structures despite their old age.

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

UNESCO: the World Heritage natural site requirements compared to the new "Global Geopark Network" concept and its requirements.

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UNESCO lists six cultural and four natural criteria for inscription on the World Heritage list that originated in 1977. A given site ("property") may be inscribed on the strength of its fit to just one criterion in either category butthe case is always stronger where two or more criteria can be satisfied. This will be illustrated by the example of current efforts to expand the South Nahanni River Natural Reserve of Canada (one of the first two natural sites to receive WH approval, in 1978) to include the entire river basin and that of the Ram River to the north of it; three of the four natural criteria and one of the cultural can be met in the expansion.

The concept of a GLOBAL GEOPARKS NETWORK was approved by UNESCO in 2002. Here, an acceptable geopark ".....comprises a number of internationally important geological heritage sites on any scale, or a mosaic of geological entities of special scientific importance, rarity or beauty. These features are representative of a region's geological history and the events and processes that formed it." A geopark must be "....an area with well-defined limits and a large enough surface area for it to serve local economic and cultural development (mainly through tourism)." The concept is bold in scope but the criteria to be met are not as strong as those for WH status. The case for an International Geopark will be illustrated by a transect through the geology and geomorphology of the Mackenzie Mountains at Lat. 66° N in the Northwest Territories, Canada.

Geology of Jeju Island, Korea: Growth of a shield volcano on a continental shelf

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Jeju Island, 7432 km^2 in size, is a Quaternary shield volcano constructed upon the ca 100 m deep continental shelf off the southern coast of the Korean Peninsula in the Yellow Sea. The island is composed of basaltic to trachytic lavas and numerous volcanic cones, which resulted from decompression melting of the shallow asthenosphere in response to dramatic changes in the regional stress regime during the Late Cenozoic. Thousands of groundwater bores have been drilled all over the island since the 1960s, greatly improving the understanding of the surface and subsurface geology of the island. The basement of the island is composed of granite and silicic volcanic rocks of Jurassic to Cretaceous age. The overlying U Formation is 70 to 250 m thick and composed of well-sorted, quartzose sand and mud. This formation is interpreted as continental shelf sediments that accumulated before the onset of volcanism during the Pliocene. The U Formation is overlain by about 100 m of basaltic volcaniclastic and fossiliferous deposits, named the Seoguipo Formation. The formation comprises numerous superposed phreatomagmatic volcanoes (tuff rings and cones) intercalated with marine or non-marine, volcaniclastic or non-volcaniclastic deposits. Paleosols and erosion surfaces are also common throughout the formation, suggesting multiple episodes of exposure, erosion or soil development, and submergence of the deposits associated Quaternary sea-level fluctuations. Deposition of the formation began at about 1.8 Ma and continued until ca 0.4 Ma, suggesting that hydrovolcanic activity, together with volcaniclastic sedimentation, was the most important and long-lasting geological process that formed Jeju Island. Extensive distribution of such deposits in the subsurface of Jeju Island highlights that there can be significant differences in the eruption style, growth history and internal structure between shelfal shield volcanoes and oceanic island volcanoes.After the deposition of the Seoguipo Formation and the emergence of proto-Jeju Island above the fluctuating Quaternary sea levels, lava effusion became dominant, forming the gently sloping lava shield dotted with numerous volcanic cones. Isotopic ages of these volcanic rocks range generally between a few hundred thousand years to a few tens of thousand years, suggesting that the construction of Jeju Island was mostly completed before the Holocene. Hydrovolcanic activity resumed, however, at several places after the last glacial maximum (18 ka), forming several tuff rings and tuff cones along the present shoreline. There are also historic records of minor eruptions about one thousand years ago, although the exact locations of the eruptions are unknown.

Basalt cave types and paleoclimate of Harrat Ash Shaam, Middle East

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Harrat Ash Shaam is one of the largest volcanic fields in the Middle East, ranging across ~40,000 km^2 the north-western Arabian plateau, from Saudi Arabia through Jordan and Syria to Israel. Volcanism in Harrat Ash Shaam occurred intermittently since the Oligocene. The present study deals with voids in Pleistocene basalts of the last 500,000 years.The caves are classified into several types.

Circular isolated voids seem to be associated with large volcanic gas bubbles. They commonly appear on the surface as circular depressions, with vertical or sloped walls.

Erosional caves have developed by underground stream water captured along soft layers of paleosols between lava flows.

Lava tubes and pressure ridge caves are common around Hauran plateau. The pressure ridge caves are commonly some tens m long, located very close to the surface, within the last local lava flows. The longest lava tube is Hsheifa Cave, within a porphyritic and vesicular olivine basalt flow, ~460,000 years old. The cave is entered through a central skylight, has one level with tributary and distributary systems. Several stages of internal lava flows are distinguished, with a final aa basalt filling the lower reaches of the tube, covering a former pahoehoe surface.

Khsheifa Cave developed in the Jawa flow basalt, which covers 250 km2 east and south east of Jawa archeological site, within the "Black Desert" of northeastern Jordan. The basalt is attributed to the mid-Pleistocene Fahda Formationof the Bishriyya Group. The flow direction of the lava within the cave was to the east and than to the north.

Two small entrances lead into the central part of a 920 m-long tube. Fluvio-eolian deposits are currently swept into the cave during storm-runoff events, covering partially the bottom of both upstream and downstream parts of the lava tube. On February 2006 we observed the aftermath of a runoff flood event which entered the western entrance, reaching 100 m in the downstream portion, and 70 m in the upstream portion of the tube, along the modern gradient of the washed-in sediments covering the cave bottom. The flood water gradually infiltrated along these two routes, eventually disappearing into the cave bottom.

We dated calcite speleothems fromthe lava tube by U-Th to marine isotopic stage 7 and stage 5/4 transition. The available evidenceindicates general aridity of the Black

Desert during most of the mid-late Quaternary, punctuated by short wetter periods, when the Mediterranean cyclones systems intensified and penetrated the north Arabian Desert. These Mediterranean systems had a longerand more intense effect closer to the Mediterranean and only rarely penetrated the Black Desert of Jawa. The speleothems reported here are the first ones dated to the last 300 ka from the north Arabian Desert. The mid-Holocene, when Jawa city flowrished, as well as most of the late Pleistocene, were too arid for speleothem deposition in Jawa region.

Hornito caves on the Aðaldalshraun lava field, Iceland

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The Aðaldalshraun lava field and their hornitos formed about 2300 years ago, when the younger Laxárhraun lava flow reached andspread over the alluvial wetland of the Aðaldalur valley south from Skjálfandi bay, NE Iceland. The cupola-like hornitos of the Aðaldalshraun basaltlava field evolved as the outrushed semisolid lava pyroclasts (agglutinates) derived from the inner parts of the flow, piled up and welded togetherat the surroundings of some openings on the encrusted lava surface. The lava fragmentation and the outrush of the molten lava agglutinates are caused by the relatively small steam explosions induced by the interaction between the hot lava and relatively greater amount of groundwater below it. Simultaneously with the building up of the agglutinate hornitos a certain volume of space is enclosed into them forming caves. To distinguish these types of basaltlava caves the suggested terminology is "clastogenic". The hornitos of the Aðaldalshraun have a rounded or elliptical ground-plan. W and SW from the Knútsstaðir farm, and NE from the Hraunkot farm, the size of the hornitos ranges from 1-4 m in height. There are larger examples of them W from Helluland. In many cases, the diameter at the bottom of the hornitos and their height have a similar size. The flanks of these hornitos have a surface slope angle of 40-60 degrees on average. Thereare also several narrow-shaped, tower-like hornitos, the flanks of which have a slope angle of 70-90 degrees on average. The hornitos generally have a round or flat summit region. The peaky-topped ones are often entirely closed without any skylights or with very narrow ones (a few cm or dm) on the roof. The natural syngenetic summitskylights of the hornito have a round, elliptical or more irregular form with an undulating edge.Their diameter can range from 10-20 cm up to 1-1.5 m on average. They are usually widened as a result of the collapse of the environment. Entirely closed hornitos without any skylights are rare. The roof regions of the larger flat topped hornitos are usually sagged or a round segment of them sank in (eg. at NE from the Hraunkot farm). The hornitos of the Aðaldalshraun are scattered in location, a few or dozen of metres from each other. In certain places 2, 3, 4, 5 hornitos form aligned groups, or irregular clusters, where, in some of the caverns of the adjacent hornitos, they are connected to each other forming compound hornito caves. On average the height of the caves in the hornitos is 1-5 m, which generally exceeds the relative height of their enclosing hornitos. The internal diameters of the hornito caves decreaseupwards and in some cases are of similar or even greater sizes than their height, but they are generally smaller, particularlyin the chimney-like hornito caves. The walls of the hornitos thicken downwards and at the bottom they can reach a thickness of 1 - 1.5 - 2 m. The thinnest wall segments of the hornitos generally develop at the roofs, the thickness of which can reach 5-10 cm. During the build-up of the hornitos the deposited agglutinate bombs (cow dung bombs in other words) plumped to each other resulting in their flattening, which was contributed by the pressure of the accumulating agglutinates over them. Simultaneously with their accumulation the dissolved gases in the interior of the bombs began to expand, which resultedthat the agglutinate pieces were pressed close together. Right after the impact of the agglutinate bombs they flowed downwards a few centimetres or decimetres onto the previously accumulated agglutinates below them and weld to them. This process on the outer side of the hornito greatly contributes to the stability of the edifice and the cave in it as well. The walls of the hornitos have porous structure because of the many air enclosures between the agglutinate pieces in it. The sidewalls of the interior hornito cave are generally covered by "coat of plaster", which is an inner spatter lining resulting fromthe molten lava derived from small explosions splashed onto the cave sidewalls and ceiling. This degassed lava "coat of plaster", which levels the uneven inner agglutinate surface, can reach 5-8 cm in thickness, and with its support it greatly contributes to the stability of the hornito edifice from below. In many hornito caves the "coat of plaster" is preserved, but inseveral caves they are more or less collapsed along contraction cracks of cooling origin. In these cases the inner structure of the hornito walls are revealed. The hornito caves of the Aðaldalshraun in vertical cross section have either an almost regular, elongated cupola, or egg-shape, flattened cupola, or they can have a cylindrical, and chimney-shape. Spatter stalactites are common on the hornito cave ceilings and on the upper parts of the hollows on the sidewalls, which evolved from molten lava splashes or squeeze onto the inner wall surfaces. The spatter stalactites on the ceilings are often compound coral-shaped. Lava glaze developed directly on the inner side of the agglutinate walls or on the inner lava lining ("coat of plaster"). Smaller stalactites in greater density can be formed by the stretching of the still molten lava glaze. Due to the decrease in the energy of the lava fragmentation in the hornito cave’s bottom, small scattered lava droplets deposited onto the surface of the lava glaze. In hornitos where the lava withdrawal into the deeper parts of the lava flow took place suddenly, the sidewalls of the cave became relatively featureless. This is because at the bottom of the cave there were no smaller explosions which usually sprinkle with molten lava spatters and/or droplets onto the sidewalls of the cave. In these relatively featureless sidewall segments the lava glaze has a smooth surface, in some places with flow wrinkles originated by the down-creeping of the molten viscoelastic lava glaze. The bottom of most hornito caves is covered with debris of broken spatter fragments, detritus and alluvium. South from Sílalæikur farm there are hornitos which have a flat and uncovered floor. In these cases the floor of the caves consists of ropy pahoehoe flows, whichmeans that the last eruptive stage of the hornito development was effusive here. This is proved by the flow wrinkles which bent concentrically around the centre of the hornito’s bottom.

Study on the structure of Hornito Cave of Mihara-yama in Izu-Ohshima Island, Tokyo, Japan

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A lava tube cave recently found under the hornito of Mihara-yama in Izu-Oshima island was surveyed and investigated by the vulcano-speleological society. This lava cave was formed inside of 1951 eruption lava flow located at the edge of inner crater[1][2][3].

The lava tube cave consists of a flat region and a sloped region whose total length is about 40m. Inside of the lava tube cave, general characteristics such as lava stalactites and lava benches can be found.

Two important lava characteristics, yield strength and surface tension,"@were obtained from the observation of this lava tube cave.

By using a simple model of steady state flow in circular pipe for analysis based on Bingham characteristics of lava flow in the tube(T.Honda,2001[4][5][6]) and from the height and slope angle of the lava tube on the sloped region, the yield strength of the lava can be obtained as 50000dyne/cm^2. This value is very near to the value calculated as 43000dyne/cm^2 by G.Hulme(1974)[7] for 1951 eruption lava flow configuration observed by T.Minakami(1951)[1].

From the pitch of lava stalactite on the roof surface(3 to 4cm) which can be obtained by simple model of instability of liquid film attached on the roof surface,the surface tension of lava was determined as 600 to 1000 dyne/cm. This value seems to be a reasonable value compared with the value obtained by I.Yokoyama(1970)[9] in"@the melting lava surface tension measurement experiments in his Laboratory.

In the following table, the values compared with Mt.Fuji are shown.

Table1. Yield strength and Surface tension

Name of volcano	SiO2 fraction of lava	Obtained yield strength	Obtained surface tension
Mihara-yama	52~53% [1]	$5x10^4$dyne/cm^2 (by T.Honda) $4.3x10^4$dyne/cm^2(by lava flow)[7]	600 to 1000 dyne/cm(from lava cave surface) 600 to 1000 dyne/cm[9] (in laboratory)
Mt.Fuji	49.09~51.3% [8]	2.5 $x10^4$~$5.0x10^4$dyne/cm^2 (by T.Honda)[6]	600 to 1000 dyne/cm(from tree mold surface by T.Honda)

The following three conclusions can be deduced from this study[10]:

-The lava tube cave under the hornito of Mihara-yama, though this is a small scale lava tube cave, is a typical lava tube cave which can be explained by discharge mechanism of lava by gravity under the solidified surface of lava flow.

-As a results of this study based on the measured configuration, Bingham fluid model seems to be well applied for an explanation of formation process of lava tube cave. Obtained yield strength has a well accordance with the results obtained by other method.

-As for surface tension, it can be obtained by simple model of instability of liquid film attached on the roof surface. The estimated surface tension agrees with the experimental results by melting the lava in the Laboratory.

References

[1] T.Minakami(1951)Bull.Earthq.Res.Inst,vol29,p487

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[3] S.Murauchi(1951) Journal of Geology,vol 60,No.3,p117

[4] T.Honda(2000): On the formation of Subashiri-Tainai cave in Mt.Fuji. The 26th Annual Meeting of the Speleological Society of Japan,August,p.64.

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Under ground cavity of Mt-Fuji -Volcanic cave and Lava tree mold-

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Special Feature of Mt Fuji is a basaltic lava eruption which can form a volcanic cave and a lava tree mold which is a results of interaction with vegetation[1][2][3][4]. The lava flows for caves and tree molds are ranging from 14000 to1100 years ago, in which the trace of large tree of over 1000 years is found.

Mt Fuji is a scientific field where lava flow and large trees show a complex interaction between them because of long non-active period between eruptions[3][4]. There are largest tree mold in the world and associated secondary gas cavity phenomena and there exists large time scale historical variation of volcanic caves which show various inner structures such as lava stalactite, lava stalagmite, lava ball, snake rock, etc.,[5][6].

By observation and study from the hydrodynamic view point of lava cave and lava tree mold,important hudrodynamic parameter decisive to lava cave and lava tree mold:yield strenght,viscosity,surface tension were deduced[7][8][9].

As for lava cave of Mt.Fuji, by using a simple model of steady state flow in circular pipe for analysis based on Bingham characteristics of lava flow in the tube(T.Honda,2001[4][5][6]) and from the height and slope angle of the lava tube on the sloped region, the yield strength of the lava can be obtained as 1 x10^4 dyne/cm^2 ~7.5x10^4 dyne/cm^2 .

Obtained values are compared with other basaltic lava flow as shown in Table 1.

Table 1. Comparison with other basaltic lava flow

Yield strength of lava	Etna	Cameroon	Kilauea	Maunaloa	Mt Fuji
Obtained value from lava cave height and slope angle by T.Honda	5x10^3~7x10^4	1x10^5	5x10^3~5x10^4	5x10^4	1x10^4~ 7.5x10^4
Obtained value from other method	7x10^4 (G.Hulme,1974) 5x10^3~2.7x10^4 (Sparks,Pinkarton&G.Hulme, 1976)	~1x10^5 (J.G.Fitton et al,1983)	2x10^3~5x10^3 (G.Hulme, 1974)	8x10^4 (G.Hulme, 1974)	No existing value for Mt Fuji. Izu-Oshima lava of 1950-51 is 4.3x10^4 (G.Hulme,1974)[11]

As for lava tree of Mt.Fuji, the lava flow speed was estimated by the diameter d of living tree resistive to the lava with its thickness. The viscosity is determined by the equation of down stream on the slope as ~4000 Poise. The obtained value is compared with other basaltic lava flow as shown in Table 2.

Table 2. Comparison with other basaltic lava flow

Name of Lava flow	Temp (℃)	Velocity (m/sec)	Thick-ness(m)	Width (m)	Slope angle	Viscosity(Poise)
Higashiusuzuka-marubi lava flow(T.Honda"FThe diameter of Tree mold less than 15cm is not observed). Density supposed as 2.5 g/cm^3	Unknown	4.0	1.0		9.0	4x10^3 Remarks"FHiroaki Sato(Kobe Univ.Scie) "Measurement of the viscosity of basaltic lava of Fuji 1707 eruption in subliquidas "(Volcano Seminar, 27,January 2003) 1220℃: 4.8 x10^2 Poise 1140℃:5.7 x10^3 Poise
Izu-oshima mihara-yama 1951 eruption lava. (by Minakami)[10] Density: 2.5 g/cm^3 SiO2 fraction:52-53%	1125 1108 1083 1038	1.0 0.35 0.15 0.08	0.31 0.5 0.77 1.3	1.1 1.6 2.1 2.5	35 27 16 11	5.6x10^3 1.8x10^4 7.1x10^4 2.3x10^5
Miyake-jima,Akabakkyo 1940 lava (by Ogiwara) Density: 2.0 g/cm^3 SiO2 fraction:56%	1000	4.0	10	40	17	7x10^5
Hawaii,Maunaloa 1919 lava Density: 1.4 g/cm^3	1150-1200	5.0	6	9	7	4.3x10^4

Regarding with the surface tensionof lava, from the ceiling surface wave and pitch of lava stalactite in secondary cavity of tree mold, the surface tension was estimated as :560~990 dyne/cm. Though we have no values to be compared with this value for Mt.Fuji, Yokoyama(1970)[12] have found similar value for Izu-oshima 1951 lava.
As conclusion, the important hydrodynamic parameters decisive to lava tube cave and lava tree moldformation such as yield strength, viscosity and surface tension are obtained from the observations of the structure of lava cave and lava tree mold.

