CONTENTS

The page numbers on the contents pages in this PDF file are "hot links." Clicking on one will take you to the page.

X

continued on next page

2002 SYMPOSIUM ABSTRACTS

Compiled by Sigurður S. Jónsson

Geology of Harrat Kishb, Saudi Arabia, in Relation to the Formation of Lava Tubes

Mahmoud A. Alshanti
Geologist, Saudi Geological Survey

Basaltic lava fields cover 89,000 square kilometers of western Saudi Arabia. One of these lava fields, named Harrat Kishb, has an area of 5,890 square kilometers and is located 300kms northeast of Jeddah. The nature of lava found in this area and the thickness of the flows were propitious for the formation of lava tubes one million years ago.

The lava tubes of Harrat Kishb are found in three different structural and physical positions relative to their parent volcanic cones. The three-km-long lava tube associated with the Jebel Hil volcano was formed by the emptying of the arterial tube as the lava front advanced downslope. Instead, the Ghostly Cave and Kahf Mut'eb lava tubes are found 7km from the volcano which gave birth to them and were caused by blocking of the lava flow by an older cone. The third manner of formation is seen in Dahl Faisal, where a thin part of the roof of the lava tube was sucked down to form a funnel-shaped entrance for surface air.

More than 2000 basaltic volcanoes can be found in western Saudi Arabia and many of these are associated with multiple lava flows. Because of the discovery of caves in Harrat Kishb, it is likely that many of these volcanoes have also produced lava tubes.

Data Base on Icelandic Caves

James Begley
Shepton Mallet Caving Club, Priddy, Somerset, UK, and
Icelandic Speleological Society, P.O.Box 342, 121 Reykjavík

The first list of Icelandic lava caves was compiled by Hróarsson in 1990 in his book "*Hraunhellar á Íslandi*" (Lava caves in Iceland). The list comprised a geographically sorted list of about 170 caves, mostly caves mentioned or described in earlier publications but also several newly discovered caves and caves only known to locals in the vicinity of the caves. Hróarsson's list laid the foundation for a "*dbase IV*" table with cave names, lava flow, length and other relevant data and the "*dbase IV*" file was maintained for several years. Later that format was abandoned and the whole list was imported and maintained in a large "*Excel*" spreadsheet.

The author will present a whole new design of a cave database, running on Microsoft Access®, using data and data fields from the previously existing Excel spreadsheet. Attempt has been made to simplify data input, and general

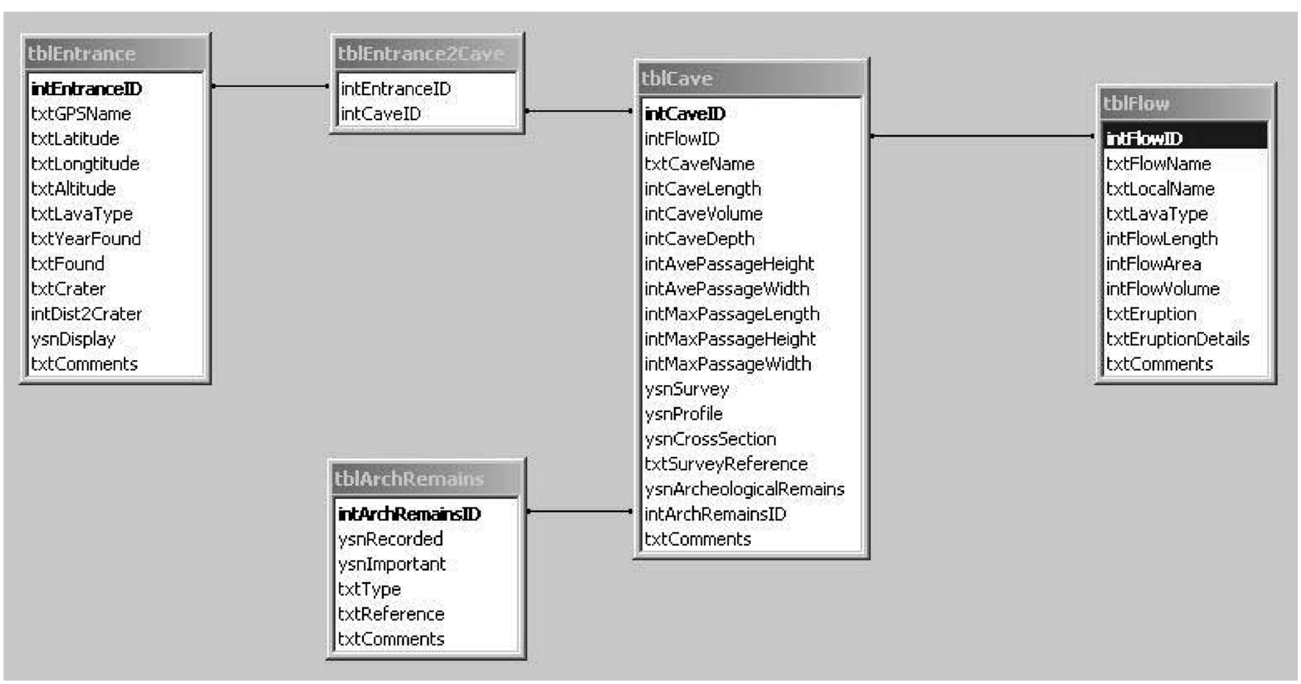


Figure 1 (Begley, "Data Base"). An example of ISS cave database table relations.

filtering, sorting and other data extraction capabilities. The ISS cave database now holds about 60 caves with known GPS-coordinates, but a large pile of data waits to be inserted into the ISS cave database.

Ranking Azorean Caves Based on Arthropod Fauna

Paulo A. V. Borges[1,2]
[1] Univ. dos Açores, Dep. Ciências Agrárias, Terra-Chã, 9700-851 Angra do Heroísmo,Terceira, Azores, Portugal. pborges@angra.uac.pt
[2] "Os Montanheiros", Rua da Rocha, 8, 9700 Angra do Heroísmo,Terceira, Azores, Portugal.

Endemic arthropods and in particular troglobian species were used to evaluate the conservation value of volcanic caves of the Azorean islands. For each of the 44 Azorean endemic species of arthropods recorded to caves, a rarity index was calculated, using distribution and abundance data obtained from the literature. In addition, several scoring indices based on diversity and rarity measures were used to rank 16 caves from which standardized sampling has been performed. About 47% of the 19 endemic troglobian arthropod species are "single cave endemics", that is, are known from only one cave. Based on the Jackknife estimator we estimated the occurrence of 28 (± 3) species of troglobian arthropods in the Azores, which implies that there is the need of further biospeleological surveys in these islands. The most beautiful caves based on a "Show Cave Index" are also the most diverse in troglobites ($r = 0.55$; $p = 0.01$), which means that geological diversity could be a good surrogate of fauna diversity. Moreover, there is more trogobite species on largest caves ($r = 0.66$; $p = 0.0099$). Based on the complementarity method, to preserve the Azorean arthropod troglobite biodiversity there is a need to protect at least 10 caves in order each species is represented at least once. However further caves will be needed to have each species represented at least twice. The standardized sampling provided valuable guidance for achieving the goals of practical conservation management of Azorean biological cave diversity, but further research is required to have better knowledge on the real diversity of Azorean troglobites and their distribution. There is also the need of special measures of protection for the aboveground native habitats in order to maintain the flux of nutrients for the cave environment. This study showed that cave fauna could be used to identify a network of caves for protection that are also of great geological interest.