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The Geomorphology of Cavernous Lava Terrains

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Caves are well known features in lavas and are to be foundas fissures and vents, sub-crustal cavities and parts of former lava tube systems. Not so well known is that caves are just one of a number of distinct, but genetically-related, landforms that are associated with inflated pahoehoe lava flows. Such flows therefore have a characteristic geomorphology, bearing common internal structures, a suite of distinctive surface landforms, and formed by a unique geomorphic process in which cave formation, operation and decay holds the key. At the morphological leveltherefore cavernous pahoehoe terrains are analogous to karstic terrains, but because the method of formation is endogenous (constructional), rather than exogenous (destructional), it is not correct to call them psuedo-karstic.

This paper will make the case for the recognition of a distinct cavernous geomorphological terrain, not currently described in any academic text, and will describe the principal landforms that may compose it. The paper will explain through the use of case studies how landforms suchas flows, flow lobes and toes, lava rises, tumuli, lava tube caves, shatter rings, closed depressions, hornitos, rootless shields and psuedo-craters, are genetically linked through the tendency of fluid lava to insulate itself within, and operate through,a self-made system of arterial conduits. Although this terrain is principally manifested in inflated pahoehoe lava flows, the extent to which some features are also represented in aa lava flows will be explored.

Lave Tube Caves of the Odaðahraun; Iceland

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The Odaðahraun is a large barren wilderness in central Iceland, bounded by the vast Vatnajökull icecap to the south, lake Mývatn to the north and huge glacial rivers to the east and west. The rugged terrain of barren black sand, shield volcanoes and vast spectacular pahoehoe lava flows ensures that access to the area is physically difficult, and as such it is only recently that speleologists have taken a serious interest in the area with expeditions in 2005 and 2007.

Prior to these expeditions, only one major cave had been recorded, the 500m long Lofthellir close to Mývatn which is famous for its fabulous ice formations. However, local tales of caves in remote areas encouraged speleological expeditions to the area, leading to significant and interesting discoveries.

Exploration of the area has been physically difficult, and extremely frustrating. Many of the promising areas examined proved to be speleologically barren. Other areas proved to have significant cave development, and there are still many areas which have yet to be visited, and further discoveries are highly likely.

To date, significant caves have been recorded in several areas of the Odaðahraun. Namely the areas around Bræðrafell, Fjárholadyngja and Svartadyngja. Several caves with over 500m of passage have been mapped. The presentation will discussthe main areas examined, and describe the major caves recorded, and some of the future prospects for cave exploration in the area.

Studies of XRF Analysis, X-ray Analysis, K-Ar Age Determination and Polarization-Microscope for Lava, Jeju Lava Caves, Korea

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1. Introduction

This research is a part of scientific investigation (1981 to 2006) about the lava samples and speleothem of the lava caves in Jeju volcanic island (JVI). JVI is located at the souternmost part of Korea, between 33°06'31″ to 34°00′00″ north latitude and 126°08′43″ to 126°58′20″east longitude. The length is 73km of east-west, 31km of north-south, and 253km of coastline. The covering area of JVI is 21,831Km2. JVI forms almost an elliptical in shape. The volcanic activity began in about 1,800,000 years before. The island consisted mainly of basalts and a part of tuffs. The composition of basalts are the range of SiO_2:46.68 ~ 57.14wt.%, Na_2O:8.42 ~ 2.10wt.%, and K_2O:0.23 ~ 4.88wt.%. In this research, the result of having performed XRF analysis, a part of X-ray analysis, age determination, and observation by polarizing microscope of the lavas produced from CVI are reported.

2. Fluorescence X-ray Analysis of Lava

Average major chemical composition of the specimens from lava caves are as follows (Total 100 wt.%) ; (SiO_2:46.68 ~ 57.14, TiO_2=1.06 ~ 3.20, Al_2O_3=12.87 ~ 20.26, Fe_2O_3*=9.08 ~ 13.69, MnO=0.10 ~ 0.33, MgO=0.71 ~ 8.78, CaO=2.01 ~ 10.65, Na_2O=46.68 ~ 57.14, K_2O=0.23 ~ 4.88 and P_2O_5=0.16 ~ 0.60) (Table 1). The lavas of JVI range in composition from basaltic to rhyolitic, but the lava cave specimens are mainly of basaltic composition. In order to study the relationships between siliceous and alkali components of the lavas, the chemical constitution of each lavas are plotted by the SiO_2-(Na_2O+K_2O) figure. It has checked that the lavas belong to high alumina basalt series. In order to study the relationships between siliceous and potassium components of the lavas, the chemical constitution of each lavas are plotted to the SiO_2-KO_2 figure. As a result, it has checked that the lavas belong to the domain of medium-K.

3. X-ray Diffraction Analysis of Beach Sand Shell

Formation of Kimnyoung-gul cave (KC) was stopped by rapid cooling while the lava flow became curve-like toward the north side (coastline) in Manjang-gul cave (MC). In lower layer of KC, beach sand shell is dissolved by ground water, serves as calcium carbonate, and is invading from the crack of lava. On the other hand, it is thought that it is because KC has covered the surface of the earth of caves, such as a beach sand shell, since it is located under the sea water surface. A beach sand shell is distinguished from calcite by its composition. Calcite is a mineral belonging to a "trigonal system."

Table 1. Representative whole-lock chemical compositions of lavas in America(Hawaii, n=1), Japan(Mt.Fuji et al., n=22), Korea(Jeju, n=8) Russia(Kamchatka, n=2), China(Changbai, n=3) and. Kenya(n=2) $T\text{-}Fe_2O_3$:total Fe as Fe_2O_3. Note: values are normalize. Note:values are normalized on the basis of total =100%.

No.	Sample Name	SiO_2	TiO_2	Al_2O_3	$T\text{-}Fe_2O_3$	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Total
1	Kazumura Cave, Hawaii	49.90	2.41	12.87	12.63	0.17	8.59	10.65	2.10	0.42	0.24	100.0
1	Kashiwappra,VLT, Fuji	50.22	1.51	17.31	12.20	0.18	5.07	9.71	2.71	0.77	0.31	100.0
2	Aokigahara,VLT, Fuji	50.71	1.44	17.20	11.80	0.18	5.18	9.74	2.69	0.77	0.29	100.0
3	Aokigahara,TLT, Fuji	50.67	1.47	17.09	11.99	0.18	5.22	9.63	2.66	0.79	0.30	100.0
4	Children's WVT, Fuji	50.35	1.55	16.38	12.49	0.19	5.70	9.59	2.57	0.82	0.36	100.0
5	Inusuzumiyama Fuketsu, Fuji	50.90	1.56	16.00	12.10	0.18	5.86	9.38	2.74	0.91	0.37	100.0
6	O,Subashiritainai, Fuji	51.28	1.33	18.00	10.99	0.10	4.73	9.79	2.71	0.75	0.27	100.0
7	I, Subashiritainai, Fuji	51.22	1.30	17.91	10.90	0.17	4.86	9.90	2.80	0.68	0.26	100.0
8	U,Subashiritainai, Fuji	50.98	1.27	17.49	11.30	0.17	5.64	9.54	2.70	0.67	0.25	100.0
9	Atsuhara Fuketsu, Fuji	49.13	1.44	16.41	12.61	0.19	6.35	10.38	2.55	0.66	0.28	100.0
10	Hachiman ana, Fuji	47.97	1.56	16.99	13.69	0.20	6.76	9.76	2.29	0.52	0.26	100.0
11	Tachibori Fuketsu, Fuji	50.52	1.69	15.47	13.13	0.20	5.97	9.17	2.52	0.94	0.40	100.0
12	Mitsuike Ana, Fuji	50.70	1.72	15.76	12.77	0.20	5.76	9.15	2.61	0.96	0.39	100.0
13	Mt.Nagao, Hyouketsu, LF, Fuji	51.06	1.39	17.84	11.25	0.17	4.69	9.91	2.66	0.74	0.30	100.0
14	Aokigahara, Karumizu, CL, Fuji	51.25	1.43	16.79	11.84	0.17	5.26	9.58	2.62	0.76	0.30	100.0
15	Aokigahara, Mt.Nagao L, Fuji	51.37	1.46	16.82	11.89	0.17	5.11	9.51	2.60	0.78	0.29	100.0
16	Mt.Fuji, Houei, Fuji	52.72	1.28	20.26	9.80	0.14	4.33	8.03	2.55	0.63	0.25	100.0
17	Hinoki-marubi LF1, Fuji	50.73	1.51	17.16	12.21	0.17	4.99	9.51	2.64	0.77	0.31	100.0
18	Hinoki-marubi LF2, Fuji	50.78	1.52	17.02	12.29	0.18	4.97	9.55	2.62	0.77	0.31	100.0
19	Hinoki-marubi LF3, Fuji	50.58	1.51	17.42	12.15	0.17	4.93	9.60	2.60	0.73	0.31	100.0
20	Hachijou Fuketsu,Tokyou	50.56	1.45	16.57	13.67	0.20	4.07	10.49	2.42	0.40	0.16	100.0
21	Yuuki-do, Daikon, Shimane	48.61	2.26	16.46	12.80	0.18	6.91	8.42	2.74	1.16	0.46	100.0
22	Ryusei-do, Daikon, Shimane	48.53	1.86	17.92	12.87	0.16	7.29	8.27	2.62	0.23	0.25	100.0
1	Gaengsaengi-gul, Jeju	49.45	2.53	14.14	12.37	0.16	7.65	9.11	2.92	1.23	0.44	100.0
2	Kaeuset-gul, Jeju	47.03	3.16	18.41	13.53	0.14	5.05	8.66	2.81	0.67	0.55	100.0
3	Lava column, Manjang, Jeju	51.07	2.15	15.19	12.58	0.16	6.16	8.08	3.27	1.04	0.30	100.0
4	LB 1F, Manjang, Jeju	50.59	1.93	14.40	12.40	0.16	6.39	9.59	3.71	0.63	0.20	100.0
5	LB 2F, Manjang, Jeju	53.10	1.79	14.30	12.40	0.15	6.23	8.85	2.64	0.38	0.16	100.0
6	LB 3F, Manjang, Jeju	52.60	1.74	14.30	12.40	0.15	6.89	8.84	2.54	0.36	0.18	100.0
7	VLT, Hallim, Jeju	47.50	2.58	14.40	12.60	0.16	8.63	9.12	2.95	1.54	0.51	100.0
8	TLT, Hallim, Jeju	47.38	2.58	14.59	12.60	0.16	8.57	9.13	2.93	1.48	0.60	100.0
1	Gorely K-1 Cave, Kamchatka	55.12	1.25	16.07	9.41	0.16	5.01	7.21	3.39	1.92	0.45	100.0
2	Gorely K-3 Cave, Kamchatka	55.09	1.25	15.85	9.54	0.17	5.10	7.19	3.39	1.96	0.45	100.0
1	Luming Cave, S, Changbai	49.31	2.52	19.12	9.46	0.14	4.33	9.46	3.92	1.31	0.44	100.0
2	Luming Cave, C, Changbai	49.29	2.72	18.11	10.06	0.14	4.63	9.25	3.92	1.41	0.48	100.0
3	Luming Cave, N, Changbai	53.08	2.70	18.03	9.11	0.11	3.41	8.21	3.51	1.50	0.33	100.0
1	Leviathan Cave, Kenya	46.68	3.20	13.29	13.28	0.17	8.78	9.49	3.15	1.41	0.55	100.0
2	Mt.Susua ∘∘Cave, Kenya	57.14	1.06	16.10	9.08	0.33	0.71	2.01	8.42	4.88	0.25	100.0

4. K-Ar Age Determination of Lava

The K-Ar age determination data on the lava specimens of JVI indicate the oldest Mt. Sanbansan formed in 740,000 years ago. And youngest “Paengnoktam” of Mt.Halla summit which is the highest place in JVI was 25,000 years ago (Won et al., 1986). The lava pillar (420,000 years before : 0.42±0.42Ma) in “MC” was in the mid-term (Sawa et al., 1989-1990-1991). Furthermore, “lava bridge of MC” formed in the middle of “lava pillar of MC” and “Paengnoktam”, in 190,000 years ago (Sawa et al., 1999-2000).

5. Observation of Lava by Polarization Microscope

As a feature which observed lava specimens, an outer black circum-crusts which is almost made of the opaque mineral (Fe-Ti oxidization mineral) in about 10μm in thickness. A mantle part of the lava specimens to about 40μm in thickness from an outer shell to an inside, granule compared with an inner side (core part) further. The form of needle-like minerals growing up in the acute angle that are near from the integumentary covering to the inside perpendicularly are plagioclase and augite. Moreover, the Fe-Ti oxidization mineral of mantle part is characterized by making the form of rapid cooling growth compared with a core part. Basalt, lava column of MC, consists of plagioclase in tiny laths and large olivine phenocrysts and fine-grained clinopyroxene in a matrix of glass. Basalt, lava bridge of MC, consists of phenocrysts of olivine, fine laths of plagioclace and fine grained clynopyroxene are in a matrix of glass, with large vesicles (gas cavity). Basalt, Pillemot-gul Cave, consists of olivine in a matrix of plagioclase laths and fine grained olivine.

6. Conclusion

The result of the XRF analysis, observation by polarization microscope, age determination of JVI lavas and X-ray analysis of the beach sand shell can be summarized as follows. The XRF analysis indicates that these lava specimens are described of alkali-basalt and may belong to tholeiitic rock series. According to observation by polarization microscope, the lava basalt samples are consists of phenocrysts (Ol, CPx, PI), glass matrix, and vesicles. K-Ar age of the lava specimens, it is between 30,000 and 420,000 years ago.

Many Forms of Secondary Feature in Lava Cave

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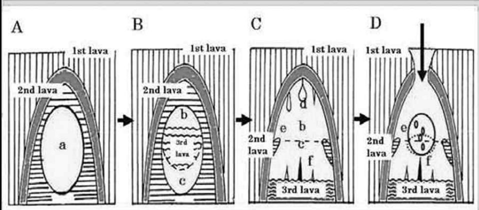
1. Introduction

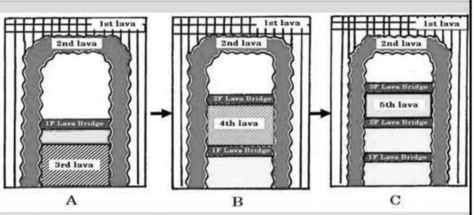
The lava is a general term of using it to the eruptive rock which melted.Volcano and lava cave can be classified into the volcano cave related term a "volcano", and the lava cave related term "lava." The distribution and origin etc of a cave which form a volcano and a lava cave have the formation process of a primary lava cave.

The formation place of speleothem in lava cave can be classified into cupola, the floor of a cave, the surface of a wall of a cave, and a cave pool.Cave environment can be classified into fall lava, flow lava, collapse lava, volcanic gas, etc.This model is a part of the volcano lava cave.The formation model about a lava cave was summarized to the model of ten types.

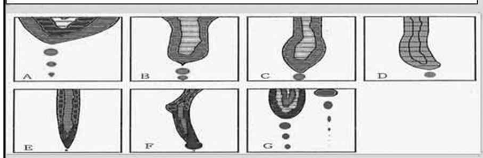
2. Lava Cave Model



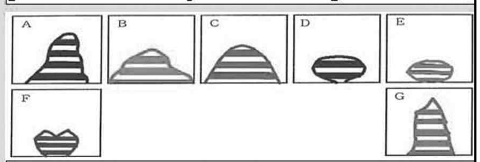
Model 1. The transition process on lava cave



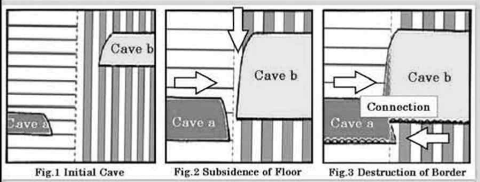
Model 2. The Forming of lava bridge the process of multi layer cave's being made



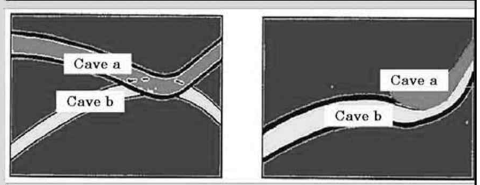
Model 3.The form of lava stalactite



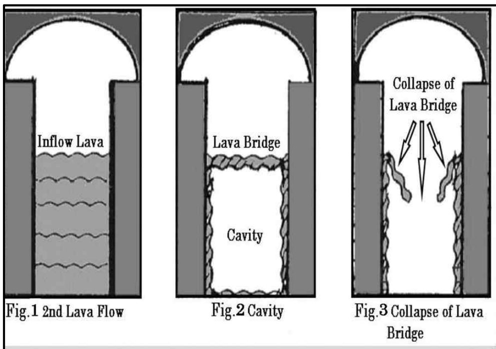
Model 4. The form of lava-stalagmite



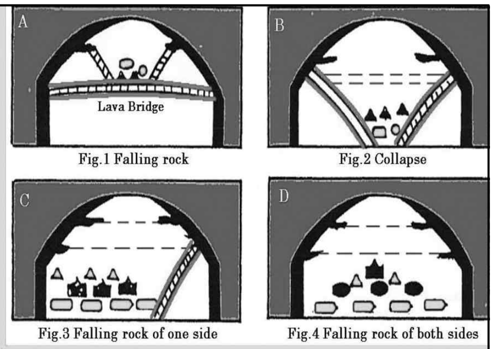
Model 5. The section which lava cave connected



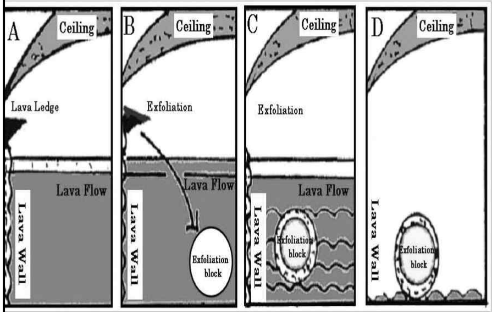
Model 6. The plan view of the cave unification by lava flow



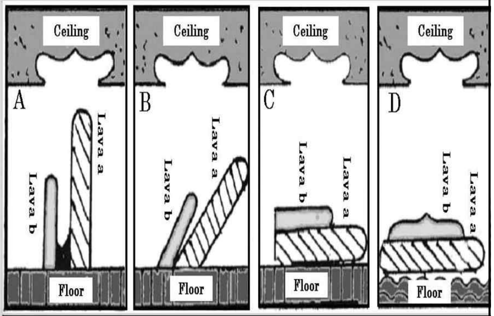
Model 7. The process of the destruction of lava cave and transformation



Model 8. The rupture process at lava bridge inside multi layer cave



Model 9. Lava ball reversed by exfoliation from wall of cave



Model 10. Driblets of lava of the reverse twin lava pillars

3. Model Consideration.

Model 1 is transition process on lava cave. Much stalactite by transition process is formed of the 3rd lava flow from a primary lava flow (Fig. A - D). Model 2 is forming of a lava bridge the process of multi layer cave's being made. The mimetic diagram of a lava bridge and multi layer cave's is a process formed of the 5th lava flow from a primary lava flow.