A Data Base and Classification System for the Azorean Volcanic Caves

João Paulo Constância[1], João Carlos Nunes[1,2], and Teófilo Braga[1]
[1] "Amigos dos Açores" Environmental NG. P.O. Box 29. 9500 Ponta Delgada. Azores. Portugal. constancia@mail.telepac.pt, teobraga@hotmail.com
[2] Azores University – Geosciences Department. Rua da Mãe de Deus. P.O. Box 1422.9500-801 Ponta Delgada. Azores. Portugal. jcnunes@notes.uac.pt

The Azorean Regional Government, being aware of the importance of the volcanic caves and pits as elements of our natural heritage, created in 1998 a multidisciplinary task force to promote its study. One of the main objectives of this group was to act as a consultant to the government, by recommending initiatives concerning de conservation and preservation of these volcanic underground structures.

As a first priority, this group decided to develop a database, which could be used as a managing tool for the Azorean volcanic caves and pits. To achieve this goal it was found necessary to create a field form, to register as many data as possible, allowing a satisfactory description of the underground volcanic structures, and also that could provide the principles for the database structure.

Due to the geographical dispersion of the Azorean islands, and the number and diversity of the lava tubes, it was consider most relevant that managing decisions should be based on accurate knowledge. At that time it was settled the idea of an instrument that could organize the information, in a way it would be possible to evaluate among several parameters of each volcanic caves, to build different sorting accessions, and to produce meaningful lists. These fundaments gave origin to a computer application built over FileMaker Pro 4.0, combining both a database and a classification system.

The sorting and classifying systems presume an objectively chosen criteria set, so that the results are logical, coherent and reliable. It is also significant the possibility to generate diverse classifications based on different preset criteria, deduced from established objectives and aimed to real applications.

The Azorean Speleological Inventory and Classifying System (IPEA) incorporate six major classification issues, as follows: scientific value; potential for tourism; access; surrounding threats; available information and conservation status. Each classification comprises five classes (I to V) where the volcanic caves are sorted as a result of weight calculation upon the values given by nine criteria sets. These criteria are: biologic component; geologic features; accessibility; singularity and beauty; safety; caving progress; threats; integrity and available information. For each of these criteria were established six parameters, where 0 is the lack of information and the other five parameters are objective and clear statements that describe the cave within the criteria.

Each volcanic cave is than characterized by choosing one of the six parameters of the different criteria, that allows among other possibilities to sort the caves in many different ways and to produce relevant lists. It is expected that this application becomes a useful tool to managing Azorean caves for conservation, study and exploration.

Ranking Azorean Caves Based on Geological, Biological, and Conservation Attributes

João Paulo Constância[1], Paulo Borges[2,3], Paulino Costa[4], João Carlos Nunes[1,2], Paulo Barcelos[3], Fernando Pereira[3], and Teófilo Braga[1]
[1] "Amigos dos Açores" Environmental NGO. P.O. Box 29. 9500 Ponta Delgada. Azores. Portugal.
teobraga@hotmail.com, constancia@mail.telepac.pt
[2] Azores University – Geosciences Department. Rua da Mãe de Deus. P.O. Box 1422. 9500-801 Ponta Delgada. Azores. Portugal.
jcnunes@notes.uac.pt, pborges@angra.uac.pt
[3] "Os Montanheiros" Speleological Society. Rua da Rocha. 9700 Angra do Heroísmo. Azores. Portugal.
paulo_barcelos@clix.pt
[4] Direcção de Serviços da Conservação da Natureza. Matos Souto. Pico. Azores. Portugal.
paulino.costa@mail.telepac.pt

With the Azorean Speleological Inventory (IPEA) in a computer data base format it is possible to have a better characterization of the Azorean volcanic caves and pits, spread all over the nine islands of the archipelago. Once the existing data is often poor and incomplete, all the analysis and ranking should be considered, by now, as a preliminary approach.

The IPEA data base comprises 206 records that correspond to the Azorean caves and pits whose existence was confirmed by the team created form that purpose. It is also important to emphasise that there are several reports and bibliographic notes that allows to expect, in a near future, to raise up that number. Moreover, 57% of these 206 caves are unsatisfactorily described, in particular on their biological and geological features, and only 67 are mapped.

The Azorean volcanic caves are located at Pico (81), Terceira (66), São Miguel (17), São Jorge (16), Graciosa (11), Faial (8), Santa Maria (5), and Flores (2). About 63% are lava tubes, 13% pits, 4% fractures, 4% erosional caves and the remaining are combine or undetermined types.

Troglobic species were identified in 25 underground structures, namely the blind ground-beetle, *Thalassophillus azoricus*, which can only be seen in Água de Pau cave (São Miguel island) or the genus *Trechus* found in Pico caves. In 59 caves there are rare and uncommon geologic features, such as long lava stalagmites and sets of burst bubbles of lava, e. g. Soldão and Torres caves (Pico), and Natal and Agulhas caves (Terceira). In 12 caves severe threats were identified in the surrounding area, and thus prevention and protection measures are needed. It is recognized for 22 underground structures their high integrity status, for example Gruta dos Montanheiros (Pico), Gruta da Beira (São Jorge) and Furna do Enxofre (Graciosa).

"Gruta das Torres" Project

Manuel P. Costa
Direcção Regional do Ambiente da Região Autónoma dos Açores. Ed. Matos Souto 9930-210 Piedade, Açores, Portugal.
paulino.costa@mail.telepac.pt

In the Archipelago of the Azores there are a large quantity of lava tubes and pits, in almost every of the nine islands. At present, result of field work made during the last years by the Society of Speleologic Exploration "Os Montanheiros", by the Ecological Association "Amigos dos Açores", by the "Círculo de Amigos da Ilha do Pico", and by the Regional Services for Nature Conservation, there are 239 volcanic caves marked in the Azorean Archipelago.

This geological and biological richness lead the Regional Government of the Azores to promote, through its resolution nr. 149/98 of June 25, the creation of a working group responsible for the study of the Azorean volcanic caves. This group has already created a database and a classification system that will allow the raise of a management model for these caves. In this field of action, and taking into consideration the high speleologic value of "Gruta das Torres", its proximity to population centres and its great accessibility and therefore the facility of being visited, the Regional Environmental Services of the Azores has conceived this project and thus created a pilot experience in the Management and Exploration of volcanic caves in this Region.

"Gruta das Torres" is a volcanic cave, located in Criação Velha – Pico Island, that had its origin in *pahoehoe* lava flows expelled from Cabeço Bravo. It is the biggest lava tube known in the Azores with a total extension of 5 150m. It consists of a main tunnel of large dimensions, attaining in some areas more than 15m in height. There are also secondary ramifications of smaller dimensions where, at times, it is necessary to crawl. Its interior is full of interesting lava formations, such as lava stalactites and stalagmites, silica deposits, lateral benches, flow marks, ropy lava, and lava balls.

The walking tour inside the cave is 400m long and the access to its interior is attained through one of the cave's natural openings.

The improvements to make in the cave, namely to turn the access more easy, will be minima in order to keep the cave's aspect the most original as possible.

In the cave's interior only the ground will be cleaned, clearing out breakdown of the ceiling and walls so as to facilitate the passing through of visitors.

The visits will take place in small groups, with individual lightening system and in the presence of a guide who will give all the informations about the cave.

Besides the route inside the cave, one intends to familiarise visitors with the local geology, flora and fauna, through a briefing given at the cave's support installations, as well through the creation of complementary routes to be explored at surface near the site.

References:

Borges, P.A.V., Pereira, F. & Silva A., (1991), Caves and Pits from the Azores with some comments on their geological origin, distribution and fauna. 6th International Symposium on Vulcanospeleology. Hilo, Hawaii, pp. 121-151.

Nunes, J.C., (1999), A Actividade Vulcânica na ilha do Pico do Plistocénico Superior ao Holocénico: Mecanismo Eruptivo e Hazard Vulcânico, Tese de Doutoramento no Ramo de Geologia Especialidade de Vulcanologia, Departamento de Geociências, Universidade dos Açores, Ponta Delgada, pp. 239-241.

Costa, M.P. & Barcelos, P., (2001), Cavidades Vulcânicas dos Açores, Congresso Internacional sobre Património Geológico e Mineiro, Beja, Outubro, 2001.

Costa, M.P & Verissimo, E.F. (2002), Projecto Gruta das Torres, 2nd Pico Island Internacional Volcanological Meeting, Abril, 2002.

Subcrustal Drainage Lava Caves; Examples from Victoria, Australia

Ken Grimes
PO Box 362, Hamilton, Victoria 3300, Australia.
ken-grimes@h140.aone.net.au

Most documented lava caves are large, linear or anastomosing tubes formed by roofing of lava channels or development of major feeder tubes within a flow. However an increasing number of small shallow caves is being recorded that have simple to complex patterns of interconnected low chambers and small passages that form by a different process.

In reviews of active volcanoes in Hawaii, Peterson & others (1994) and Hon & others (1994) proposed two distinct models for the formation of lava tubes: firstly by the roofing over of linear surface lava channels; and secondly by the draining of still molten material from beneath the solidified crust of pahoehoe flow lobes. This paper will concentrate on the second type: the smaller, but occasionally complex, caves formed by localisation of flow beneath the crust of thin flow lobes or sheet-flows, and subsequent partial draining - as illustrated in Figure 1. More recently Halliday (1998a & b) has described two types of small lava cave: His "sheet flow caves' and 'hollow volcanic tumulus caves' which he regards as being distinct. I will argue that these are just two of several possible end-members of a continuum of forms which I will refer to as "Subcrustal drainage lava caves". Examples are drawn from the basaltic Newer Volcanic Province of Victoria, Australia.

Subcrustal drainage caves involve a broad array of styles ranging from simple single chambers (Figure 2) to multi-level, complexly-interconnecting systems of tubes and chambers (Figure 3). However, while we can identify distinctive types at the extremes, there are many that fall in the middle ground and are hard to classify. All members of the group have in common the dominance of shallow, low-roofed, irregular chambers and small-diameter tubes running just below the surface of the host flow. They also grade (and possibly evolve over time) into larger and more-linear tubes. In long-lasting lava-flow systems, continuing evolution of these small caves in the upstream parts of the flow could produce larger "feeder-tubes' which would converge on the form of, and be difficult to distinguish from, the large "roofed channel" type (eg. the proximal end of H-53, Figure 3).

The simplest caves are small chambers; typically only 1m high with a roof about 1m or less thick, that occur scattered through the stony rises and have been called "blister caves" in Victoria. These can be circular, elongate or irregular in plan; up to 20m or more across but grading down to small cavities only suitable for rabbits. In section, the outer edges of the chamber may be smoothly rounded or form a sharp angle with a flat lava floor. The ceiling may be arched or nearly flat, with lava drips, and can have a central "soft" sag that would have formed while the crust was still plastic. Alternatively, the thin central part of the roof has collapsed and we find only a peripheral remnant hidden behind rubble at the edge of a shallow collapse doline (e.g. H-78, Figure 2). The more elongate versions grade into small "tubes" (e.g. H-31). These caves generally are found beneath low rises (with or without the central fissure required to class them as "tumuli"!), though some have no surface relief at all.

Larger systems show more evidence of directed flow beneath the crust, either radially from a central feeder (H-33, Figure 2) or laterally from the breached levee of a lava channel (Figure 3). They are commonly branching systems with complexes of low passages that bifurcate and rejoin, or open out into broad low chambers. The form suggests draining from beneath the thin solidified roof of a series of coalesced flow lobes.

A Small Cave in a Basalt Dyke, Mt. Fyans, Victoria, Australia

Ken Grimes
PO Box 362, Hamilton, Victoria 3300, Australia.
ken-grimes@h140.aone.net.au

The Volcano: Mt. Fyans is a volcano within the Newer Volcanic Province of Victoria, Australia. The age of the province dates back at least 5 million years, but this is a youthful eruption, undated, but possibly less than 100,000 years old – judging by the well developed "stony rises" (remnants of the original hummocky lava surface) and minimum soil development. The volcano is a broad shield of basaltic lava with a low scoria cone at the summit and possibly a crater - though an extensive quarry in the scoria makes the original form difficult to deduce!

The scoria at the summit has a thin cap of basaltic lava, and ropy patterns on the underside of this are well-exposed on the southern margin of the quarry. The loose scoria has been intruded by two large basalt dykes up to 12 m across (which would have fed the lava cap) and a number of smaller pipe or finger-like basalt bodies, some of which have been partly drained to leave small cavities. The quarry operations have worked around the large dykes, but damaged the smaller intrusive features (which is how we know they are hollow!).

The dyke cave: A small horizontal cave occurs within the largest dyke. It lies close to the west edge of the dyke and runs parallel to it (see map). Entry is via a small hole broken into the roof. The cave is about 17 m long and generally less than one metre high. The roof and walls have numerous lava drips. The floor is a horizontal ropy pahoehoe surface which rises gently towards the northern end – but the ropy structures suggest a final flow direction from south to north. The drainage points for the lava are not obvious. Both roof and floor have common patches of pale-cream coatings over

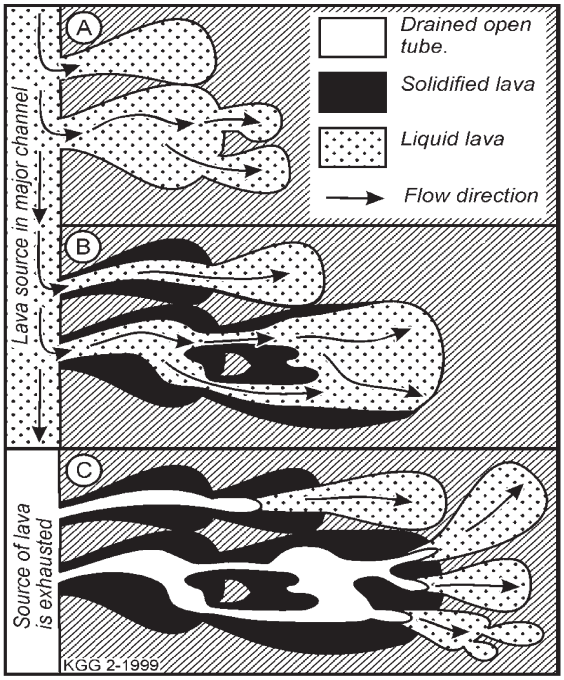


Figure 1: Development of subcrustal caves by partial drainage of successive lava lobes

Figure 2: Examples of small subcrustal caves.