Model 3 is form of lava stalactite. Many forms change with environment at the time of formation in a cave.Model 4 is form of lava-stalagmite. Lava stalagmite is a form which changes with environment which falls from lava stalactite.

Model 5 is section which lava cave connected. The lava flow of sectional view is modification process (Fig. 1-3) in which initial cave (Cave a, b) was formed.Model 6 is section which lava cave connected. The plan view of the formed lava flow (left figure) is a changing process as shown in an initial cave (Cave a, b) to the right figure.

Model 7 is process of destruction and transformation in lava cave. The modification process in cave is a process which caves in, deposits and disappears from Fig.1 by Fig.3 generated by the lava flow.Model 8 is rupture process at lava bridges inside multi layer cave. The destructive process of lava bridges is a process (Fig.1-4) which changes in multi layer cave.

Model 9 is lava ball reversed by exfoliation from wall of a cave. Lava ball is a process formed after collapse of lava shelf (Fig. D) from lava wall (Fig. A).Model 10 is driblets of lava of the reverse twin lava pillar. Driblets of lava are processes formed like Fig. D by the fall of lava pillar (a and b) in Fig. A.

Speleology : a powerful tool in scientific research

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The word "speleology"usually indicates the different activities man can complete inside the caves (Fig. 1). Speleologists are, above all, explorers.

Therefore, speleology cannot be considered as a science in itself, in this context, as geology, biology or physics are, but its practice may reveal a strong means of support in the most different fields of human knowledge.

The cave environments, in fact, should be considered amongst the most important natural laboratories; where it is possible to complete studies and research in the caves that, in some cases, would be absolutely impossible to do in any other place, while others are easier and simplier when carried out in the subterranean environment.

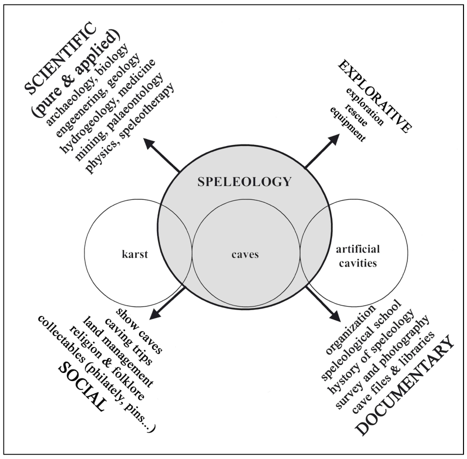

Fig. 1. Sketch of the 4 main branches of Speleology and of the environments in which they may be active

Thinking of a scientific discipline that can take advantage of the underground environment the first that comes in mind is geology in a general sense or one of its specific branches (hydrogeology, stratigraphy, mineralogy etc.). In fact, it is certainly true that practically every field of geology has deep motives for interest in caves, which represent a real and actual access to the underground and sometimes to a notable depth (more than 2000 metres).

In general, though, this identification of the cave's scientific interest for geology is limiting and ends up by losing sight of other fields which, contrarily what one would suppose, have the same scientific interest if not even more.

The caves have some peculiar characteristics that distinguish them from the other natural environments and therefore make them much more interesting and important from a scientific point of view. Caves are underground environments characterised by a constant total absence of light and often have minimum variations of mostenvironmental parameters (temperature, relative humidity, etc.). The rock walls that separate them from the outside world minimise, or even eliminate completely, the influence that the external climatic and/or other environmental variations can have on the cave's inside.

To put it in a few words, a natural cave is a very stable environment generally characterised by little energy, which can be considered the perfect "accumulation trap", that conserves everything that it collects in time.
These intrinsic characteristics are exploited in one way or another by most of the scientific researchers interested in the cave environment.

Tab. 1 - Main pure and applied sciences interested in cave environment

Discipline		Fields of interest
Archaeology		remains, graffiti, rock-paintings
Biology		adaptation strategies, microbiology, chemioautothropic environments
Physics		meteorology, climatology
Engineering		large voids, oil deposits, show caves
Medicine		speleotherapy, psychology, psychiatry
Geology	Geomorphology	karst, speleogenesis, paeoenvironmental reconstruction
	Geochemistry	stable isotopes, absolute dating
	Geophysics	earth tides, seismology
	Hydrogeology	karst aquifers
	Mineralogy	cave minerals, low enthalpy processes
	Palaeontology	lairs, sedimentation traps
	Sedimentology	physic sediments, speleothems
	Stratigraphy	stratigraphic sequences
	Structural Geology	structural elements, neotectonics
	Vocanology	lava flow morphologies, deep volcanic structure

The scope of the present paper is exactly that of briefly mentioning the principal scientific researches in caves which can be, and in many cases are, being undertaken worldwide and to see how it would be possible to improve scientific cave research in the near future in a quantitative and qualitative way.

But the most important problem the pure and applied scientific research will have to resolve even before improving its presence inside caves is the preservation of the cave environment.

To ensure a satisfying preservation of caves and karst for the future generations it is necessary that the Speleological Community will cause a voluntarily worldwide control and/or limit to the activities to be performed in caves and this should be the main target of the whole Scientific Community in the near future.

Immanuel Kant's remark on lava cave formation in 1803 and his possible sources

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Text book understanding of lava cave genesis is generally still poor. For example, Peter Francis (1996 p. 149) in "Volcanoes, a Planetary Perspective" writes: "*Lava tunnels form when the surface of a flow crusts over, while hot lava continues to flow beneath*". This is far from how lava tunnel formation is seen today, i.e. as a more complex process of sheet-advance, inflation and erosion (e.g. see Kempe, 2002). Such simple views as the "crusting-over-hypothesis" are historically quite old, dating back to the time when geology became an individual science at the end of the18th century during the period of enlightment.

Among those to hypothesize about lava cave formation was the famous philosopher Immanuel Kant (22 April 1724 – 12 February 1804, Königsberg in Prussia, now Kaliningrad, Russia Fig. 1). He is mostly known for his seminal "Critique of Pure Reason" (first publ. 1781). Kant, in his later works ("Critique of Practical Reason",first publ. 1788), became the first philosopher to remove God from his philosophical reasoning in saying: "*Two things fill the mind with ever new and increasing admiration and awe, the more often and steadily we reflect upon them: the starry heavens above me and the moral law within me*". Thushe named the two driving forces of human existence: the physical laws and the rules of moral (which do not need a god to be formulated) and he became the founder of modern, religiously unbiased philosophy. Normally it is not well known that he also wrote about natural science. Possibly the best publicized idea of Kant was thatthe nebulae among the stars are other galaxies, a fact that was proven only more than 100 years later. Among other works, he wrote six volumes on "Physical Geography". In the first edition, published 1803, he speculated about cave genesis (2nd volume, 2nd part, p. 76):


Fig. 1: Immanuel Kant

"Man konnte sie (die Höhlen) *nach der Entstehung einteilen in ursprüngliche und später entstandene: Die ursprünglichen waren die, welche durch das erste vest werden und Zusammenziehen der Erde beym Trocknen entstanden sind, wie etwa kleine Luftbläschen in einer gerinnenden Masse: Man findet sie nicht in Granit sondern nur in Kalk (Gips) am Sandsteingebirge. Es muss eine Masse sein, die von außen her austrocknet und eine Rinde bekam, wenn sie in der Mitte noch fließend war. Wenn nun dies mittlere länger flüssige, endlich auch trocknet und sich verziehet so müssen Höhlen entstehen. In der Lava und allem von ihr aufgetürmten Gebirgen kann man diese Entstehungsart der Höhlen deutlich sehen.*"

Translated: "*One could differentiate them* (the caves) *in those created initially and those of later formation: The initial caves were those, which formed by the first solidification and shrinkage of the drying Earth, similar to small gas vesicles in a curdling (*solidifying*) mass. These are not found in granite only in limestone (gypsum) near the sandstone mountains* (most probably referring to the Triassic Buntsandstein Formation in Germany below we find the limestone and gypsum of the Zechstein and above those of the Muschelkalk, all cave-bearing*). It needs to be a mass that dries from the outside and forms a crust, while still being fluid inside. If now this central mass - that is much longer fluid - dries finally up and retracts, then caves are created. In lava and all mountains formed by it, one can observe this kind of cave creation.*"It is to note that this citation was omitted from the 2nd authorized edition and is thus very difficult to find.

Kant differentiated (to my knowledge) for the first time between primary and secondary caves and correctly placed lava caves into the first group. He was, however, wrong when speculating about the origin of the limestone and gypsum caves. Part of the explanation for this is that he never travelled more than a 100 km from home, and that he therefore never saw any limestone or gypsum outcrops or any cave. However, at the time, the genesis of limestone caves was much debated (see Shaw, 1992, for overview) and even the origin of the much publicized Baumann's Cave in the Harz (e.g., Kempe et al., 2004) was not at all clear. Kant must have had the knowledge about lava caves from the literature (without citing his sources though). In 1799 Rosenmüller and Tillesius published a compendium about caves from existing literature. In it they mention at least four lava caves: Baardar-Hellir, then a cave near Oenverdtnas-Eischlager, further Ragnahellir and Surtshellir. On lava cave genesis they state: "*es ist wahrscheinlich, dass diese und andere Höhlen um den Schneefelsen herum, wie die Surthhöhle entstanden sind, und den durch Erdbrände geschmolzenenen Flüsssen zu Rinnen gedient haben"* (p. 52). '*It is possible that this and other caves in the vicinity of the Westerjökkelformed like the Surtshellir and that they served for channels of the earthfire-molten rivers.*" Rosenmüller and Tillesius, however, cited their sources, the travel report of Olafsen (1774-75) who visited Island between 1752 and 1757. In the original description of Surtshellir (§ 358, p.130 which was copied by Rosenmüller and Tillesius almost verbally in their description) we read: '*Der fließende Hraun ist wie ein Strom durch diesen Canal geflossen;…*" (i.e. "the *running lava flowed through this channel like a river…*"). Troil (1779; p. 225) who visited Island with Joseph Banks and Daniel Solander in 1772 wrote: "*Die obere Rinde wird bisweilen kalt und fest, obgleich die geschmolzene Materie noch unter derselben weglauft, dadurch entstehen große Höhlen, deren Wände, Betten und Dach aus Lava besteht, und wo man eine Menge Tropfstein aus Lava findet.*" ('*The upper crust sometimes cools and solidifies, even though the molten matter keeps running underneath; in this way large caves form, the walls, floors and ceiling of which are composed of lava and where a lot of dripstones of lava occur*".) All three books could have been known to Kant and served as a source of his knowledge that lava caves exist.The sources are, however, much more specific than Kant's own formulation thus making his remarks not a prime source for the early scientific perception on lava caves.

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Kempe Cave: an unusual, meandering lava tunnel cave in NE-Jordan

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KempeCave was discovered and named by A. Al-Malabeh in 2006 in the northeastern section of the Jordanian Harrat at 32°N16.806’, 37°E33.945’ and at an altitude of 939 m a.s.l..It is situated near the prominent Ashgaf 3 tephra cone and west of the 88 km long series of fissure eruptions called "the Train"that transgresses the entire eastern part of the Harrat from the northwest to the southeast. The cave is the first lava tunnel in Jordan (out of eight yet discovered; Kempe et al., 2008) that can be attributed to a specific volcano: Kempe Volcano is a small shield volcano 1.81 km away that has a crater 120 m across, now filled with windblown sediments of unknown depth. The crater at 976 m a.s.l. produced rough pahoehoe flows that overflowed the crater to all sides forming an even, circular cone. To the west a pre-existing valley was filled with an over 600 m wide flow that can be traced for at least 7 km. The slope between the crater and the cave amounts to 1.2° it is in the range of slopes of tube-fed pahoehoe flows (compare Kempe, 2002). A second cave was discovered recently in the same flow by A. Al-Malabeh in 2008.

Kempe Cave itself is 124 m (main passage) plus 14.5 m (side passage) long and has unusual characteristics. As the map (Fig. 1) shows, it bends around in a meander of 180°. Furthermore the primary roof consists of only one sheet of pahoehoe lava. Therefore it was not formed by multiple inflations as usual with pahoehoe tunnels.

The roof was, however, secondarily strengthened by at least four further surface pahoehoe sheets that have transgressed the primary roof slightly after the lava tunnel was established (but within the same eruption sequence). Within these sheets, small

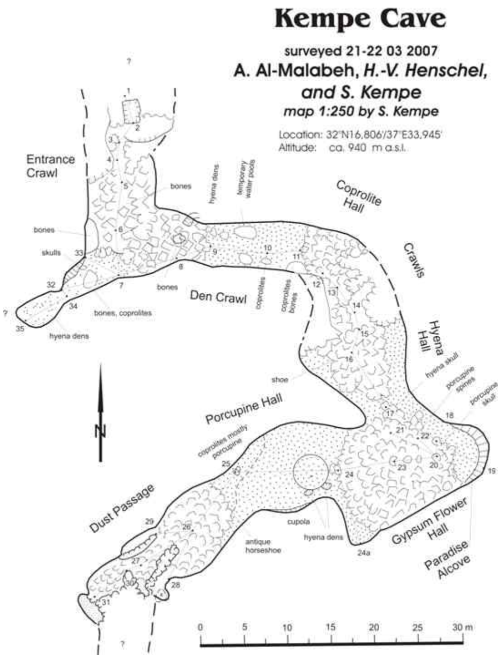

Fig. 1: Ground plan of Kempe Cave

cavities are encountered, that form wide but low cupolas, caves on themselves. Overall the cave is wide but rather low and has several breakdown areas, making visiting the cave a real task. It also contains several areas with flowstone, among them small gypsum flowers.

Paleontologically, the large number of coprolites is remarkable. We can differentiate four types, those of hyenas, wolves, foxes and, for the first time in a Jordanian cave, of porcupines. Bones of hyena, camels, and horses are present. The cave has enough washed-in sedimentto make it a potential site for paleontological digs. The entrance was originally walled, suggesting that it may have had some function in the past, possibly connected with some crude stone walls near-by used formerly for interim habitation by seasonal herders.

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Skrúðshellir and two other littoral caves in Iceland

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Abstract

Three large littoral caves in Iceland are reported. One is located in tertiary rhyolite, one in tertiary belted lava and one in a modern belted lava. All are located in exposed fowling cliffs. One of the caves is inhabited by a few puffins, fratercula arctica, one by hundreds of kittiwakes, rissa tridactyla and one by some tens of Brunnich´s guillemot, uria lomvia. The largest cave is about 130.000 cubic meters located on the island Skrúður just off the east coast of Iceland. The second, over 30.000 cubic meters, is located at the tip of Snæfellsnes. The smallest cave, over 20.000 cu. meters, located at the tip of Látrabjarg, is the westernmost cave in Europe.

Four references are cited.

Introduction

The authors have been kayaking in stages along the Icelandic coastline for many years. Last summer they had covered a little over 2000 km or abbout a third of the total coastline. Theyhave stuck more to exposed coastline than infjords. On their trips they have among other things, encountered many sea caves. Some years ago, outside the swimming pool in Akureyri, after washing some sweat off from one of the trips, they stumbled upon Jan Paul van der Pas much their joy. They told him about a rather big cave in the protected island Skrúður and about the inching along of the Þríhnúkagígur project. Jan Paul insisted on reports. This the report on Skrúður.

Location and circumstaces

The lushly vegetated rock island Skrúður stands 3-4 km off Hafnarnes, the tip of the penisula between the fjords Reyðarfjörður and Fáskrúðfjörður, on the east coast of Iceland. It is 161 m high and with Bjarnarey in the Vestmann islands, the second highest island in Iceland. Skrúður and its immediate vicinity, with its splendid bird colonies, very special rock formations, vegetation and littoral caves, has been a natural reserve since 1995. The island is supervisedBaldur Rafnsson at Vattarnes. He keeps some sheep there, collects black gulls eggs and nets puffins.

Skrúður is often called the pearl of the East fjords. It belongs to the farm Vattarnes. The authors took up at Vattarnes in 2002, and it was their starting point in 2005. They did not intend to visit Skrúður, but Baldur insisted and graciously invited them to use his ingenious shelter. It is built under an overhanging cliff, or a 25 m deep cavern, high up in the cliffs. He also insisted they visit the Skrúður cave, the largest cave in the East fjords, he said. The light at hand was a 3 watt diode light.

There are heavy currents off the East coast, especially off Reyðafjörður where Skrúður is located. Even though it was spring tide, they took Baldur on his word. They crossed over on the hour of the high tide. Boarding the island from the kayak on to the steep seaweedcovered slippery rock side was a bit tricky, the ground swell going up and down.

Skrúður, the decor

Skrúður is very special. It holds the tightest puffin, or fratercula arctica colony in Iceland. The island and its two vegetated neighbour rocks is about 80 hectars in size. A little over two hundred thousand puffin holes were counted there a few years ago. With geldbird included, the island must boast with over half a million puffins. On most of the vegetated part of the island one can hardly put a foot down without stepping on a puffin hole. Gannets have been breeding in Skrúður since 1946 and the present colony with hundreds of birds is very impressive. Apart from puffins and gannets many other bird species breed in Skrúður. Guillemot, Brunnich´s guillemot, kittywakes, fulmars, great black backed gull, black headed gull, lesser black backed gull, black guillemot, arctic tern, raven, white wagtail, snow bunting, house martin, eider. The Iceland falcon fests there.