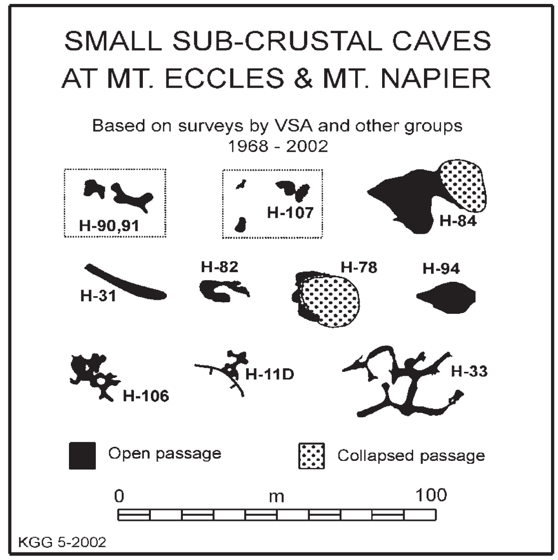
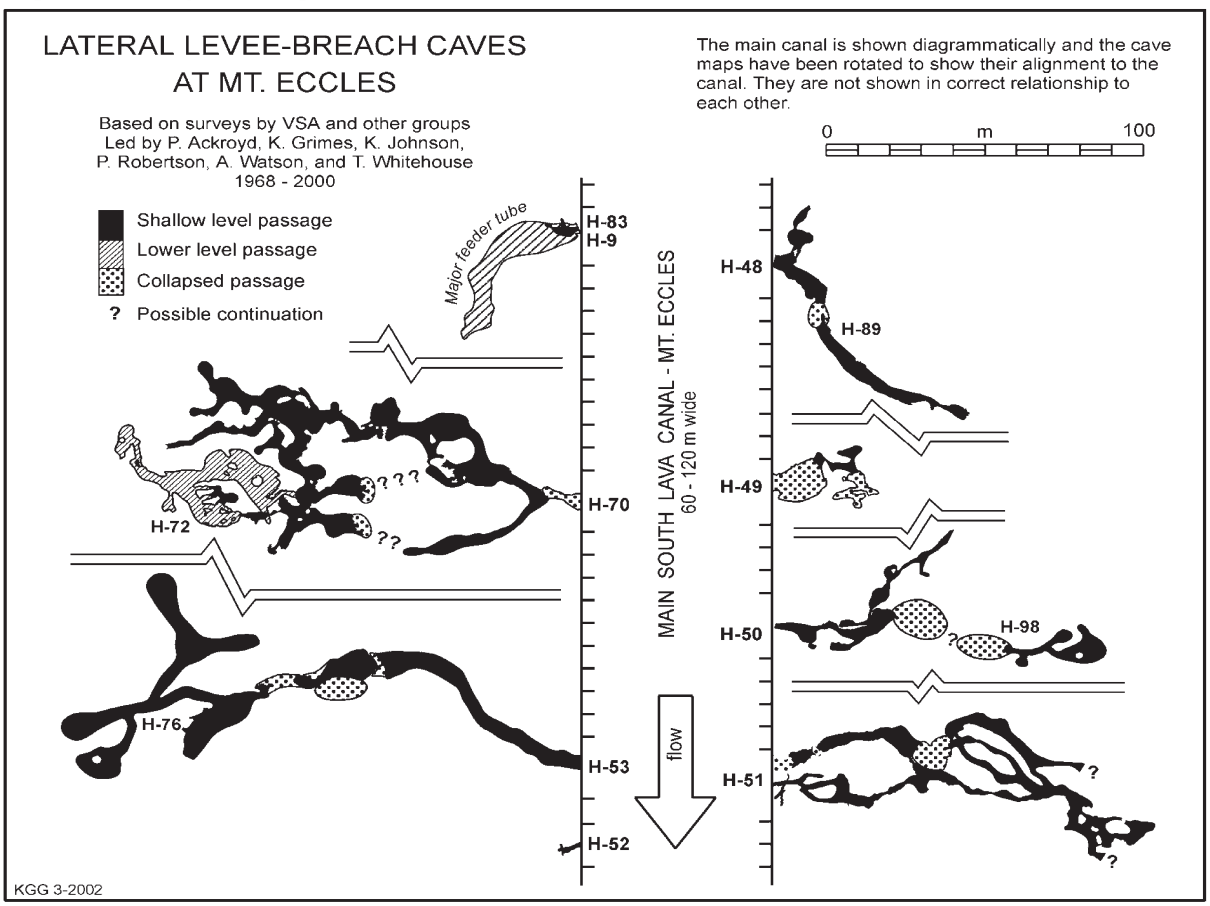


Figure 3: Examples of larger subcrustal caves formed in thin overflows from a lava channel.



Figures for Grimes "Subcrustal Drainage Lava Caves."