Geology

Skrúður is geologically a bit complex. These parts of the East Fjords were formed in the tertiary, during the middle and upper miocene. The nearby Gerpir has been dated about 16 mi. years old. Skrúður may be about 14 mi. years old. Skrúður consists for the main part of rhyolite on a basalt base, The lower part of the island, the part where Skrúðshellir is located, is rhyolitic conglomerate of volcanic origin and stems from a subglacial or submarine eruption. On top of this conglomerate is solid rhyolite and the top of the island consists of beautiful columnar rhyolite.

Skrúðshellir, the Skrúður cave

Skrúðshellir is a littoral cave, formed when the sea level stood 6-10 m higher than now. Probably early in the holocene. Eroded by the powerful waves of the north Atlantic into the soft ryolitic conglomerate on the exposed east coast of the island.

The Skrúður cave is remarkable for three tings. The size of the inner chamber, for the fact that puffins breed there and because it is inhabited by a troll, the Skúður farmer

With a volume of about 130.000 cubic meters, the Skrúður cave is by far the largest puffin "hole" in the world. Several puffins nest in the inner cave. The troll that lives there, conjured the priestdaughter at Hólmur in Reyðarfjörður several ages ago. It has not been seen for over a hundred years, but that is no proof it does not still live there.

The Skrúðshellirs floor is for the most part pretty level, sloping inwards about 10° and stands about 6-10 m above sea level. It consists of two huge parallell rooms connected with a 22 m wide and about 14 m high passage. The size of the outer room, or entrance if you will is about 90.000 cubic meters and the size of the inner room is about 40.000 cubic meters.

There are no formations in the cave. The water in the pond in the inner cave is rainwater that seeps through the conglomerate. I contains nitrates and phoshates from birdshit way above healthy levels. A neat net of puffinfootpaths can be seen in the mud on the floor in the outer cave and somewhat into the inner room. A puffin was seen flying into the darkness and some came flying from way inside. A few puffins breed between rocks in the inner room.

A sea cave at the tip of Látrabjarg

On the southside of the westernmost tip of Icelands largest fowling cliff Látrabjarg, there is large a sea cave. The rock in Látrabjarg is tertiary belted basalt. Its base is about 14 mi. years old. Even though the sea was a bit unquiet one of the authors (ÁBS) could not resist paddling into the cave as they passed in July 2006. Brunnich´s guillemoths breed in the lower part of fowling cliffs and a few of them had their nests high the entrance. The cave is over 12-15 m wide and 12-15 m high. About 40 m inside, the cave enlarges a bit and divides around a huge pillar about 15 m in diameter. At this spot one could hear the hoarse swelling and breaking of waves on the other side of the pillar, ending way in the darkness. He did not dare to paddle on because of the darkness and uneasy sea and turned around. The cave is probably about 80-100 m long. Outside it was just starting to blow up from the southeast. Half an hour later they encountered tubulent side gusts up to and over 20 m/sec. in Látravík on the leewardside of Látrabjarg. Paddling was not a problem because the wind was blowing from off shore and the sea was relatively calm.

A sea cave in Svörtuloft in Snæfellsnes

Three years ago the authors gave up crossing the tip of Snæfellsnes because of the many orcas feasting on fry just offshore. Last summer they did not see any and used the opportunity. Several unevenly distributed volcanic cones, Öndverðarneshólar, form the landscape at this spot. The eruption taking place some 5-6 thousand years ago, was not the usual linear, but a not quite understood, so called areal eruption. The lava has all the caracteristics of shield lavas. Quite fluid and rich with gases,it boasts of interesting caves, hornitos and rootless vents. The 20-30 m high seashore cliffs of Svörtuloft, or Blackceilings, form an interesting cross section of these belted lavas. Just south of the lighthouse on Svörtuloft there is a small rockpeninsula. Undermined by the powerful seas,this peninsula is litterally standing on pillars. Within the pillars is a cave. The cave is T formed and the upper part of the T penetrates the base of the peninsula 80-90 m from north to south. The leg of the T, at least 40-50 m,forms a huge window towards the west. The cave is inhabited by hundreds of kittywakes, or rissa tridactyla. Their modern natural symphony orhestra, screes, wingflatter and swishing blending with the sounds of the sea, filled the cave. A world crowded with birds, their smeel, the seaair, and the ground swell underneath, created a strange feeling, an intraterrestrial strangeness, some kind of an indescribable reminder that we are just guests on this hotel earth. Cave with care.

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Árni B. Stefánsson is 59 years of age, a medical doctor with opthalmology as subspeciality. He has been interested incaves and caving for over 50 years. At a very young age he came to know the great caves of Hallmundarhraun in Iceland, learned among other things about their damage and felt strongly how much some of the grown ups took this damage to their heart. Árni hasbeen interested in caves, wildwater boating and kayaking since young age. After 1990 he turned to sea kayaking.

Gunnhildur Stefánsdóttir is 56 years of age, a nurses aid, pharmacician, opthalmological assistant, mother of two and grandmother of three. She has been married to the first author for over 30 years. She has either since been a partner or an invaluable assistant, in various enterprises. She started sea kayaking in 1995.

Petrology and Geochemistry of Jeju Volcanic Island, Korea

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Jeju Island, located in 90 km south of Korean Peninsula, is a major Quaternary volcanic island in the Korea. The island covers an area 1,792.06 km^2 and is 32 km wide north-south, elongated 74 km east-west. The island is a shield volcano and is characterized by a symmetrical form whose peak is Mt. Halla (1950m).

K-Ar age determination indicates that the island was formed from 1.20 to 0.025 Ma(Yoon et al., 1986; Won et al., 1986; Lee et al., 1987; Tamanyu, 1990; Park et al., 1998). The historical time eruptions(AD 1002, 1007, 1445, and 1670) were recorded in the old books (Donggukyeojiseungnam vol. 38)and geologists have been tried to find the geological evidences of the historical time eruptions.

The volcanic activity can be divided into four stages: basal lava flow, lava plateau, Mt. Halla volcanic edifice and scoria cones, respectively(Lee 1982; Lee et al., 1994). At the basal lava flow stage, basaltic lava formed basement as a plateau from the marine floor to sea level (Lee, 1982). The lava plateau stage commenced with eruption of basaltic lava distributed as forming a lava plateau. The Lava plateau is composed of a voluminous basaltic lava flow which extends with a gentle slope to the coastal region. Mt. Halla volcanic edifice whose peak is about 1950 m in height, and finally marked Backlockdam crater (400m in diatmeter) at third stage. Final activity produces more than 360 score cones which mostly distributed on the vicinity of long axis of the island. There are about 10 tuff cones and rings are distributed along the coastal regions.

Korean government has been obtaining many drilling core samples in the Jeju Island to get a groundwater and hot springs since 1960s. Geological information from the drilling core samples indicate thatvolcanic rocks exist in 100 m sea level below as well as a few hundred meter thick sedimentary rocks and unconsolidated sediments of Plio-Pleistocene age under the volcanic rocks.

Cretaceous volcanic and plutonic rocks as well as mantle rocks, enclosed in alkali basalt rocks, were found in some place in the Jeju Island. These enclusions give us the physical and chemical properties of the upper mantle and crust beneath the Jeju Island.

Geochemical compositions of the volcanic rocks indicate that the rocks of Jeju Island are composed of alkali basalts, hawaiite, mugearite, and trachyte with minor tholeiite and pyroclastic rock as well as the volcanic rocks have characteristics of oceanic island basalt and the eruption which is the hot-spot related to the mantle-plumes (Lee, 1982, 1989 Park, 1994; Park and Kwon, 1991, 1993a, 1993b, Park et al., 1998).

Key words: Jeju Island, Volcanic Rock, Volcanic Activity, Enclusion.

Lava tubes of the Rohio lava field (Rapa Nui, Chile): exploration and scientific interests

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Introduction

Rapa Nui is the most insulated inhabited land of the world and still now only few tourists have the chance to pay a short visit to this volcanic land. Its triangular shape is due to the coalescence of three volcanic structures (Terevaka, Rano Kau and Poike), which from 7000.000 to 200.000 yr BP generated the island. With a total surface of about 170 km^2 and far more than 2000 known cave entrances (anyway presently only 800 cavities areofficially listed), Rapa Nui has one of the world's highest density of lava tubes. Mostof these caves were discovered not by speleologists but by archaeologists. In fact the most significant traces of the moai people were found inside caves.

Apart some sporadic visits in the 1960s and 70s speleologists have become interested in this island only recently (see speleological references below).

The present paper presents a short outline on the exploration and the research carried out in the framework of three international speleological expeditions to Rapa Nui (2005, 2007, 2008) organized by the Sociedad de Ciencias Espeleologica Alfonso Antxia from Bilbao (Spain).

The Rohio lava field and its caves

This lava field (about 10 km^2) was generated by Terevaka volcano in its SW flank. It was chosen for speleological explorations because it was never interested before by archaeological research even if extremely rich in lava tubes.

The surface of the lava field is highly altered due to the hot and humid climate characterizing the island: thus well developed pseudo-karren and kamenitzas are widespread.

Two kind of volcanic caves are present in the area: gas bubbles and lava tubes. Gas bubbles never reach huge dimensions, ranging from a couple to a maximum of eight metres in diameter and never exceeding two meters in height. Lava tubesmay reach considerable lengths: the Ana Te Pahu-Ana Heva-Ana Ohoka, some 3 km in length, is presently the largest volcanic system not only of Rapa Nui but also of whole Chile. The biggest lava tube is the Ana Te Pahu, the diameter of which exceeds 4 metres. Some lava tubes like the Ana Heva tube host widespread and beautiful lava formations. In the three expeditions some fortycaves have been explored and mapped for a total survey of over 7 km.

Speleothems and their scientific significance

One of the main targets of the expeditions was the study of the speleothems of Rapa Nui's caves. The lava formations consist mainly of small, partially erratic soda straws and decimetric sized stalagmites. The presence of widespread organic matter, coming from well developed external soils, allows for the evolution of widespread "mucolites", normally stalactites but, in a single case, also a thick and tall dark-brown stalagmite.

This speleothem proved to have a very thin layered structure: the extremely high number of growing laminas (close to 1000) suggest that this speleotem greatly pre-dates the colonization of the island by the moai people.

The most common true speleothems are the small opal popcorns, always developing close the mucolites, thus suggesting a biogenic control on their development. The only other observed speleothems were some pale yellow to dark brown opale rich (with traces of Fe and Mn) microgours: also these are in strict contact with mucolites.

The biogenic control on the development of all the opal formations was later proved by the analyses performed on the small samples of them, found already broken over the floor mainly of Ana Heva cave.The analyses carried out with optical and electronic microscopes evidenced that many of the sampled formations from the Ana Heva lava tube where composed by living and/or dead diatoms (Pennales order) and cyanobacteria.

Other scientific interests

Beside the speleogenetic and minerogenetic interest the lava tubes of Rohio lava field proved to be of great interest from the archaeological and biological point of view.

New archaeological deposits were found in most of the explored caves: normally they consisted of human bones and skulls and obsidian tools. Some new petroglyphs in caves explored in the area of the lava field close to the sea are worth mentioning.

A biological investigation, started during the 2007 expedition with the unexpected discovery of a white beetle (Coleoptera), was systematically performed during the 2008 expedition. The study of the collected fauna is still in progress but it already proved the presence of some new and endemic species.

Final remarks

The exploration and the study of the Rohio lava field, far to be completed, has put in evidence the extraordinary importance of the hosted lava caves not only for vulcanospeleology but also for many other sciences like mineralogy, biology and archaeology.

In the near future, the systematic study of this area will continue until all the caves of the Rohio lava field will be explored, mapped and scientifically analysed.

Anyway it would be important if other volcano-speleologists should consider the other areas of Rapa Nui worth for exploration and study in the near future.

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The preservation of Þríhnúkagígur and the status of the studies of the feasibility of its access.

A report compiled by Einar K. Stefánsson VSÓ consultants and Árni B. Stefánsson. Presented by Árni B. Stefánsson

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Abstract

A preliminary report on the status of the preservation of Þríhnúkagígur and the status of the studies of the feasibility its access, is presented. The idea and the runup of the project is discussed. Ten finished tasks are reported and the status of nine defined tasks mentioned. Preventive and safety measures are presented, choices of tunnel and accessroutes discussed. There is a conviction for the singularity of the project and no doubt that the opening up of Þríhnúkagígur is a feasible idea. **But**, do we have the right to deflower pristine lavas? The area is within the farwater reserve of the capital area. What about the paradox, preservation / human access? The main objectives are to secure the conservation of the crater, share, educate and enhance peoples respect for nature and life in general. The project is very interesting and enjoys interest and goodwill. Whether and how the rather sublime idealistic goals will be reached remains to be seen.

Background

An idea about how to make the Þríhnúkagígur vault accessible to the general public and secure its preservation at the same time was presented at the 11. Vulcanospeleological Symposium on the Azores in 2004. Since then some water has run to the sea.

The idea and the run up of the project

The idea was first presented in a newspaper article in Iceland in January 2004. It was very well received, in fact so well, it was decided to jump aboard and finish aswering the rather complex open questions. Two introductory exhibitions were held. A firm was established about the idea 'Þríhnúkar ehf'' and its role defined. Differences were settled and the finance of the project secured. The government of Iceland, the city of Reykjavík, the Ministry of tourism and traffic, the municipality of Kópavogur and the financing firm Burðarás supplied money. A contract on the subject was made with the landowner, the municipality of Kópavogur. The main objectives are: a) To answer the question whether an access is feasible and to give back a high quality report. b) To secure the preservation of the Þríhnúkagígur cinder cone and the inside of the crater. c) To prevent accidents.

The status of the project and the next steps

The following tasks are finished.

1. Survey of the crater
2. Demarcation of walking paths and the installation of a safety fence at the opening.
3. Proposals of tunnel and access choices and preliminary work.
4. Specialist report on hydrology and groundwater.
5. Specialist report on geology.
6. Specialist report on vegetation.
7. Specialist report on opportunities in tourism.
8. Introduction to interested parties and review parties.
9. Investigative drilling and removal of core samples.
10. Several university level student assignments.

The following tasks are in progress.

1. Geotechnical evaluation of drillcores.
2. Specialist report on earthquakes and risk analysis.
3. Preliminary design and comparison of choices.
4. Contour design of buildings and stuctures.
5. A three dimensional computer model.
6. Analysis of environmental factors. The conservation and "sightseeing" value.
7. Walking paths, studies of nature.
8. Cost evaluation and feasibility studies.
9. Photoprocessing, illustrations, maps, final report.

Discussion

The preventive and safety measures taken are discussed. Access routes discussed. Three choices of tunnels and two tunnel openings evaluated and discussed. Choice B, with road access from Bláfjöll and tunnel from the southeast, which seems to be the only feasible choice is discussed.

Possibilities and opportunities

There is a conviction for the singularity of the project. Þríhnúkagígur could well become the center of a vocano- or geopark. With a connection with schools and the educational systemt it could become a center for natural science studies. Conferences and meetings, restaurant, refreshment, lodgingneed to be evaluated. The relatively small size of the cinder cone, its sensitive surface and the limited space on a viewing platform within the crater must be respected and carefully considered. Observation of the winter sky, stars, and aurora borealis is very well possible. The furious weathers on the exposed mountain edge where Þríhnúkar are located, with winds / gusts up to and even over 100 m/sec, can be experienced in a memorable way in a safe environment. Possibilities in tourism in general and the multiplication effect need to be carefully evaluated. Connection with the ski resort in Bláfjöll must be evaluated.

Speculation and matters of opinion

There is no dobt that the opening up of Þríhnúkagígur is a feasible idea and there is no doubt that this idea is especially interesting, **but!!**

1. Do we have the right to deflower pristine lavas.
2. The area is within the farwater reserve of the capital area. Future water reserve?
3. Respect for the "shrine".
4. The purpose of the opening? Must be clearly defined!
   The extent of human construction and the nature of the activities / operation?
   Plans / goals concerning the numbers of tourists – danger of trampling?
   Steering / control of traffic – conservation?
   Solid walking paths – or undefined run of visitors?
   Easy access by car or longer walking paths?
   The general tourist or outdoors people?
5. The paradox: Declaration as a national monument / Opening ceremony
6. Another paradox: If nothing is done the Þríhnúkagígur crater will not only slowly deteriorate like it had begun, accidents are bound to happen, both human and environmental / Therefore something must be done.
7. What should be the extent of this something? If it is possible to make the crater and its opening accessible to the public without significant damage and preserve it at the same time, should not we do it? If cavers have the right to enjoy and experience it, should not other people too?

It all began and ages ago, we as individuals are just transient commas, letters or words in a never ending story. The intention is to disturb the Þríhnúkagígur cinder cone, the crater and the underlying pit, **as little as possible**, less than otherwise would have been the case. The surface was seriously beginning to deteriorate, both the vegetation and sensitive cinder- spatter surface. The formation was unattended and the opening dangerous. Þríhnúkagígur has been more and more frequented by cavers, rescue squads and hiking groups which inadvertently have trampled it down.

This development has now not only been brought to a halt. The vegetation is recovering, people stick to the path on the east ridge, at least more or less. The opening can hardly be said to be dangerous any more.

The story goes on. The main objectives at Þríhnúkagígur are: Preservation, conservation, respect, sharing, education, give back and to enhance peoples respect for nature and life in general.

Einar K. Stefánsson / Árni B. Stefánsson

The authors:

Einar K Stefánsson is 42 years of age, a civil engineer with environmental engineering as subspeciality. He has been a member of one of the rescue squads in Iceland since the age of 16 and has been one of their forerunnuers for almost 20 years. Einar is an experienced mountaineer, climbed for an example Cho You in 1995 and Everest 1997 and he is still active.

Árni B. Stefánsson is 59 years of age, a medical doctor with opthalmology as subspeciality. He has been interested in caves and caving for over 50 years. At a very young age he came to know the great caves of Hallmundarhraun in Iceland, learned about their damage and felt strongly how much some of the grown ups took the damage to their heart. The reasons for the ambitious proposal to make Þríhnúkagígur accessible is first and foremost to share. First its preservation must be secured as inconspicuously as possible, second accidents must be prevented also as inconspicuously a possible and, the two former given, it is the idea to make it accessible to the general public in as modest and secure a way as humanly possible.

About the preservation and conservation of sensitive formations in Icelandic lava caves

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Summary

The negative impact human visits tend to have on cave environment is discussed. The relatively profuse lava production in Iceland, because of the magma plume underneath is touched upon. The lavas are geologically very young and so are the lava formations. The vulnerability of these formations, often pristine, geologically fresh, very fragile, often hard to see and the fact that they have suffered heavily in most of the best known lava caves in Iceland,is discussed. The authors interest in preservation is mentioned, the long history behind, and the connection with damage. The importance of carefulness in revealing the location of sensitive caves in Iceland, before the preservation of sensitive formations is secured, is discussed. The publication of GPS locations of cave entrances in Iceland, in the reports of two British groups, is mentioned. The rather stringent view of the NCA against secrecy (carefulness) as a conservation measure, is touched upon and discussed why it can not be transferred on to the present lava cave environment in Iceland. The publication of over 500 cave entrances in a recently published book, *"Íslenskir Hellar"* is criticised. Some of the authors contradictory statements in the same book are discussed and criticised.

The connection between a newspaper article about a newfound cave and its whereabouts and the removal of most its sensitive inventory within a month and a half, in the nineteensixties, is presented. Data about ongoing damage in three specific caves is presented. At the end the difficulties facing the preservation of sensitive lava cave formations at present time in Iceland are mentioned.

Twenty seven references are cited.

Introduction

It is an accepted fact (1-11) that human visits tend to influence and have a negative impact on cave environment. Lava caves in Iceland have suffered heavily and have by far not enjoyed the same preservation status and conservation measures as karst caves in the western world. Most lava formations are very fragile, vulnerable too. The lighting most people use, many cavers included, is often insufficient in the light absorbing lava cave environment. Lava formations tend to blend in, often small and always fragile, especially if the lighting is limited, they are hard to see and tend to be inadvertently broken. One reason for damage is that lava formations, at least in Iceland, somehow do not enjoy the same respect as formations in karst caves. Also they are smaller and easier to break and collect.

The mentality of visitors may be affected by how lava caves are formed, how raw some of them are, how dark and cold, at least in Iceland, they are. The relative darkness in a basalt cave and the light absorbing lava cave environment may affect how people approach and behave in the lava caves. All cavers know formations are broken accidentally, on intent and removed (1,2,3,7,8,12-16). Vandalism can be a problem too (17-21).

A report 2002

It is a well known fact that all the best known Icelandic lava caves have been extensively damaged (11). Sensitive formations have been more or less removed from most of these caves. The author spoke on this topic on the X. Vulcanospeleological symposium in Reykjavík in 2002 (20). The proceedings have not been published. For this reason there is a slight repetition in this presentation.

Geologically young, fragile formations

Because of the magma plume underneath, Iceland boasts of more lava production per unit of land than any other place of similar size on earth. Holocene lavas cover 1/10 of the land, or over 10.000 sq. km. These lavas are geologically fresh, all under 10.000 years of age, so are of course the lava cave formations. Some of the formations in Icelandic lava caves and some of the lava caves have a singular human heritage value and many have a great national conservation value. Many of these caves demand utmost respect and that every effort be taken to preserve them. Few people, cavers included, seem to understand their silent language, why and how they deteriorate.

Interest, preservation

The author has been interested in the preservation of lava cave formations since he remembers, or over 50 years. As a child he observed the deep sorrow and helplessness of the owners of the great caves in Hallmundarhraun, observed and learned about the damage, how it took place and how people behaved. In the late fifties and early sixties he heard about new cave finds (11,12). In the sixties he heard and read about damage to these and other caves. Late in the sixties and in the seventies he experienced how people started being careful about revealing the locations of caves. The Icelandic geodaetical survey even took out some cave names on their maps in the seventies. The author has listened to people, heard, experienced, seen and studied why and how damage is done, inadvertently, by collection, greed, carelessness and for other reasons. He has observed signs of damage in most frequented lava caves in Iceland he has been to. Realised that damage of formations seems to lie in human nature and seems not be preventable in open and publicly accessible caves (6,7,8,10,11,13,16). Many sensitive caves in Iceland have to be closed, accessrestricted and properly managed, if future conservation is to be satisfactorily secured (19). A handful of caves should not to be visited, except by trained individuals, for very specific and previously defined reasons. Icelandic lava caves need to be classified as to whether and/or how much human traffic they can take.

Location of sensitive caves

From the beginning of the ISS in 1989, one of the authors key topics within the club, (6,16,24) was how to handle the location of sensitive caves. Because how accessible (once the location is known) and hard to close the lava caves are, there is no other way, than carefulness, when giving away the location of a sensitive cave. Not exactly secrecy, rather trust, respect and carefulness. Whom you tell, how the information is given on and most important, how the responsibility is transmitted or transferred over. The prerequisite of this method is the mutual trust it is based on, at the same time it is its vulnerability. On the opposite however, if the location of a sensitive cave becomes generally known, the cave is bound to be damaged. Has anyone the right to reveal the location of a cave that is impossible to preserve? Where do we start, where do we end? We cavers have obligations to our subject and damage is not acceptable! Sensitive formations in frequented caves in Iceland tend to be broken and disappear. It is as simple as that and it has been that way a long time. Just as if it were a law of nature. Some people have even accepted this as a fact.

GPS

After GPS instruments came along, the ISS started collecting GPS data on entrances. It was often discussed within the club how to handle this data and the views differed. One of he authors (ÁBS) always reasoned against publishing data that discloses the whereabouts of sensitive caves,before protective measures are taken (21). All included, hints, photograps, description and now GPS. The arguments were always the same, the bitter experience, human nature and how hard it is to close and manage the caves.

All tour guides know how to use GPS. There are numerous foreign groups, some with little or no knowledge of Icelandic language or customs. Great many Icelanders now own and know how to use GPS instruments. Part of the problem is how unaware people are of the fact that damage is taking place. Some still break and/or collect broken stones.

Publication of GPS data in reports

GPS data on cave entrances in Iceland appeared for the first time in the Laki Underground 2000 expedition report (22). The Laki 2000 and two following expeditions were done in collaboration with the ISS. The reports contribute significantly towards the understanding of lava caves in Iceland and lava flow in general. The reports are excellent, especially the geophysical part, which is quite special. However because of the GPS data the report(s) contains, one of the present authors (ÁBS) mentioned his concern about revealing the location of sensitive caves and specifically discussed this with one of the authors of the Laki report. He also discussed this with his fellow cavers in the ISS. Asking about their opinion on the preservation of the two caves in the Laki area that can be considered sensitive, Rauðsteinshellir and Blámi. There was no agreeing on the subject and the discussion, important as it was, was at the moment more academical the practical. Neither of these caves can be considered very sensitive and they are certainly off the beaten track.

The Laki reports did not have a wide distribution and can in spite of the GPS information they contain, not be said to endanger the subject.

The SMCC (Shepton Mallet Caving Club) reported 2004 about an expedition to the Reykjanes peninsula in June 2003 (23). Over 170 caves are reported, most of them with a GPS location. Some of these caves are sensitive and some of the frequented ones have been from somewhat, up to significantly damaged. The members of the SMCC neither seem to have noticed much damage, nor do they seem very concerned. It must be said in their defence that the bases of removed stalagmites can be very hard to see and damage to the stalagtites, the lava straws, which often crumble into dust, is even harder to notice. Except for agreeing on the gating of Árnahellir, which they neither visited, nor give up the GPS point on, there is no discussion about the importance of conservation in any of the caves reported. The present author mentioned his concern about the GPS locations with one of the authors in 2006 and told him he strongly objected to publishing such data, at least on some of the caves. The answer was, the SMCC had found many of the locations on the internet and that the report did not have a wide distribution.

The SMCC report does not contain any suggestions as how to manage the reported caves, or how to prevent damage, as for an example the NCA Minimal Impact Caving Code suggests (1).

Why give up the GPS location?

The reason the British cavers give up almost all GPS points in their reports, may at least in some part lie in the NCA policy (2 (Chapter 11. Conservation: Assessment and Implementation)). In the 11.1.1: '*Secret conservation*", chapter, the NCA deems a careful approach, at least as the present authors sees it, as secrecy and say: '*It is totally inappropriate as a method of cave conservation...It is elitistic, divisive and often counter-productive*". Deeming from the way the NCA chapter on secret conservation is formulated, there must at the least be some disagreement behind it. The NCA policy does not enjoy an international approval (6,7,8,19,24,25) and this policy, or view, certainly does not apply to a thinly populated land like Iceland. Land with history of damage, wide lava fields, numerous caves, weak caving community and very limited, or no management.

GPS data on almost all cave entrances in Iceland published

In November 2006, a list with the GPS location of over 500, almost all cave entrances in Iceland, appeared in the book *Íslenskir Hellar* (26). With the help of the text, maps and photographs, it is possible for knowledgeable individuals to deduct the whereabouts of someof the few caves not listed. Many of the underlying caves are quite sensitive and some have a significant conservation value. In spite of connection with British cavers, the author, neither cites nor mentions the NCA Cave Conservation Handbook (2), nor the NCA Minimal Impact Caving Code (1). Neither does he mention, cite, nor discuss any other litterature concerning conservation.

Only three very sensitive caves have to this date been gated in Iceland. Among the GPS points published, are the locations of several dozen sensitive caves. The book is beautiful, at least on first look, not in the least because of the photographs, the majority of which are of formations. Some of the readers will certainly want to see the caves and experience them for themselves. A few may even want to come into possession of formations, protected or not, forbidden or not. All caves, except for three, are open. The discussion about general conduct in caves and preservation is insufficient and when it comes to conservation, the author seriously contradicts himself (19). For an example by (wrongly) maintaining that insignificant damage has been done since 1990. That he even credits himself for this 'fact"(26 (page 45)), is incomprehensible.

Dozens of caves must be closed!

The amount of tourists in Iceland has multiplied. There is a great demand for novelties in a booming, not very considerate, tourism industry. Each and everyone wants to see points of interest for himself, caves included. Most do not notice and many do not even care about a little accident here, or a minor damage there. Some collect. Hardly anyone realises the multiplication effect, the additive effect on the long run, or the fact that formations, once gone, never come again. Given he is able, hardly anyone is willing to deny himself a visit to a beautiful cave, even knowing it means a 'little" damage. The dozens of sensitive caves mentioned and described in the abovementioned book, can now, once their location has been given away, be considered publicly open. Some of the caves have even been made amost irresistible to visit. People tend to go to the most interesting caves first, often the most sensitive ones. The groups tend to be too large, the lighting too limited. Many, even most of these people are inexperienced and many overenthusiastic. Apart from a few collecting, most people simply bump into and inadvertently break formations. Neither the ISS, nor the author of *Íslenskir Hellar,* have come forward with ideas about a classification of caves, or how to preserve the ***'dozens of caves.."*** mentioned in the introduction to the GPS list; ***'.. must be closed before the publication og this book."***!! (26, (page 660)).

Specification of sensitive caves, management, problems

Except for suggestions from the present authors, the 'dozens of caves", now endangered, have not been specified. The ISS has not been functioning for many years and there is noone to manage the caves at present. The Environmental Bureau (Umhverfisstofnun) has shown understanding and recently paid for the material cost of the gating of the sensitive section of Kalmanshellir. The institution, like all such institutions is overburdened, has limited means and must priorities. The Environmental Ministry has also shown understanding and paid for example for some of the preventive actions at Þríhnúkagígur in 2005 and 2006. There really is some understanding within the governmental and municipal system and the municipality of Hafnarfjörður recently paid for most of the material costs at Leiðarendi. The number of caves where action must be taken, is however overwhelming. There is limited understanding of the importance of caves and their environment in the universities, whether it is geology, geography, environmental, or tourism programs. Philosophical and ethical questions regarding caves need to be dealt with. Archaeological remains need both to be conserved and made accessible to tourists.

An interesting task

To emphasize the importance of preservation measures, one of the rather sad, but also highly interesting tasks, was to document that damage is serious and ongoing. The authors were somewhat handicapped by the fact they seldom go more than once to any cave and have not searched for and hardly entered lava caves for some, or even many years. Although there is more to take from, they decided only to focus on four important caves. Some of the data presented was collected earlier, but most of it has been compiled and collected since March 2007. First a connection between a newspaper article giving up the location of a sensitive cave and the removal of most its formations within weeks, is presented.

The data, discussion

1. Vegamannahellir is the only cave in Iceland known to the authors to be damaged in a very short time (13). Caves usually suffer gradual damage (6,11,16,19,20,21). Deteoriation that usually takes place in tens of years and goes unnoticed by most people, cavers included. It was probably the rapid damage to Vegamannahellir that lead aware people to carefulness in the sixties and seventies. One of the present authors (ÁBS) was helping out at the farm Kalmanstunga, near the great caves of Hallmundarhraun, when Vegamannhellir was found. He knew caves tend to be damaged by pople and followed the news with interest. First he heard about the cave find, which was also reported on the radio. News about damage came later an then a 'loud" nothing. He registered all this, but being only 14 at the time, he could not do much about it. Twenty years later, 1983, when looking into the files of the Council for the Conservation of Nature (Náttúruverndarráð), he came upon a letter dated 31.08. 1963(13), complaining about damage done to a newly found cave, Vegamannahellir. Searching for the connection last January, he found what lead to the damage. A forty five year old newspaper article (12), dated seven weeks before the letter. A whole Sunday front page and two inside pages with photographs, in the second most widespread newspaper at the time. What surprised was the short time interval between the publication and the damage. Something he did not remember, but which more or less underlines the connection. It is mentioned in the informative and

rather well written article, that it is prohibited to damage and remove formations (10). The cave, its exploration and breathtaking pristine formations, are beautifully described and the precise location is mentioned. At the end the readers are specifically asked to be considerate and careful in this 'untouched" cave. According to the letter from Þorleifur Kristófersson (13), the old dripstonemaid (also named woman with a child), the decorative shelves and most of the other dripstone formations were gone within weeks. When one of the authors of the article was contacted last April, he did not see the damage as any of his concern, not even in retrospect. 'Why should he?" 'The authorities are responsible." To the comment: 'Primum non nocere! " 'U-.. humm." Who are these authorities? Other people! ? Us? Cavers? As a matter of fact, there was a feeble effort from behalf of the authorities. The local administrative officer put up, a now long gone sign by the entrance, forbidding damage.

2. Formations are literally being removed from under our noses (18). One of the authors took a photograph of the 'twins" in Vatnshellir in 1996. Pointing at the same time out, they were in danger, because of the evidently increasing traffic in the cave. On a trip with foreign cavers four years later, he found these formations gone. As a part of their effort collecting evidence about ongoing damage after 1990,the authors decided in April 2007, to find and photograph the place where the dripstone twins stood. What they found surprised them, thanks to her (like every wives), ability to see everything. After finding and photographing the bases of the twins, they examined the cave. About fifteen meters further inside, a stone lay on the floor. On closer inspection, unbelievable as it was, this was one of the twins. Someone had evidently removed it from its base and thrown it on the floor. It was somewhat damaged and broken after the fall. The other twin lay a little inner, also damaged. After this they carefully inspected the cave. Near the pit at the downflow end they found, first one large round piece, then another, and a third. The pieces fitted together into one of the largest stalagmites ever to be found in an Icelandic lava cave, about 145 cm high. Because of its size it can not have been broken accidentally and judging from the circumstances, it is improbable it broke from natural causes.
3. Gullborgarhellar were found in July 1957. The find was reported in Morgunblaðið, where it is mentioned the caves were off limit to the general public, until they had been examined. In October same year, a four page article (11) appeared in the same newspaper, written by the geologist Sigurður Þórarinsson (worldfamous because of his teprochronology), which had just inspected and mapped the caves with his companions. Sigurður had backthoughts about bringing the attention to the caves the way he did. Reflecting on the conservation of the caves, he mentions the damage done to Raufarhólshellir and the great caves of Hallmundarhraun and urges the readers to be responsible and spare the formations. His final words were: *"Natural protection is not first and foremost about setting laws, it is a part of upbringing and maturity. The treatment of the caves in Gullborgarhraun can be a touchstone on the*

situation in these matters". It was decided not to try to gate the most important cave, Borgarhellir. It was also decided that the people at the nearby farm Heggstaðir would guide all visitors to the caves. No fees were decided and this management, although for the most part respected, came slowly came to an end, for several reasons, in the next 15-20 years (16). Sigurður was behind an announcement from Náttúruverndarráð in 1958, a year after the find. In this announcement, the dripstones of all lava caves are declared national monuments and their breakage and removal forbidden (10). Damage to the caves of Gullborgarhraun was reported at least four times in the newspapers in the sixties and into the seventies. A chain was set up in 1975 to protect what was left of the formations on the 'altar", at the end of the about 600 m long Borgarhellir. In 1983 one of the present authors, somewhat to his surprise, came upon photographs from an Irish caving group, in the files of Náttúruverndarráð. Of formations, he had thought long gone. Two years later he visited Borgarhellir and took a few documentary photographs. On the next visit, in September 2007, almost all the dripstones still left in 1985, were gone. Even though often hard to find, the bases of thirty seven broken stalagmites could be counted in the 20-30 m^2 'altar" area, (behind the chain). Only a few minors were left, a faint reminder of the former glory. The chain had evidently fallen down a long time ago. In the light of photographs taken in 1957, 1983, 1985, 2007 and a few hints, the damage on the 'altar" seems to have been gradual. One stalagmite has been removed on the average, every year and a half. Great many (all) stalagmites have been removed from the rest of cave and the stonestraws and helictites, i.e. the stalagtites, have suffered beyond description.

4. The fourth cave is Leiðarendi. A geologist Sigmundur Einarsson, at the time the editor of Náttúrufræðingurinn, (the journal of the Icelandic Natural History Society) pointed the opening out to one of the authors (ÁBS), on their way from lava analysis at Þríhnúkagígur in 1991. He subsequently explored this interesting and at the time pristine cave. A little later he measured its length with his son Stefán. In 1992 he instigated and took part in surveying the cave with Jay Reich and others. When a young geologist he showed the cave to in 1994, called him in March last year, he decided to use the opportunity and visit the cave. He had not been there since about 1996, but had heard rumors of damage and knew something was going on. The cave has been used as a 'pristine", or wild cave by a few tourist firms since a little before the turn of last century. On visit there was an obvious brown, up to 1 m wide tramplepath, in the greymoss, leading from the road to the cave. Several meter wide brown tramplearea was around the entrance. Most of the stalagmites had been broken and many had been removed. Three stalagmites over 40 cm high were still standing and a few minor ones. The sheep‘s skull and some of the larger bones had been somewhat dislocated. Finger and handmarks were in the clear, whitish, and bit yellow, whale-rib-like, bands of cave slime, covering the walls of the upper end.