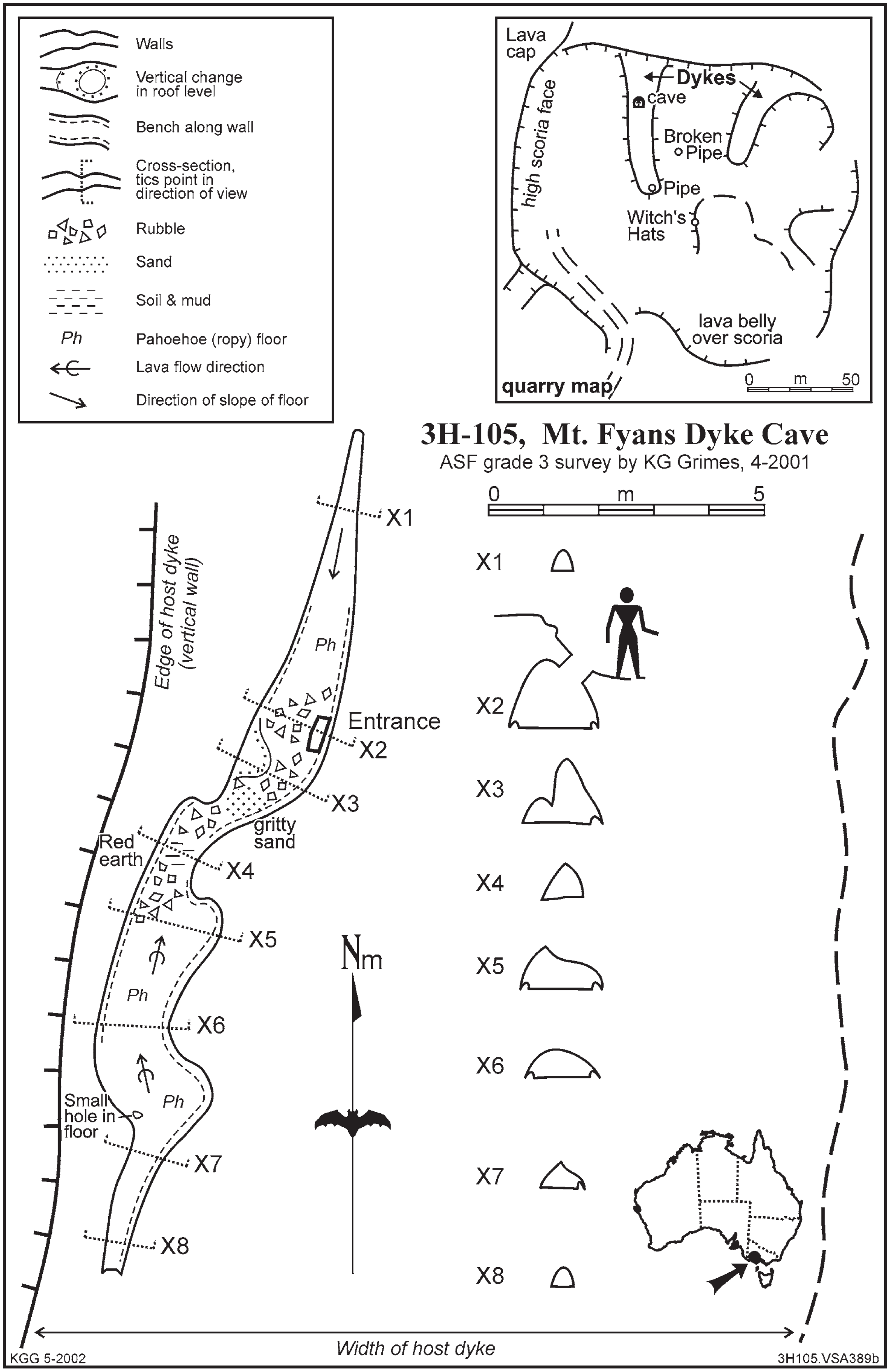


Figure for Grimes "Small Cave Mt. Fyans."

the basalt – possibly fumerolic alteration? There are well-developed rolled benches (10 cm diameter) along the edges of the floor. One small hole in the roof, near the entrance, opened into broken scoriaceous material.

Related features: As well as the cave, the main dyke also has a drained vertical pipe at its southern end – this has been broken into by the quarry operation and we found the upper part lying on its side 20 m to the NE. This pipe had spatter and dribble patterns on its inside walls. Elsewhere in the quarry there are intrusive pipes and smaller fingers of basalt that have pushed up through the loose scoria. Several of these have drained back after the outside had solidified so as to leave a hollow core, some with lava drips. Probably the most distinctive are conical "Witch's hat" structures.

No other volcanic caves formed in dykes have been reported in Australia, but a larger one has been reported from the Canary Islands (Socorro & Martin, 1992).

Genesis: The dykes and other bodies would have been intruded into the loose scoria towards the end of the eruption, would have cooled and partly solidified, and then as pressure was lost those liquid parts that were still connected to the main feeder channels would have drained a little way back to leave the cavities. There may have been some oscillation to form the rolled benches in the dyke cave.

Reference:

Socorro, JS., & Martin, JL., 1992: The Fajanita Cave (La Palma, Canary Islands): A volcanic cavity originated by partial draining of a dyke, in Rea, GT., [ed] *6th Int. Symp. Volcanospeleology.* National Speleol. Soc., Huntsville. pp 177-184 [in spanish].

Preliminary Data on Hyalocaves in Iceland: Location, Formation, and Secondary Mineralogy

Jakob Th. Guðbjartsson and Sigurður S. Jónsson
Icelandic Speleological Society, P.O.Box 342, 121 Reykjavík.
geokobbi@hotmail.com

Hyalocave is a new type of volcanospeleological phenomena. *Hyalo-* is a word derived from Greek and means glass. Hyalocaves are associated with subglacial volcanic eruptions and are the result of entrapment of large ice-fragments inside or atop volcanically generated gravity flows and pillow lavas.

Evidence of basaltic subglacial eruptions have be found in Iceland, British Colombia in Canada and Antarctica. Subglacial eruptions form very distinctive geomorphological mountains called "*tindar*" (hyaloclastite ridges) and "*stapi*" (steep sided tuya). Interaction between magma and meltwater produces pillowlava or fragmented volcanic glass, depending on the hydraulic pressure inside the glacier. Scientist tend to associate subglacial eruptions with englacial lakes. Formation of basaltic subglacial eruption is often divided into three stages: 1) Magma under hydrostatic pressure, pillowbasalt is formed, 2) hydrostatic pressure is low - explosive face; volcanic glass is formed when magma comes into contact with water, gravity driven currents flow down the slopes of the mountain and 3) the main magma feeder is blocked from the water and subaerial lavas starts to flow. Lavas may flow into the englacial lake forming flowfoot- or foreset breccias.

Hyalocaves have been found on the Reykjanes peninsula (Stapafell), Mosfellssveit (Mosfell), Laugarvatn-area (Laugarvatnsfjall, Hlodufell, Mosaskardsfjall, Kalfstindar), Snaefellsnes (Songhellir in Stapafell), Eyjafjallajokull glacier and Thorsmork. Most of them are small: only few meters in length, width and height, although few are tens of meters in size.

These formations haven't been given much attention, due to lack of understanding of basaltic subglacial structures and their chaotic fashion. Hyalocaves are clear evidence of ice in the system. They can help scientists to estimate the waterlevel in the "englacial lake". They also indicate that the mountain was "roofed" by ice during the formation of the particular sediment- or pillow-pile. In the future hyalocaves might even help sedimentologist to estimate the density of gravity flows in subglacial environments.

Two new minerals in Iceland are associated with hyalocaves, these are *monohydrocalcite* ($CaCO_3$*H_2O) and *weddellite* (CaC_2O_4*$2H_2O$). Monohydrocalcite has been found in basaltic lava tubes in Hawaii, limestone caves and lake sediments in salty environment. Weddellite has been found in few limestone caves in Australia and Namibia in Africa. Weddellite is often associated with urea and feces of bats, birds, rats and other mammals. Ideally monohydrocalcite needs the following conditions to form: pH>8, Mg/Ca >1, temperature <40°C, water droplets or aerosol, salt, bacteria or algae. Formation of monohydrocalcite in Iceland is associated with oceanic originated precipitation (pH 5,4) that becomes isolated from the atmosphere as soon as the water seeps into the hyaloclastite and comes into contact with volcanic glass. Volcanic glass is ten times more easily dissolved then crystalline rock. Elements from the glass are dissolved by exchanging positive ions from the glass (Mg^{++}, Ca^{++} et. al.) while hydrogen ions go into the glass. Due to this hydrogen loss the pH increases and ends in 8-9. Micro-organism are know to exist in basaltic glass. Bacteria was seen in thin-sections made from the site where monohydrocalcite was found. Monohydrocalcite was only found in selected hyalocaves and only in the entrance with clear evidence of great leakage and moss growth (*Hymenostylium recuroirostrum*). Minerals formed only in the roof and on walls. The crystals are very small and form thin layer on pillow-fragments or 1-3 mm knobs on both the pillow-fragments and the glassy matrix. The color is white to light-brown. Weddellite is white and powdery. It is located both on walls and ceiling. Its occurrence is associated with sheep feces and urea, but they use the caves for shelter. Weddellite is the first organic mineral described from an Icelandic cave.