Visiting the cave three months later with their granddaughters, the authors found the largest of the three large stalagmites missing. Two months later when one of them went to find and photograph the place the removed stalagmite had stood, the second, the more beautiful of the two still left and a pretty singular one, was also gone. Feeling almost as if I had lost a relative, he decided to do something about it. Compiled a report (27) and sent to all parties involved. Got the necessary permissions and two grants and just recently finished putting up two information signs and a little over 100 m of demarcation chain. The grants, around 3000 Euros covered 85% of the cost. About 200 hours were spent on the project. All bodies and people informed beforehand, including the tourist firms, more or less agreed on this intervention, which is also bound to be criticised. The next steps could be to pronounce the cave a natural monument, gate it and try to manage it. Some people in present time Iceland may find that hard to understand, most will probably accept it.

Final words

Of course we have to live with damage, but it is irresponsible for serious cavers, to regard damage as inevitable or acceptable. At present, caution and certain amount of discretion is the only way to preserve sensitive lava caves in Iceland. In spite of words to the contrary, there is no question that damage to sensitive formations in Icelandic lava caves, is an ongoing and serious problem. In the light, that it is us humans who are to blame, there is no doubt that the media coverage, incl. the internet, publications, etc. which disclose the whereabouts of a cave, lead, or at least may lead, to its damage. There seems to be a direct relationship between human traffic (cavers, tourists, general public) and damage in publicly accessible caves (and caves with restricted access!). Of course this is common knowledge, but this knowledge is somehow difficult to tackle. How to react and how put it into practise, is controversial, not in the least because of conflict of interests. Preservation and conservation and the interests of cavers, the general public, tourists, media and publishing companies only go hand in hand, if the first two are given priority.

The seriousness that almost all available data on Icelandic lava caves, including the GPS location of over 500 cave entrances was recently published, can hardly be overemphasised. Ddozens of the underlying caves can now be considered publicly open and some are seriosly endangered. Under the present circumstances, it is impossible to take the necessary action except in a very few of these caves.

Public and tourist education in Iceland must be improved, public, tourist and tourist firm behavior must be improved. A number of caves must be gated (6,19). A time-consuming and complicated consensus must be reached, agreements must be made, etc. The cost of gating and other preventive measures is overwhelming, there are difficult legal and logistical problems to be dealt with. The ISS is not functioning. There is no other caving club, or organisation of active cavers interested in conservation in Iceland at the present time.

The relevant authorities possess limited knowledge about cave management, or as how to intervene. There is some understanding, which is of course very positive, but these authorities must be better informed and that takes time. A certain amount of goodwill is not enough, generous grants and a serious action is needed. The legal environment must be improved. Some kind of central management, with a functioning advisory body with some kind of legal status, is needed. Local management should be evaluated. Whether responsible tourist firms can foster, i.e. gate and take care of specific 'tourist" caves must be evaluated. etc. etc.

It is quite a task to prevent the foreseeable damage. An 'agreement", or understanding can only be reached with the general public, hiking groups, tourist firms e.t.c., if specific caves are 'opened up" and made more accessible. Some caves must be gated, in some demarcation of footpaths must be set up, formations fenced off, or specifically marked. With or without discretion, it is neverending story, only slower with!

Voila! Vale! Thank you.

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About the authors:

Árni B. Stefánsson 59 years of age, is a medical doctor with opthalmology as subspeciality. He has been interested in caves and caving for over 50 years. He came to know the great caves of Hallmundarhraun in Iceland at a very young age, learned about their damage and felt strongly how much some of the grownups took this to their heart. This feeling, newspaperarticles and news about damage in the sixties and seventies, carefulness shown by experienced individuals regarding the location of caves, personal experience and gut feeling, lead Árni to start fighting for the preservation and conservation of Icelandic lava caves a quarter of a century ago.

Gunnhildur Stefánsdóttir, 56 years of age, a nurses aid, pharmacician, opthalmological assistant, mother of two and grandmother of three, has been married to the first author for over 30 years. She is a full time partner and has assisted and/or taken part in many of his enterprises ever since. She even courageously worked herself out of an attack of claustrophobia in a tight cave several years ago. Without her contribution this presentation/article would not have come to light.

Exploration, surveying and photo-documentation of the Aariqa Lava Tube (Quaternary – Es Suwaida, southern Syria)

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The cave Aariqa lava tube was also called Aahiréand it is found within the Quaternary volcanic deposits that covers Es-Suwaida Plateau in the southwestern part of Syria. The cave was used during the Arab rebellion against the French mandate in Syria. The entrance is impressive open-collapse with constructed structures (restaurants, rooms, etc…) that functions as facilities for operational personnel and visiting tourists. This contribution is the first documented exploration and surveying of the Aariqa lava tube.

The cave, whose general orientation is east-west, consists of two main tubes that are connected with a narrow crawl passage. The overall surveyed length of the cave does not exceed 500m. The Tube 1 is just beyond the entrance door and it is as long as 165m with a section that is about 16m wide and 8m high. At the westernmost end of this tube, a mud talus almost blocks the gallery.

The Hall of the Barricades could be described as the eastern side of a huge roof collapse that makes a big hill at the eastern portion of Tube 2. Thiscollapse area has steep east and west sides (around 25˚). Tube 2 is relatively a smaller gallery than Tube 1, with a development of about 60m beyond the collapse area. It is worth noting that Tube 2 is also lower than Tube 1. This huge gallery with flat floor hosts many construction remnants in the shape. It is believed that it may have served for housing and protected by the barricades. Morphologically, it ends to the west with a narrow passage (The Narrow Junction) that leads to an irregular pattern of chambers with relatively low ceiling. In the hall Terminus Jan 2008, a sort of a construction that could be a water pool was observed. Here water drips from the ceiling. There might be some potential continuation at the end of this hall with the necessity of crawling in tight passages.

In general, no speleothems (of carbonate mineralogy) were found in this cave, except for tiny little stalactites found near the entrance.

The unexpected discovery of a Dodo *Raphus cucullatus* Linn. (Aves, Columbiformes) in a highland Mauritian lava cave

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During a survey of Mauritian caves in September 2006, a skeleton of a Dodo (*Raphus cucullatus* Linn. 1758) termed 'Fred'was serendipitously discovered in a highland lava cave. It was subsequently removed from the cave and studied. It is only the second individual associated skeleton to be found, the only one recorded in context and in modern times, and has been called 'the most scientifically important Dodo in the world'. This paper records the circumstances surrounding its discovery, and provides additional information concerning other dodo subfossil deposits. The preservation of bone material in lava tubes is also discussed.

A new survey of the lava caves of Mount Suswa, Kenya

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Mt Suswa is a large dormant Holocene trachyte-phonolite shield volcano, exhibiting nested calderas, located in the Eastern Rift Valley, 80km due west of Nairobi, Kenya. Earlyinvestigations of caves on the volcano were undertaken by a group led by P E Glover in 1962 and 1963, and subsequently by the Cave Research Group of East Africa after its formation in 1964. As a result of these activities caves were discovered and explored in the newer lavas on the south side of the volcano, and in an extensive phonolite pahoehoe flow - called here the Main Cave Flow - that had erupted down the eastern flank. Although some of the caves were mapped by the early explorers and CEGEA, a comprehensive survey of all of the caves and the 50 or more impressive collapse pits in the Main Cave Flow was never completed, and so the relationship between the various cave segments could not be worked out. This problem was rectified in June, 2007, when the opportunity arose to re-map the caves with modern techniques and locate the collapse pits with GPS. This current project mapped 7.376km of cave passage, although it is considered that the total length of passage so far known in the Main Cave Flow may be as much as 9km.

The Suswa caves of the main group are very unusual because they have formed in a lava flow of phonolitic composition. Phonolite is an intermediate acid, alkali rich lava, which may effuse at significantly lower temperatures than basalt, although it may have greater fluidity. The main cave flow is probably the best example in the world of a tube-fed phonolitic lava flow, bearing characteristics of inflated pahoehoe, and a cave system comparable in length, volume and complexity to other leading systems more commonly found in basaltic lava flows. This paper describes the caves and attempts to compare and contrast the internal features with basaltic caves. The incentive to map the caves came from the local Maasai, who have plans to provide guiding services to some of the caves and to develop the wider geotourism potential of the volcano. A long term goal will be to develop Mt Suswa as one of Africa's newest Geoparks.

Introduction to the lava caves of Payunia, Argentina

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Until recently cave exploration in Argentina has focused upon the small outcrops of Jurassic gypsum and limestone.Many caves have been discovered but none more than a few kilometres in length. The reasonably close proximity of extensive lava flows to the Jurassic caves has meant that in recent years attention has turned to thepotential of the volcanic rocks. Some exploration has been conducted by INAE and GEA caving groups based in Malargüe and Neuquén respectively. Several reasonably extensive caves have been discovered but the great size of the lava flows associated with thePayun Matru volcano suggests that there will more discoveries in the future. This paper provides a short introduction to the area and discusses the future potential for cave exploration.

Umm Jirsan: Arabia's longest lava-tube System

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This system is located in Harrat Khaybar Lava Field, 130 kilometers north of Medina in the Kingdom of Saudi Arabia. The system consists of three lava-tube passages separated by two collapses and measures 1481.2 meters in length with a typical passage height of 8-12 meters and a maximum passage width of 45 meters. Sediment covering the cave floor was measured at 1.17 meters deep.

Wolves, foxes, swifts and snakes inhabit or use the cave. Caches of human and animal bones are found in many places, lying on the surface of the floor sediment. Carbon dating revealed that various human skull parts are from 150 to 4040 years old and the oldest animal bone dates 2285 bp.

Many basalt fragments of a size and shape useful for gouging or scraping were found inside the longest cave passage, about 180 meters from the closest entrance. It is conjectured that older bones and tools might lie beneath the sediment and excavation under the guidance of an archeologist is recommended.

Umm Jirsan is one of at least 40 strings of collapses appearing on the most accurate geological map of Harrat Khaybar. Some of these strings are over 15 km long, suggesting that other, much longer lava tubes may be found in this area.

The Karst Information Portal:
A Vital Resource for Non-Karst Caves and Related Phenomena

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Data access, management, and evaluation challenge the progress of speleology. Crucial information is scattered throughout mainstream journals and buried in gray literature, which includes maps, databases, technical reports, theses, dissertations, images, and videos. This problem is exacerbated in vulcanospeleology, where information is often excluded from or overlooked for inclusion with karst speleological data, and due to overlaps into other disciplines.

The Karst Information Portal (KIP) is a solution to these research problems. KIP developed as an international partnership to solve information access and management problems through an Internet gateway to karst data and services. While volcanic terrains are not karstic, they contain many related features, environments, and research and management issues which are well served by data management through KIP. Key KIP features complete or in development include:

- Federated (simultaneous multi-source) Internet searches to more reliably locate key information;
- A searchable of multidisciplinary speleological database;
- An on-line speleological library;
- A collaborative on-line workspace to promote knowledge discovery through the posting and evaluation of images, maps, databases, and other published and unpublished information.
- A cave mineralogy database;
- Oral histories of noted speleologists.

Like other well-known portals, KIP will continue to grow as users and partners add pertinent databases, maps, gray literature, and other information of interest to speleologists. KIP will not duplicate existing databases but will serve to more efficiently access and process them. KIP has the potential to transform speleological research by creating new knowledge through the integration of international information in the discipline.

Lava caves with calcite speleothems: some international comparisons and a plea for more information

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Abstract

The nomination and subsequent inscription of sites on Jeju Island for World Heritage status included the Geomunoreum Lava Tube system. Two lava tubes in the system, Dangcheomulgul and Yeoncheongul are overlain by late Holocene carbonate sand dunes that have been leached of their carbonate producing abundant displays of fine calcite speleothems within these caves. Other lava tubes on Jeju, particularly at Hallim Park, also contain calcite speleothems.

As part of the comparative analysis for the World Heritage nomination investigations were made as to the presence of other calcite speleothems in lava caves around the world. A few sites had very small calcite deposits derived from the basalts themselves and one site, Duck Creek Lava Tube in Utah in the USA had relatively abundant speleothems. No other substantive sites were identified at that time.

In Australia, Quaternary calcareous aeolinites overlie Tertiary basalts at a number of sites. At a least two sites, Cape Schanck in Victoria, **Cape Beaufort (Black Point) in Western Australia, sea caves withsignificant calcite speleothems occur. At Cape Bridgewater, in western Victoria, significant tufa deposits are derived from the aeolinites and are deposited on the basalts. Similar deposits are found surrounding, and within basalt sea-caves in the Woolnorth area of Northwest Tasmania. On the far offshore Macquarie Island in the Antarctic Ocean, a series of sea caves have formed. These also contain significant carbonate speleothems although not on the same scale as Jeju Island, Duck Creek, or the other Australian continental sites.**

This paper describes and illustrates the three Australian sites and lends weight to the comparative analysis for Jeju Island as having lava tubes with calcite speleothems of 'outstanding universal value.' However, there may well be other lava caves around the world that are not known to the current authors.

Discovering New Diversity in New Mexico, Hawaiian, and Azorean Lava Tube Microbial Mats

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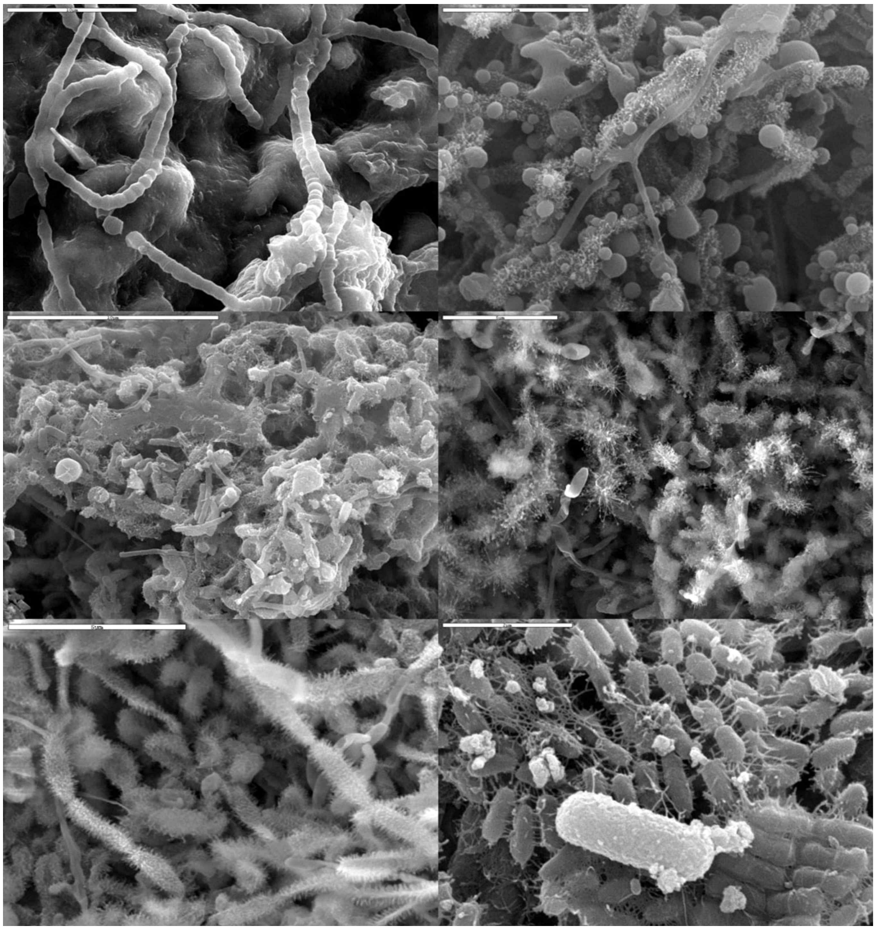
Bacterial mats cover walls and ceilings of lava tubes around the world, yet little is known about their composition, role in the ecosystem, or what controls the species diversity of the differently colored mats. Specifically, we addressed (1) how do bacterial communities in Hawaiian, Azorean, and New Mexican (USA) lava tubes differ? 2) Does species composition differ between differently colored mats? (3) Does diversity vary with respect to the different ages of lava flow, surface land use, temperature, or elevation? 4) What is the amount of organic carbon present in the drip water entering the cave system that can fuel heterotrophic growth? and , (5) Do lava tube microbial species produce antibiotics?

A study of the bacterial mats was done in Pahoehoe Cave and Four Windows lava tubes in El Malpais National Monument (ELMA), New Mexico; in Bird Park, Epperson's, Kaumana, Kula Kai, and Beall's Caves found on the Big Island of Hawaii; and Gruta dos Buracos and Gruta da Branca Opala in the Azores. Rock samples covered with differently colored microbial mats (yellow, white, pink, and tan) were aseptically collected from each cave, from which DNA wasextracted and then purified. The 16S rRNA gene was amplified using PCR (~1365 bp), cloned, and then later sequenced. From this, closest relatives werefound using the Ribosomal Database Project II and BLAST databases, and a phylogenetic tree was constructed using PAUP. Yellow microbial mats appear to be less diverse than other colonies and were dominated by *Actinobacteria*, *Alphaproteobacteria*, and *Gammaproteobacteria*... Overlap existed between clones of Pahoehoe and Four Windows Caves (New Mexico), particularly within the *Actinobacteria*. Overlap also was found in the *Alphaproteobacteria* and *Gammaproteobacteria* between El Malpais (New Mexico) and Hawaiian lava tubes. In contrast to El Malpais lava tubes, where an abundant number of *Actinobacteria* were found, none have been found in Beall's Cave in Hawaii, thus far. Other Hawaiian caves sampled do show an abundance of *Actinobacteria*. Hawaiian lava tubes show a great deal of diversity; closest relatives were found to be *Cyanobacteria, Actinobacteria, Acidobacteria, Bacteroidetes,TM7, Nitrospira, Plancotmycetes, Gemmatimonadetes* and *OP11.* Pink and white microbial mats show the greatest diversity. Our preliminary results show a moderate amount of microbial diversity among the three sites, while suggesting the presence of common microbial groups between the different sites.

Hawaiian lava tubes studied to date range from 118 to 2300 years old, while the New Mexico caves are 10,000 years old. Preliminary sequence analyses suggest that younger lava tubes are more diverse in terms of their microbial inhabitants.

We obtained cultured isolates by swabbing microbial mats and inoculating R2A and other low nutrient media plates, which were incubated on site for several days. Tests of antibiotic production in cultured isolates from Pahoehoe Cave (NM) and Gruta da Branca Opala (Azores) against common pathogens such as *Escherichia coli* and *Staphylococcus aureus* reveal the presence of a small number of isolates that produce antibiotics.

These results shed light on the heretofore unknown diversity of lava tube microbial mats.



Cavernicolous Animal Diversity of Lava Tubes in Jeju Island, Korea

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Abstract

As the results of the review about cavernicolous fauna surveyed from lava tubes in Jeju Island from 1966 to now, a total of 121 species, 72 families, 26 orders, 9 classes of 5 phyla was recognized from 97 caves.

Lava tubes of Jeju Island are characterized by short formation history comparing with lime stone caves of Korean peninsula, high effects from the outer environmental changes and mostly located in less than 500m altitude.

Among the cavernicolous animals (121 species) from Jeju caves, the number of troglobite species is only three species (2%), including *Gammarus*sp. of the class Crusstacea but troglophile one are 18 species (15%) and the others (83%) are regular visitors or twilight zone dwellers.

This study is a preliminary one on Lava caves, dealt with species diversity, cave altitudes and habitat types. It is, however, seriously demanded for more detail investigation on lava caves of Jeju Island because of increasing the damage of lava caves recently by human acts.

Management requirements that apply to World Heritage karst and volcano-karst properties

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1. Conditions of Integrity

Paragraph 78 of the 'Operational Guidelines for the Implementation of the World Heritage Convention' (2008) requires that for a property to be deemed of outstanding universal value it must meet the conditions of integrity and must have an adequate protection and management system to ensure its safeguarding.

Integrity is defined as a measure of the wholeness and intactness of the natural heritage and its attributes. However, the World Heritage Committee appreciates that no area is totally pristine, that activities of traditional societies often occur in natural areas, and that where these activities are ecologically sustainable they may be consistent with the outstanding universal value of the World Heritage area.

2. Requirements for Integrity that Apply to Karst and Volcano-Karst

The unusual characteristics of karst and volcano-karst

When compared to other landscape styles and ecosystems, karst and volcano-karst have a number of unusual characteristics that must be taken into account when integrity is assessed:

1) Karst and volcano-karst are unusually complex because they comprise both surface and subterranean features and values. They integrate surface and subterranean processes, both biological and physical. Karst also has natural archives of its own history, because cave deposits record stages in the evolution of the karst and of the environment and ecosystems around it.
2) Subterranean ecosystems are fragile because environmental conditions can be extreme. The ecosystems are remote from light and food sources and may be subject to periodic flooding.
3) The ecological integrity of subterranean karst and volcano-karst depends above all on hydrological conditions, because solar energy input is moderated mainly through the hydrological cycle which powers the karst system, transporting organic detritus from the surface. Energy flows are transmitted underground by water, the quality of which is critically important for survival of the subterranean ecosystem.

4) Most water passing through karst and volcano-karst is introduced by infiltration of rainwater and by sinking streams. Many of the sinking streams are derived from impervious catchments that lie beyond the boundary of the karst area.Consequently, conditions upstream can have a critical influence on the integrity of the subterranean ecosystem. Recharge zones are of critical importance and need to be identified and managed. Pollution carried in streams and percolation water is a major threat to the viability of vertebrates and invertebrates and to other animals that may depend on them for their food. In fragile subterranean ecosystems,serious damage can occur unwittingly because the major effects are underground and out of sight.
5) Drainage areas within karst and volcano-karst are not easily delimited. The drainage basins and routes followed by water are not obvious, because drainage paths are largely subterranean. Large springs are a feature of karst and volcano-karst, but groundwater basins do not necessarily follow surface divides and headwaters may be derived from sinking surface streams located many kilometres away. The flow-through time for water from its first sinking underground to its reappearance at a spring can vary from days to years depending on the size and nature of the groundwater system.

Meeting the Requirements for Integrity

World Heritage properties have superb features of outstanding universal value. How can we be sure that these features are protected and that the conditions of integrity are still being met? To make that judgement we need to ask several questions and obtain satisfactory answers to them:

a) The intactness of the natural heritage and its attributes.
   Since the property was first inscribed on the World Heritage list, has it suffered from the adverse effects of human development, excessive tourism impactor neglect? Does on-going human activity in the area or in the region around it threaten the long-term sustainability of the natural ecosystem? Are there possibilities for environmental rehabilitation that will lead to effective repair of any damage?
b) The adequacy of the size of the property.
   Has the size of the protected area shown itself in practice to be sufficient to ensure that on-going natural processes will continue uninterrupted, so that the World Heritage property'ssignificant features and values will be maintained for the foreseeable future? Is there a sufficient buffer zone that might absorb the impacts of human activities in the surrounding region?
c) The prospect of maintaining integrity into the future.
   Is the World Heritage site optimally delimited for management? Are the boundaries of the property appropriate for effective protection of the important features of the area: both surface and underground; both physical and biological or do the property's boundaries need to be readjusted? Is the area adequately protected by effective legislation?

The boundaries of nominated properties require very careful consideration. Nature does not recognize administrative boundaries. Where possible boundaries should follow natural watersheds (including groundwater divides), because that will facilitate catchment management, especially through the control of water quality in recharge zones and the maintenance of high quality habitat for subterranean species. The largest area practicable should be demarcated to ensure living space for endangered species above and below ground. If necessary, legal boundaries should be adjusted to ensure high level legal status and protection of the core World Heritage area. This will help obviate future problems and so facilitate effective environmental management.

3. Requirements for Management that Apply to Karst and Volano-Karst

"The purpose of management of a World Heritage property is to ensure the protection of its" outstanding universal value"for the benefit of the present generation, and its transmission unimpaired to future generations" (Thomas and Middleton 2003, p. 65). World Heritage status often brings considerable tourist pressure that may threaten the integrity of the site, but with good planning and appropriate practices tourism in protected areas can be managed sustainably (Eagles et al. 2002).

Responsibility of the State Party

The inscription of a property on the World Heritage List implies that theState Party will carry the ultimate responsibility for management of the site to the highest level of international conservation practice.

Management Options

Thomas and Middleton (2003) and Hockings et al. (2006) have reviewed options for effective management of protected areas. Specific guidelines for karst and cave protection are provided by Watson et al. (1997). Management planning starts with the present situation and asks the question: where are we now? It then proceeds to consider a vision for the area: where do we want to be? Management involves a sequential process of planning, implementation and outcome, at each step there being a process of evaluation. The management cycle is perpetually implemented with a view always to making improvements and getting closer to an ideal outcome.

A management plan should consider such topics as: documentation of the present situation concerning principal values for conservation, land use, visitors and legislation; documentation of the scientific and aesthetic values of the World Heritage area, threats to them, and actions necessary to preserve them; strategic directions for the next 10 or 20 years; monitoring reserve values and the efficacy of management practices; visitor services, facilities and visitor management; communicating reserve values via interpretation and education; new proposals and their impact assessment; staff management and development; and measuring progress towards attaining goals.

Management Issues in Karst and Volcano-karst

Runoff from Upstream Areas

It is not an overstatement to assert that water quality management of streams and percolation water draining into karst is the key issue of environmental management in any karst area. It is critically important in Natural World Heritage properties because so much is at stake. The deleterious effects of water pollution, particularly underground, can be widespread and insidious. Its effects can also be long-lived and difficult to remove, because the residence time of polluted water underground can be long and storage can occur in inaccessible places.

Some examples: the transport of water-borne pollutants by an allogenic river sinking at Skocjan Cave World Heritage property in Slovenia was once a very serious problem, but has been largely resolved. It is a potential problem requiring careful management at Libo World Heritage property in the South China Karst because of agricultural and urban land upstream. Contaminated runoff from the land is affecting values in the Bay of Halong World Heritage site in Vietnam and shipping lanes through the Bay pose a continuing threat. Only community education and involvement, agreement to work together, and strict enforcement of standards can ensure that these kinds of problems are kept under control.

The difficulties confronting World Heritage park managers are not to be underestimated, because pollution frequently comes from areas over which they have no direct jurisdiction. The best way to deal with the problem is to ensure in the first place that the nominated area boundary is manageable by following the natural watershed. This leaves catchment supervision in the hands of park management. However, sometimes that is impractical because allogenic catchments can be very large and may contain agricultural, urban and industrial centres. In such cases, effective partnerships have to be established with authorities responsible for management of the upstream area with a view to reaching agreement on a total catchment plan of the highest possible standard, effectively enforced and monitored. The maintenance of high water quality is a common good that is in everyone's interests.

No untreated waste water from cities, towns and industries –or park facilities-must be permitted to enter waterways that ultimately drain into World Heritage properties. High water quality standards must be set and regular monitoring must be undertaken, both of dissolved materials and aquatic indicator species of water quality.

Monitoring stations should be established at input and output points in the karst system, i.e. where streams and rivers flow into inscribed areas and at springs, because spring water integrates the effect of all contributing water sources in the catchment. Monitoring plans should be public documents and results of monitoring should be published annually.

A Key Tool for the Management of Karst and Volcano-Karst Areas

Because of the paramount importance of catchment management in karst and volcano-karst areas, the most important tool for the manager is a hydrogeologicalmap. It should cover the World Heritage property and any surrounding areas that drain into it. An excellent example of this is provided by the hydrogeological map of the Mammoth Cave World Heritage area in the USA. It maps all sinking streams and springsand shows proven paths (by water tracing and cave survey) followed by underground water through the National Park. Cave plans are superimposed on the map. Thus, if there is an accidental spillage of a pollutant inside or outside of the park,then managers can see where the pollution is likely to go and plan appropriate remedial action.

Every World Heritage property with karst and volcano-karst of outstanding universal value should have a hydrogeological map of this kind. It may take several years to develop, but detail can be added progressively as the knowledge base is built up. A scale of 1: 50 000 to 1: 25 000 is appropriate, depending on the size of the protected area. Also highly desirable as management tools are vulnerability mapping and recharge mapping using Geographical Information Systems, because they help delimit protection zones, classify their importance, and highlight where most management attention is required.

Restoration of Impoverished Ecosystems

Another important issue that arises in many World Heritagesites is environmental rehabilitation, particularly restoration of natural vegetation and improvement of faunal habitat. Problems of biological restoration are not a major issue when inscription is on the basis of World Heritage criteria(ix) and (x), which are concerned with biodiversity, but may arise when inscription is on the basis of criteria (vii) and (viii) [as was the case at Jeju], which deal mainly with geodiversity (UNESCO 2008). This is because outstanding physical landscapes may have suffered considerable human impacts on their ecosystems with the result that environmental rehabilitation may have become a high priority of management.

Management of Caves

Tourist Caves

Cave management within World Heritage locations must be to international standards and should be a model for commercial tourist caves elsewhere. Special skill is required to develop a tourist cave to the standards worthy of a World Heritage location. A balance is required between the engineering required to facilitate access and the minimization of engineering for the sake of access. In a World Heritage site, this balance must err on the side of conservation: minimization of impact on natural conditions must take precedence over engineering for mass public access. Further, to maintain a cave in excellent condition, management is required not just of the cave but also of the area above and around it.

The main environmental objectives of cave management should be to keep temperature, humidity and atmospheric carbon dioxide (CO_2) conditions within the natural range of variation, to minimize light available for photosynthesis, and to maintain water quality and quantity. This will safeguard the subterranean ecosystem. Natural vegetation conditions must be maintained directly above and around the cave to protect the quality of infiltrating water (i.e. no buildings or car parks should be located there). Tourist cave lighting sources should be high efficiency lamps to minimize heat input into the cave atmosphere and to minimize light wavelengths suitable for photosynthesis. The duration and spectral quality of lighting should be such as to restrict the development of plant and algal growth (lampenflora) around light sources. A green halo around cave lights is a clear indicator of poor environmental management. In a World Heritage site, it is more appropriate to reveal natural colours than to impose artificial tints through coloured lights.

Tourist caves are particularly susceptible to damage both during development, when paths and lighting are installed, and during tourist operation. Decisions made during the development of the cave and during its operation for tourism should always try to ensure the maintenance of natural hydrological and ecological processes and the preservation of cave values and natural resources. If significant variation to measured baseline conditions occurs after tourist visitation commences, then maintenance of World Heritage values must take precedence over tourism, with tourist traffic being modified to reduce human impact to acceptable minimal and sustainable levels, even to the extent of closing the cave. A precedent for this is found at Lascaux World Heritage site in France.

Tourist routes through the cave should be designed to have minimum impact on delicate cave formations (speleothems) and on biological habitats within the cave. Cave sediment floors should be protected by raised pathways to preserve their habitat value, fossil record and sediment history. Cave entrances may be important archaeological sites, and so require special protection. Tourist guides should be aware of these special features, should help protect them, and should explain to visitors the significant features of the cave that led to its inscription on the World Heritage List.

Materials used for tourist infrastructure (paths, etc.) should be non-toxic to biota and largely removable, so that if necessary the cave can be returned almost unspoiled to nature. There is considerable international experience on tourist cave development, cave conservation, management, ethics, and restoration of damage. A rich source of ideas on these topics is available in Hildreth-Werker and Werker (2006).

Wild Caves

Many natural (or 'wild') caves are found in World Heritage properties. Park managers need to recognize that even the most experienced, careful, and environmentally conscious cavers do inadvertent damage underground, especially in caves with abundant speleothem formations and fossil deposits. Thus cave exploration needs careful management. The most important principle here is to insist that an experienced speleologist leads the group and that party size is small, usually not more than six, but this depends on the nature and size of the cave. Only electric lights should be used and allrubbish must be carried out.

There is a need to manage access to wild caves to ensure that at least 50% of the known caves or parts of caves within a World Heritage property are protected from random recreational access. Access to special sites should only be for research that cannot be conducted elsewhere, and the research should explicitly contribute to the management of the protected area.

Results of cave exploration and survey are important sources of information for park managers as they help to complete part of the hydrogeological picture and provide data on natural resources within the area; thus careful exploration by experienced cavers should be encouraged provided impact is minimal and results of exploration are reported back to management.

Scientific sampling within the cave should be by permit only, having been well justified, and kept to a minimum. Speleothems may take tens to hundreds of thousands of years to grow but can be removed in minutes. The same approach should be taken to excavating archaeological and fossil deposits that are frequently found near cave entrances. They should only be excavated by experts and for good reason; only part of the deposit should be removed and taken to a mutually agreed safe repository; and results of theresearch should be reported back to park management. Ecological survey and sampling requires a similar approach and conditions.

4. Monitoring

To be sure that management activities have been effective, there needs to be a method of evaluating progress. Monitoring measures change over time; and it is required to provide objective evidence of the effectiveness of the implementation of management practices. Dudley et al. (2003) provide a review of options. Monitoring is an essential management tool and is designed to provide reliable information on the current situation that can be compared to ‘baseline’ conditions, i.e. to the situation that existed before management commenced. By monitoring before, during and after developments, changes can be recorded and there is objective evidence of impacts and improvements.

Sensitive sites and sensitive indicators should be chosen for monitoring. In karst, for example, sinking streams, springs and percolation waters can be used as water quality monitoring stations. Apart from a range of chemical and physical measures (e.g. dissolved oxygen, temperature, suspended solids, etc), presence and abundance of sensitive species with a low tolerance to pollution should be monitored. For example, at the surface and in caves, endemic snails, arthropods and plants are examples of sensitive species that can be monitored. Invasive species should also be noted.

Water quality monitoring should cover a range of extreme conditions from drought to flood. Baseline climatological and ecological conditions should be established in the cave before development for tourism starts, a year being required to obtain reliable representative records. Climate and atmospheric measurement in tourist caves requires a professional weather station approach. Monitoring stations should be set up at sensitive sites and climatological and ecological surveys should be conducted regularly with results published annually. Automatic monitoring should be undertaken where possible. The objective of management should be to keep temperature, humidity and atmospheric CO_2conditions as close to the natural baseline values as possible, while at the same time keeping the cave free from invasive species, vandalism, rubbish, and wear and tear.

Photo-monitoring should be used extensively and regularly at established key sites, especially along tourist routes (above and below ground), because it is an effective way of showing up wear and tear from tourist pressure.

Methods and measures used in monitoring should be readily understood and applied by trained staff. Results of monitoring should be published annually. In a few years time, we will want to know if the World Heritage site is in at least as good a condition as when it was first inscribed. Objective monitoring willprovide the evidence. Although tourist pressure creates the potential for environmental impact, it is park management that can prevent or at least limit serious impact - or permit it to occur.

5. Conclusions

Managing a World Heritage site is a responsibility of global significance undertaken in trust for present and future generations. Therefore it must be carried out to the highest international standards and with the cooperation and support of the local people.

The State Party is ultimately responsible to UNESCO for the success or failure of management of World Heritage properties within its borders. Thus to assist managers and avoid competing or conflicting interests, legal authority and lines of responsibility must be clearly established. To ensure grass root support, local people must have a say in park planning and management, and should share in the benefits of having a World Heritage property in their neighbourhood.

Water quality management of streams and percolation draining into karst is the key issue of environmental management in any karst or volcano-karst area. Hence, protected area boundaries should follow natural watersheds wherever possible.

All decisions within Natural World Heritage properties must be compatible with conservation, itsvalue to posterity being more important than short-term economic gain. Thus most economic infrastructure should be located outside the World Heritage property rather than inside it, exceptions being those related to reasonable, low impact tourist access,especially in tourist caves.

The overall objective must be to ensure that the property is in at least as good a condition as when it was first inscribed on the World Heritage List.

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Preview of the 15th International Congress of Speleology

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The 15th International Congress of Speleology (ICS) will be held in Kerrville, Texas, USA, from 19-26 July 2009. An estimated 2,000 of the world's leading speleologists are expected to attend from 50-60 counties. Fifteen technical symposia are plannedas well as 22 field trips that will occur before and after the ICS. Many sessions, workshops, meetings, and social events are planned. Oral and poster papers are welcome; the abstract deadline is 1 December 2008 and the deadline for full papers is 1 February 2009. To register for the ICS or more information, visit www.ics2009.us. This video presentation is 15 minutes long and will be presented by the chairman of the ICS, who will then answer questions from the audience.

New Geological Insights for the Azores Islands (Portugal) Lava Caves

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The inventory of lava caves from Azores Islands (IPEA) includes nowadays a total of 271 caves, and about 50% of them are mapped, even just as drafts. During the last two years, GESPEA Working Group has done extensive field work, specially to gather information on GPS location for all cave entrances (now for 230 caves), and also for mapping the most outstanding caves and revising the most critical data of the IPEA database, particularly for what concerns land-use management. Moreover, all mapped caves are being incorporated on a GIS system, allowing a better knowledge on the surface use, associated with the lava caves terrains and, therefore, a better evaluation of cave's vulnerability.