Proposals for Future Vulcanospeleological Research in Iceland

Jakob Th. Guðbjartsson and Sigurður S. Jónsson
Icelandic Speleological Society, P.O.Box 342, 121 Reykjavík, Iceland. geokobbi@hotmail.com

Icelandic speleology has contributed enormously from foreign expedition during the last 3-4 decades. Prior to that, very scant information was available on Icelandic caves, and only the general public knew a few caves. Furthermore Icelandic geoscientists have always rather reluctantly approached speleological topics for whatever reasons. An accurate chronology of foreign cave-expeditions to Iceland is not available, but an effort can be made to expose the highlights.

The first expeditions are not very well known and it can be that the main purpose of those journeys was general travelling around Iceland. The British Shepton Mallet Caving Club was active in surveying the larger known Icelandic caves in the seventies, and so were Jay R. Reich and his associates. Spanish, Dutch and French cavers are also known to have visited the country and some have produced important data.

The highly successful expeditions to the eastern part of the Skaftáreldahraun (Eldhraun) in 2000 and 2001 were jointly planned by the Icelandic Speleological Society and foreign participants and organizers. (Wood 2002. this volume). Main role of the ISS was to propose a potentially prominent area for speleological studies with acceptable remoteness and road-access

The main purpose of the poster presented is to raise attention for two sites, considered to be of great vulcanospeleological interest, and offer cooperation in logistical planning and research program. The ISS has some preliminary information about the two sites.

The first site proposed is the western part of the Snæfellsnes peninsula, mostly Holocene lava flows on the flanks of the Snæfellsjökull glacier but also unexplored flows of similar age further ease along the peninsula. The ISS has conducted several short reconnaissance trips and small-scale surveying trips mostly in the Purkhólahraun and Neshraun lava flow in recent years, but also in Saxhólshraun and Klifhraun. Only few caves have been mapped, but a large number of caves and conduits await further research.

The other site is a large lava shield northeast of lake Thingvallavatn, called Þjófahraun (Thjófahraun). The ISS has organized two reconnaissance trips to the area in recent years and concluded that there is a wealth of speleological features to be explored and surveyed. Many un-surveyed caves are known, both braided tube systems and pit-like structures.

What Is a Lava Tube?

William R. Halliday
Honorary President, Commission on Volcanic Caves of the International Union of Speleology.
6530 Cornwall Court, Nashville, TN USA 37205.
bnawrh@webtv.net

Variances and imprecision in defiing the term LAVA TUBE have led to its application to a wide range of features, some of them far removed from the ordinary meaning of the word TUBE: "a hollow body, usually cylindrical, and long in proportion to its diameter..." The current American Geological Institute definition helpfully limits the term to roofed conduits and requires that they be formed in one of four accepted mechanisms. However it provides little guidance on whether a variety of injection structures traditionally termed LAVA TUBES actually are undrained or refilled examples or are entirely dfferent phenomena.

Ideally, lava tubes and lava tube caves should be defined as discrete structures with definable parameters which differentiate them from all other volcanic features, e.g., aa cores, lava tongues, tumuli, sills and related injection masses. The defining characteristics should be compatible with:

1) the common meanings of TUBE and CAVE;
2) the presence of solid, liquid, and/or gaseous matter within them;
3) observations of all phases of their complex speleogenesis, e.g., crustal and subcrustal accretion and erosion;
4) their tendency to form braided and distributory complexes, and multlevel structures of at least two types;
5) their propensity to combine with or produce other volcanic structures, e.g., lava trenches, rift crevices, tumuli, drained flow lobes, lava rises, dikes, etc.

The ideal may not be achievable at the present state of knowledge and technology. However, new concepts of flow field emplacement and drainage offer a notable opportunity to shape a clearer definition of this elusive term. I propose that the Commission on Volcanic Caves of the IUS develop such a definition, in collaboration with the AGI and other concerned agencies and organizations, for consideration at the 2005 International Congress of Speleology.

Caves of the Great Crack of Kilauea Volcano, Hawaii

William R. Halliday
Honorary President, Commission on Volcanic Caves of the International Union of Speleology.
6530 Cornwall Court, Nashville, TN USA 37205.
bnawrh@webtv.net

The Great Crack ("17 Mile Crack") is the most prominent feature of Kilauea volcano's Southwest Rift Zone. Rather than consisting of a single crevice, much of the "crack" consists of en echelon crevices of various widths in a strip locally more than 1 km wide. Numerous grabens and collapse pits are present.

Detailed studies of this complex have been begun only in the past decade. Some of the participating geologists have requested support and some leadership by speleologists in investigating cavernous pits at the bottom of steep talus slopes. The Hawaii Speleological Survey of the National Speleological Society consequently has cooperated with University of Hawaii and U.S. Geological Survey researchers in investigating cavernous pits in the principal axis of the crevice complex.

The first two such pits yielded minimal findings, but the third—labelled Pit H by University of Hawaii geologists—immediately was seen to require SRT expertise. In 2001 it was explored and mapped to a depth of 183 m. Despite extensive breakdown, accretion by laterally flowing lava was identified on several levels. A total of 600 m of passage was mapped.

In a similar crevice passage at the bottom of Wood Valley Pit Crater (which is nearby but off the principal axis of the rift zone), tube segments have been found along the crevice at a depth of almost 90 m.

No such tube segments have been found in Pit H Cave, but numerous other pits remain to be investigated along the Great Crack.

Investigation on Discharge Mechanism of Lava-Tube Cave

Tsutomu Honda
Mt. Fuji Volcano-Speleological Society

Discharge mechanism of lava-cave has been proposed and discussed based on Bingham characteristics of lava flow in the tube(T.Honda,2000,2001). A simple model of steady state isothermal laminar flow in circular pipe were used for analysis.

Flow characteristics were studied as a function of parameters such as tube radius, viscosity, yield strength of lava and inclination of down slope. A critical condition was obtained for determining the discharge parameters in which the yield strength plays a dominant role. Some existing data base form the observation of lava cave were introduced to the critical condition and yield strength can be obtained. This model was applied to lava cave of Mt.Fuji, Etna, St.Helenes, Suchiooc, Kilauea, etc., and some deduced yield strength of lava of the caves for these area are found to be good accordance with yield strength estimated by other methods.

General flow equation of Bingham fluid can be shown as,

$$f(t)=(t-f_B)/v_B \quad (t>f_B, \text{ or } r>r_B),$$
$$f(t)=0 \quad (t<f_B, \text{ or } r<r_B).$$

Here, f_B is Bingham yield strength, v_B is Bingham viscosity, which takes specific value depending on the materials. t is shearing stress at r.