In addition, it was possible to determine, on a systematic way, several parameters that help defining the spatial pattern of each lava cave or lava cave system, according with its mapping, namely the "main tube" length (MTL), the cave total length (or "map length" (ML) –Larson, 1993) and the "linear length" (LL), here defined as the smallest distance between the upper and downstream points of the mapped cave.

As a way to help quantify the complexity of Azores lava caves or lava caves systems, that ranges from unitary tubes, to branched distributaries tubes and to more or less complicated dentritic patterns, two indexes are proposed: the "Sinuosity Index – SI" (the ratio LL/MTL) and the "Branching Index – BI" (the ratio (MTL/ML)*100) – see Table.

Furthermore, the Azores Lava Caves GIS system (including recent coloured aerial vertical photos and photomaps), allows mapping caves with reference to detailed volcanological maps available or especially done, as recently accomplished to the "Malha Grande lava cave system", in Terceira Island (Pereira *et al.*, 2004; Bustillo *et al.*, 2008). Such approach allows a better identification of the lava caves eruptive sources, the existing lava cave systems (aka. a distributive network of lava tube caves that is characteristic of tube-fed pahoehoe lava flows) and also allows a better age control of the geological formations related with the caves.

Cave Name	Map Length (ML)	**Sinuosity Index (SI)**	**Branching Index (BI)**
S. Miguel Island			
Gruta do Pico da Cruz	107.9	0.95	98.9
Gruta do Enforcado	206.6	0.87	89.3
Gruta do Esqueleto	176.9	0.99	100
Gruta da Rua João do Rego	287.4	0.97	58.0
Gruta dos Valados	67.7	0.98	81.6
Gruta das Feteiras	27.6	0.96	78.3
Gruta de Água de Pau	286.1	0.76	51.6
Gruta da Giesta	35.0	0.67	100
Gruta da Rua José Bensaúde	42.7	0.99	81.4
Gruta das Escadinhas	31.0	0.88	100
Gruta do Carvão	701.8	0.93	79.8
Gruta da Quinta Irene	55.6	0.98	54.3
Gruta da Rua do Paim	880.2	0.94	74.7
Graciosa Island			
Furna d'Água	26.0	1.00	100
Furna do Calcinhas	28.0	0.99	100
Furna do Moinho	32.6	0.74	100
Galeria do Forninho	151.3	0.95	62.1
Furna da Maria Encantada	55.0	0.97	100
Furna do Lavar	93.4	0.98	100
Gruta do Manhengo	14.7	0.96	100
Gruta do Bom Jesus	16.4	0.97	100

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Korean Cretaceous Dinosaur Tracksites for the UNESCO World Heritage Inscription

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After the first discovery of dinosaur eggshell fragments in 1972 from the Hasandong Formation in the Gyeongsang Province, more than 50 dinosaurs track localities have been reported from Cretaceous non-marine deposits. Korean paleontologists have discovered remarkable dinosaur footprints, dinosaur bones, dinosaur eggs, pterosaur tracks, crocodilian skulls, and other vertebrate remains from the Cretaceous beds. Korean dinosaur tracksites have exceptional significance from the viewpoint of scientific research and public education.

The nominated serial property consists of five sites across approximately 160 km along the south coast of the Korean Peninsula. The five sites from west to east as follows: Haenam Dinosaur, Pterosaur and Bird Tracksites, Hwasun Dinosaur Tracksite, Boseong Dinosaur Eggsite, Yeosu Dinosaur Tracksite, and Goseong Dinosaur and Bird Tracksite. These dinosaur fossil sites have been studied and well recognized by national and international paleontologists since 1982.

Korean dinosaur trackways provide different types of dinosaur movements and their social behavior including migration patterns. The ornithopod trackways with sauropods and theropods in many localities indicate unique paleoecology for the Cretaceous fauna. A famous dinosaur tracksite in Haenam County produced the world's largest pterosaur tracks and bird trackways.

As one of the best-known regions in the world for Cretaceous fossil footprints, these sites have pivotal significance in helping interpret the Cretaceous paleoecology. The quality of the dinosaur tracksites preservation is excellent and provide a good model of field study and hands-on experience for earth science education. The Natural Heritage Center has investigated the sites through 3-D image analysis and regular monitoring system.

Most Outstanding Volcanic Caves Of Azores Islands as Potential Geosites of the "Azores Geopark"

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Abstract

The impressive geodiversity of Azores archipelago and the high value (or relevance) of the sites that it includes justifies the proposal of the "Azores Geopark", which is being prepared by the Azores Government, to present it to UNESCOand to propose their integration on the European and Global Geoparks Networks.

Given the archipelagic nature of the Region, it is proposed that the Azores Geopark includes a set of areas, well studied and delimited, spread all over the nine islands of the archipelago and neighboring seafloor. These areas are considered to be representative of the Azorean geodiversity and are selected among a broader group of sites taking into account the value of the geosites, trough a process of evaluation, on a quantification basis.

The ongoing Azores Geopark proposal includes 30 volcanic caves of Rank A (Table 1) among the 271 caves of the IPEA database, that were sorted (e.g. Rank A, B, C and D) in accordance to their importance in terms of scientific, singularity and beauty and integrity attributes. The ranking of Azorean caves is among the several contributions by "GESPEA", the Working Group on Volcanic Caves of Azores, and is one of the functions of "IPEA", the Azorean Speleological Inventory and Classifying System database.

This database incorporates six major classification issues (e.g. scientific value, potential for tourism, access, surrounding threats, available information and conservation status) and each classification comprises five classes (I to V) where the volcanic caves are sorted as a result of a weight calculation based on nine criteria: biologic component, geologic features, accessibility, singularity and beauty, safety, caving progress, threats, integrity and available information.

Table 1. Azores Volcanic Caves of Rank A

Volcanic Cave	Island
Furna do Enxofre	Graciosa
Algar/Gruta do Alto do Morais	Pico
Algar/Gruta do Canto da Serra	Pico
Furna das Cabras II	Pico
Furna de Henrique Maciel	Pico
Furna do Frei Matias	Pico
Furna Nova II	Pico
Gruta da Ribeira do Fundo	Pico
Gruta das Canárias	Pico
Gruta das Torres	Pico
Gruta do Cão	Pico
Gruta do Mistério da Silveira I	Pico
Gruta do Soldão	Pico
Gruta dos Azevinhos	Pico
Gruta dos Montanheiros	Pico
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Gruta do Salazar	Pico
Gruta dos Túmulos	Pico
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Gruta da Rua do Paim	São Miguel
Gruta de Água de Pau	São Miguel
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Gruta das Agulhas	Terceira
Gruta do Caldeira	Terceira
Gruta do Chocolate	Terceira
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WoMOVoC: Online Database for the WorldMost Outstanding Volcanic Caves

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The main principles for WoMOVoC, a database which aim is gathering the most important volcanic caves worldwide, were present in Mexico, during the 2006 XII International Symposium on Vulcanospeleology. Since then, GESPEA developed the concept and promoted the construction of a database and its interface on the Web, available on www.worldvolcaniccaves.org.

The Website was made as simple as possible, keeping in mind that the most important is to bring together on a single database the World most outstanding volcanic caves, assembled by known criteria, rather then ranking them. The approach also followed the principle of an easy use and of a comprehensible way to submit new caves.

As it was proposed, a scientific committee assigned by the Commission on Volcanic Caves-UIS will evaluate and score the submitted proposals, previously accepted by the executive board (GESPEA Group, Azores), according to the acceptance criteria.

Due to the fact that caves will be evaluated mainly through the submitted proposals, the accuracy of the information and the appointment of referees are considered essential for the quality and success of this project.

WoMOVoC is now a full operating Site, able to receive the first proposals and to provide information about the evaluated and approved caves. The future success of this international and multidisciplinary project will greatly depend on the involvement of the worldwide cavers and their ability to bring forward the result of their work.

UIS - International Union of Speleology: Short history and current situation

Jose Ayrton Labegalini*

UIS – International Union of Speleology - Titov trg 2, Postojna, Slovenia-
www.uis-speleo.org

SBE – Brazilian Society of Speleology – CP 703 – CEP 13076-970 – Campinas-Brazil

FCPA – Cultural Foundation "Pascoal Andreta" – Rua da Saudade, 111 – Monte Siao-Brazil/ E-mail: ja.labegalini@uol.com.br

The UIS is a non-profit, non-governmental organization which promotes the development of interaction between academic and technical speleologists of a wide range of nationalities to develop and coordinate international speleology in all of its scientific, technical, cultural and economic aspects

The UIS was founded on September 16, 1965, during the closing session of the 4th International Congress of Speleology, when its statutes were approved, and the first board of officers was elected. At present, the UIS has more than 60 member countries, located on all the continents of the world, and is open to the affiliation of all national associations and federations.

As every international entity of this kind, the UIS organizes the International Congresses of Speleology. Through its scientific and technical commissions, the entity promotes the development of the speleology in all areas of the knowledge, motives the change of information among speleologists and the exploration of new caves in the wide world, as well support the protection of the world speleological heritage.

Although UIS is an international entity, it is still unknown entity in the international speleological community. Not even countries member with a developed speleology and with national societies or federations good structured know UIS sufficiently, as the UIS Bureau would like them to know.

To the development of the speleology in all its aspects, the UIS General Assembly establishes Commissions and Working Groups that are organized in Departments. In the Department of Scientific Research was established, in 1989, the Working Group on Volcanic Caves, which later, in 1993, was promoted to Commission. Besides the organization of the ICS –International Congress of Speleology by the UIS, several Commissions also organize theirInternational Symposium. The Commission on Volcanic Caves, organizes the International Symposiums on Volcanic Caves, like its 13th version, now in 2008, in Jeju Island, South Korea.

Considering the potential development of the speleology of the South-East Asia and specially the interest of speleologists and cavers, from the whole world, on volcano-speleology, this presentation aimsto disclose the UIS in the region and at the same time to pay homage to the lovers of this kind of speleology.

POSTER SESSION

The volcanic cave of erosion in origin near Hantan River, Gyeonggi Province, Republic of Korea
(Yong-Gun Choi)

The Environmental Characteristics and Species composition of Manjang-gul Cave, Jeju Island, Korea
(Won-Rok Kim)

Cave Photograph of JejuIsland (Isao SAWA)

Research work into lava caves of the Hungarian geographer Dénes Balázs (Peter Gadanyi)

The volcanic cave of erosion in origin near Hantan River, Gyeonggi Province, Republic of Korea

Yong-Gun Choi[1], Won-Rok Kim[1] and Young-Bok Cho[2]

[1]*The Korean Institute of Biospeleology, Yeongwol 230-808, Korea*

[2]*Natural History Museum, Hannam University, Daejeon 306-791, Korea*

The investigated area includes a typical basaltic region in the inner part of Korean peninsula, which includes a large flat area with a stream (Hantan River) in a narrow valley. This survey was carried out for the region which will be submerged due to the construction of a dam in the future, that is about 30 km-long from Sinheung-ri, Changsu-myeon, Pocheon City, Gyeonggi Province to Guntan-ri, Galmal-eup, Cheolwon-gun, Gandwon Province. Basaltic layer, that is about 5 to 7m thick, overlies the granite, which is largely exposed in this area. Unlike Jeju Island, lava tube caves are not developed well, however small caves were developed along the joints and layers of lava flowing units near Sinheung-ri, Changsu-myeon, Pocheon City toward the downstream. In the mid- and upstream areas near Naengjeong-ri, Gwanin-myeon, Pocheon City, a cave of erosion in origin was discovered. The cave was developed by erosion of the weathered horizon in upper part of granite which is overlain by basalitc lava flows. Detrital sands and clays are deposited on the floor of this cave. Relative humidity is relatively higher than other caves found in the peninsula. In this cave, troglobitic blind millipedes (*Antrokoreana gracilipes*) and troglobitic blind beetles (*Kurasawatrechus* spp.) are found. Even though the most typical cave-dwelling amphipod such as *Pseudocrangonix asiaticus* is not found, the presence of Bathynella suggest the biogeographic significance of this cave.

The Environmental Characteristics and Species composition of Manjang-gul Cave, Jeju Island, Korea

Yong-Gun Choi[1], Won-Rok Kim[1*], and Young Bok Cho[2]

[1] The Korean institute of biospeleology, Youngwol-gun, Gangwon-do, Korea
[2] Natural History Museum, Hannam University, Daejeon, Korea

Manjang-gul is located in Gujwa-eup of Bukjeju-gun, east 30km apart from Jeju-city. The average temperatures are 11-21℃ throughout the year and have about 7,400m length.

This cave is shown two layers partially and have three entrances formed by the subsidence of the ceiling. The cavern of Manjang-gul is large with simple structure. Comparing the large scale of this cave, the effects of outer environment is acted highly in the inside by the irregular thickness of ceiling. So the normal temperature zone is extremely short.

Through the survey on this cave, Total of 40 species, 33 families, 19 orders belonging to 5 phyla was investigated. Among them, Spiders were shown the most high diversity with 18 species (45%). And then, insects 6 species (42.5%), millipedes, gastropodes and mammals are 3 species (7.5%) respectively. By the way, the troglobite species was only one species but the troglophile were eight species.

Cave Photograph of Jeju Island

Isao SAWA

Cave Photographs of Jeju Island

Caves occur beneath the Earth's surface, large enough for human entry. Caves can be classified into natural and artificial. Natural caves divisible into volcanic caves, calcareous caves, erossion caves and weathering caves (tafone), etc.

Volcanic caves formed in a molten lava flow. Volcanic caves can be classified into lava caves, tree-mold caves and welded tuff caves. Specific features of volcanic caves exist on the ceiling, floor, walls and pool.

Exhibitions of volcanic caves in Jeju island comprised of the model (7 pieces) and photographs (40 sheets) of 12 caves. These cave photographs introduce partly of the features in volcanic caves in Jeju island.

1. Formation Model of Volcano and Lava Cave
2. Forms of Second Order in Lava Cave
3. Man-jang and Keu-u-set cave
4. Man-jang and Kim-nyong cave
5. Man-jang cave
6. Man-jang and Pil-le-mot cave
7. Mi-cheon and Su-san cave
8. Ssang-ryoung and Hwang-geum cave
9. So-cheon cave
10. Gaeng-saeng-i pit cave
11. San-bang-san tafone
12. Hallim lava tree-mold

By Isao Sawa,Japan
Naruhiko KASHIMA,Japan
Chang-sik Ki m and Ki m, K.H.,Korea

The 13th International Symposium on Vulcanospeleology
Sep.1-5,2008 in Jeju Island, Republic of Korea

Research work into lava caves of the Hungarian geographer Dénes Balázs

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Dénes Balázs was a 'geographer' in the most genuine sense of the word. The Hungarian scientist and researcher organised and made a great number of geographical expeditions to some of the most inaccessible parts of the world, and his success was largely due to his inventiveness, resilience and great communicative skills. His ability to undertake so many and so extensive scientific expeditions and disseminate his outstanding knowledge on practically every possible field of geography within the capacity of both professionals and laymen has made him truly exceptional. In his books and other works, Balázs has a gift for discussing geography as an interesting subject matter and also succeeds brilliantly in his mission to raise his readers' interest in some of the remotest places of the globe. In respect for the work of his predecessors, Balázs founded the Hungarian Museum of Geography in 1983. "I am a devoted admirer of the brilliant creations of God Vulcanus, the giant sky-scraping, smoking cones", he writesin 1969. During the 10 years of his expeditions, he toured all the world's most significant volcanic areas. "On my journeys, I was primarily interested in the laws of surface forms, with a special focus on karstic and volcanic regions". In his geomorphological research, he devoted particular attention to the study of basalt lava caves and their relevant landforms. He was as fond of lava caves as karst caves, and thus his visits to basalt lava areas and their lava caves. After his field-trip in the Lava Beds National Monument, North-California in 1970, he studied the lava caves of the Galápagos Islands. Here, he made the first detailed maps and descriptions of La Cueva de Kübler and La Cueva de Bellavista which are typical lava tubes on Santa Cruz Island. Hesurveyed and mapped them completely alone, using his own methods. In 1972 he studied the lava caves of Fuji-san with the assistance of a group of Japanese vulcano-speleologists. On the basis of his field investigation work in the lava caves of Fuji-san, he has made the most detailed and published Hungarian descriptions in this topic up to now, titled Forms, Types and Formation of Lava Caves. He distinguished four morphogenetic types of syngenetic lava caves and divided their forms into two groups: autochtonus and allochtonus ones. He also investigated surface lava forms which are in connection with lava caves (e.g. a variety of depression forms such as lava dolines). This important scientific study greatly enriched the Hungarian nomenclature of the pseudokarstic features in lava flows. In 1985 he investigated the speleology of the Easter Island. Here he surveyed sea caves (Ana Toka Rahi Rahi, Ana Kai Tangata) and lava tubes (Ana Te Pahu, Ana Kakena), and their polygenetic combinations (preformed by old lava tubes open to the sea level), and he was the first to map and describe them, which he carried out single-handed.

IJS SPECIAL ISSUE FUND RAISING

The International Journal of Speleology is glad to announce the intention of publishing a third (special) issue this year (2008) on the topic "Palaeoclimate", guest-edited by Dominique Genty.

To take front to the extra expenses due to this special issue, since Union Internationale de Spéléologie and SocietàSpeleologica Italiana funding does only guarantee to publish two issues/year, we have to find a way of raising the money necessary to be able to print this special issue this year. Therefore we need to collect a total of 4000 Euros.

In order to collectthis amount of money, the Società Speleologica Italiana and the International Journal of Speleology make an offer.

Single cavers and scientists are given the opportunity to contribute to this special issue sending a minimum of 50 Euro to the Società Speleologica Italiana, making reference to the "Special issue IJS Palaeoclimate". Whoever helps us in getting the amount of 4000 Euros will have his name cited in the issue and will receive a set of 4 issues (of choice) of the International Journal of Speleology. Speleological organisations (national, regional or local) have the opportunity of ordering a number of 10 issues (at choice) for the price of 200 Euros: these organisations will also be cited in the Palaeoclimate Special Issue as contributors.

Only once we reach 4000 Euros the special issue will be printed!

The list of contributors will be visible also on the www.ijs.speleo.it website until the special issue will be printed.

To sustain this initiative you should compile the attached form and send it by fax to 00 39 051 250049

Jo De Waele

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