For laminar flow model in circular tube on the slope, the equation of the distribution of flow speed u of Bingham fluid are shown as follows:

For $tw = (d\ g \sin a)R/2 > f_B$,

$$u=(R-r_B)^2(d\ g \sin a)/4v_B \quad (r<r_B),$$
$$u=[R^2-r^2-2r_B(R-r)]\ (d\ g \sin a)/4v_B \quad (r>r_B).$$

For $tw= (d\ g \sin a)R/2<f_B$, u=0.

Here, tw is shearing stress at wall, a is angle of slope or inclination of tube, d:density of the fluid, g: gravity acceleration, R :radius of the tube, r_B :radius of the flowing position where Bingham yield stress takes f_B.

Here, $(d\ g \sin a)R/2=f_B$ is the critical condition to determine if the fluid in the tube can be drained out. For given and known relation between slope angle and diameter (height)of the tube, this critical condition can give the yield strength f_B. This critical condition means that when the yield strength f_B of Bingham fluid is higher than the shear stress at the wall, there is no flow of fluid, as a consequence, no discharge of fluid from the tube. Relations between slope angle and height of cave for Mt. Fuji, Mt. Etna, and St. Helenes are shown in Table 1 – Table 3. Obtained yield stress from slope angle and height of some lava caves are shown in the Table 4 together with the yield stress obtained by other methods.

References:

T. Honda: “On the formation of Subashiri-Tainai cave in Mt. Fuji”. The 26th annual meeting of the Speleological Society of Japan, 2000, August, p.64

T. Honda: “Investigation on the formation mechanism of lava tube cave”. The 27th annual meeting of the Speleological Society of Japan, 2001, August, p.11

T. Honda and T. Ogawa: “On the formation process of Inusuzumi-yama lava cave ”. The 27th annual meeting of the Speleological Society of Japan, 2001, August, p.37

T. Honda: “Formatin mechanism of lava tube caves in Mt. Fuji”. The 2001 Fall meeting of the Volcanological Society of Japan, 2001, 0ctober, p.66

On Lava Stalactite Formation in the Hollow of Tree Molds of Mt. Fuji

Tsutomu Honda
Mt. Fuji Volcano-Speleological Society

At the north-east flank of Mt.Fuji, lava stalactites are often found in the hollow located adjacent to the lava tree molds. These stalactites have a periodic distribution on the surface with 3–6 cm pitch on the roof of hollow and have almost same diameter (4–8mm) at the edge of the lava stalactites. There had been no scientific and systematic study on the formation process of this kind of stalactite in the hollow adjacent to the tree molds before long.

The author proposed a possible formation mechanism of this stalactite and a model to explain the final structure of stalactite (T.Honda, 2000). The author have investigated the initiation of the formation process of stalactite by stability/instability problem (H.Lamb, 1954) of melted liquid layer on the surface of hollow under the action of gravity force. Limit of stability/instability of this layer is determined by balance between surface tension and density of lava. Period of wave of small perturbation on this layer for this stability limit can be determined as, $Pc=2\pi(s / g\ d)^{1/2}$. Here, Pc is critical period of wave, s is surface tension, d is density of lava, g is gravity acceleration. This period is believed to be also a pitch of stalactite location .

As surface tension of lava (I.Yokoyama et al,1970): $10x10^{-2}$Kg/m(1000deg) to $6.5x10^{-2}$Kg/m (1400deg), and density of lava 1.5to2.5g/cm^3 are used for this study.

For surface tension s=$6.5x10^{-2}$Kg/m and d=1.5–2.5g/cm^3, Pc=3.2–4.1cm. For surface tension of lava s=$10x10^{-2}$Kg/m and d=1.5–2.5g/cm^3, Pc=5.1–6.6cm. Measurement by a scale shows 3cm–6cm pitch which has a good agreement with above estimation.

As for a study on the structure and diameter of lava stalactite, the author used the Bingham flow model to explain the formation mechanism and structure of lava stalactite. From the diameter of edge of stalactite, yield strength of lava was determined. From this yield strength, the temperature of this stalactite when it was formed can be estimated.

General flow equation of Bingham fluid can be shown as,

$$f(t)=(t-f_B)/v_B \quad (t>f_B, \text{ or } r>r_B),$$
$$f(t)=0 \quad (t<f_B, \text{ or } r<r_B).$$

Here, f_B is Bingham yield strength, v_B is Bingham viscosity, which takes specific value depending on the materials. t is shearing stress at r. For laminar flow model in vertical set circular tube with pressure difference P1-P2 for stalactite length L, the critical condition is tw=(P1-P2)r/2L=f_B. Here, (P1-P2)/L=dgL/L=d g. So the limiting radius for lava discharge is r=2f_B/d g. For density d =2.5 g/cm^3, when r=2–4mm, f_B=2.5–5x10^2 dyn/cm^2. For density d=1.5g/cm^3, when r=2–4mm, f_B=1.5–3x10^2 dyn/cm^2. This low yield strenght suggests that the lava was in rather high temperature condition when surafce is re-melted before re-solidified.

References:

T. Honda: "The formation process of lava stalactite in the of tree molds of Mt. Fuji". The 26th annual meeting of the Speleological Society of Japan, 2000, August, p.4

T. Honda: "The investigation on the formation process of the lava tree-molds structure of Mt. Fuji". The 2000 Fall meeting of the Volcanogical Society of Japan, 2000, September, p.110

H. Lamb: Hydrodynamics, Dover 1945, p.19

I. Yokoyama et al: "Measurement of surface tension of volcanic rocks". Technical Report of Hokkaido University, 1970, p.56-61.

Table 1. *Relation between Slope angle and height of lava cave in Mt.Fuji.*

Name of lava cave	*Slope angle*	*Height*
Subashiri-Tainai Cave Upper area	20 degree	1m
Subashiri-Tainai Cave Lower area	15 degree	2m
Shoiko-Fuketsu Cave-1	10 degree	3.3m
Mujina-Ana Cave	8.5 degree	5m
Bannba-Ana Cave	4.8 degree	5m-10m
Mitsuike-Ana Cave	3.2 degree	10m

Table 2. *Relation between Slope angle and height of lava cave in Mt.Etna.*

Name of lava cave	*Slope angle*	*Height*
Tre Livelli Cave	15.3 degree	3m
Serracozzo Cave	9.8 degree	2m-3m
KTM Cave	8.9 degree	5m
Cutrona Cave	6.4 degree	6m
Immoacolatella-I Cave	3.8 degree	10m

Table 3. *Relation between Slope angle and height of lava cave in St.Helenes.*

Name of lava cave	*Slope angle*	*Height*
Little Red River Cave	4.5 degree	9.1m
Ape Cave	3.3 degree	11.6m
Lake Cave	2.6 degree	15.5m
Ole's Cave	2.1 degree	7.6m

Table 4. *Yield strength obtained from the critical condition.*

Name of volcano which has lava tube caves	*SiO_2 fraction of lava*	*Yield strength obtained from the limiting condition (yield strength obtained by other method in paranthesis)*	*References*
Mt.Fuji	49.09~51.3%*	2.5~5x10^4dyne/cm^2	*H.Tsuya(1971)
Mt.Etna	48%	5x10^4dyne/cm2 (7x10^4dyne/cm^2*)	*G.P.L.Walker et al(1967) *G.Hulme(1974)
Mt.St Helenes	50.12~50.28%*	1~2.5x10^4dyne/cm^2	*R.Greely&H.Hyde(1972)
Mt. Suchiooc	51.23~51.35%*	7.5 x10^4~1x10^5dyne/cm^2	*R.E.Perena(1999)
Mt.Kilauea	46.46~50%	1x10^3dyne/cm^2 (1x10^3dyne/cm^2*)	*H.R.Shaw et al(1968) *G.Hulme(1974)
Mt Piton de la Fournaise	47.98%*	5x10^4dyne/cm^2	*A.Lacroix(1936)
Mt.Cameroon	43.5%*	1x10^5dyne/cm^2 (~1x10^5dyne/cm^2*)	*J.G.Fitton et al(1983)

Tables for Honda "Discharge Mechanism"

Air Quality Measurements in Lava Tubes

Julia M. James
Heavy Metals Research Center, School of Chemistry, F11.
The University of Sydney, NSW 2006, Australia.
jmj@chem.usyd.edu.au

Air quality in lava tubes is not normally recorded or investigated. Thus in some instances discomfort from poor air quality may have been misinterpreted as resulting from stress from high temperatures or high humidity. Only two gases have been recorded are ammonia from bat caves and carbon dioxide. The former is unlikely to reach hazardous levels and later has been known to reach hazardous levels in at least one lava tube. This paper will focus on the possible sources, concentrations, distribution and movement both spatially and temporally within lava tubes. The importance of air analyses including oxygen, nitrogen and water vapour will be stressed in order to establish the source of carbon dioxide. Analysis of trace gases, for example, hydrogen sulfide and methane, can also give additional information as to a CO_2 source. Simple CO_2 tests available to the exploration caver will introduced and assessed. The practical aspects of the exploration lava tubes found to contain poor air quality will be discussed. The advantages and disadvantages of using scrubber gases, oxygen re-breathers and scuba will be presented. The paper will include examples of where poor air quality has been identified from volcanic activity and will feature the author's experience with the Chillagoe Caving Club in Bayliss Cave, Undara the longest lava tube found in Australia.

The Mapping History of the Surtshellir/Stefánshellir Cave System

Sigurður S. Jónsson
Icelandic Speleological Society, P.O.Box 342,
121 Reykjavík, Iceland. ssjo@os.is

The nearly 2 km long cave Surtshellir is the best know lava tube in Iceland and is mentioned in many early manuscripts and publications of domestic and international origin. The cave is mentioned in the Icelandic Sagas and folklore and tales are associated with the cave. The cave has provoked many early travelers' attention and curiosity and many explorers visited the cave in past centuries. The first mappublished of the cave was the work of native explorers Eggert Ólafsson and Bjarni Pálsson and published in Denmark in 1772. Eggert and Bjarni's fieldwork is believed to have been carried out in the summer of 1755 but they also toured the same region in 1773. The next map that follows is the work of German traveler/explorer Zugmeyer published in 1902.

The presentation is an overview of the work carried out is Surtshellir and the adjacent and upflow continuation of Surtshellir, Stefánshellir but they upflow segment is divided from Surtshellir with an unpenetrateable boulder-choke which also contains perennial ice. The maps presented are both of Surtshellir and Stefánshellir individually and of the both. It can be concluded that early travelers were not aware of the upflow continuation since not mention is made of its presence.

Surtshellir is in the Hallmundarhraun lava flow in West-Iceland and was formed in historical times (10th century), just after the settlement of Iceland in 874 AD. Surthellir bears large and extensive remains of human habitation, but the archaeological remains have not been cared for by Icelandic archaeological authorities, and are now more or less ruined – or at least seriously affected. The Icelandic novelist Halldor Laxness had pieces of bones ^{14}C-dated in the fifties, and the dating gave grounds to conclude that the remains where of 10th century origin. This has recently been confirmed by later ^{14}C datings.

Altogether 11 maps of different grades and quality are presented and each map's history is briefly discussed.

25 Years of Icelandic Cave Surveying – Jay R. Reich's Maps

Sigurður S. Jónsson
Icelandic Speleological Society, P.O. Box 342, 121 Reykjavík.
ssjo@os.is

The Pennsylvania born caver Jay R. Reich has contributed a lot to Icelandic speleology and his work on Icelandic caves is summarized. Four large and detailed maps are presented and light is cast on Jay's enthusiasm and fine work in cave mapping and drawing, as well as his enormous interest in Icelandic caves. His first visit to Iceland was early in 1969 when he made his first attempt to survey Surtshellir but hostile weather and other logistical problems prevented him from achieving his goal at that time. He was in Iceland three more times, and completed his map of Surtshellir/Stefánshellir in 1973. His next major project was the exploration and mapping of the extensive cave system of Kalmanshellir in 1993, also in the Hallmundarhraun lava flow. The map of the roughly 4 km cave system with vast details was finished the same year.

The Icelandic Speleological Society collaborated with Jay in the mapping of Víðgelmir, also in Hallmundarhraun, and fieldwork was carried out in 1996. The map was drawn by Jay Reich, checked and corrected by ISS members and it was finished in 1998. During the Kalmanshellir expedition Jay had in collaboration with ISS members and US cavers completed a map of the recently discovered nearly 1 km long cave of Leiðarendi in 1993. In the last 30 years Jay and his collaborators have surveyed all three of the big caves of the Hallmundarhraun lava flow in Western Iceland and Jay has completed maps of over 10 km of cave passage.

Conservation of Volcanic caves in Iceland – Status and Update

Sigurður S. Jónsson, Jakob Th. Guðbjartsson, and
Guðmundur B. Thorsteinsson
Icelandic Speleological Society, P.O. Box 342, 121 Reykjavík.
ssjo@os.is

Since the founding of the Icelandic Speleological Society (ISS) in 1989 it has been the society's goal to enhance and further collaboration and cooperation with governmental bodies in the field of cave conservation and general preservation of volcanic phenomena.

A bold and brave step was taken in 1974 by the Nature Conservation authorities, when all protruding and hanging lava formations (stalactites and stalagmites) were subject to an "automatic" and undisputable conservation as a Natural Monument, in accordance to the Nature Conservation legislation valid at that time. The speleothems were protected regardless of their position in the cave and if the cave itself had any direct or indirect conservations status and if it was known or unknown. The speleotheme conservation is formation oriented and bears resemblance to protection of bird species – i.e. the protection is broadly aimed at the form and occurrence but not at an in-situ individual formation.

After removing an ice-plug in Víðgelmir in 1993 the ISS proposed the idea of gating the cave but it had been blocked since 1972 by the before mentioned perennial ice. The landowners were very positive towards the idea and participated in the project of building the gate. Since the installation of the gate all traffic has been controlled and the landowner now rents caving equipment and takes visitors on guided tours to the cave. The involvement of government authorities was not needed in the gating process of Viðgelmir, but proper authorities were notified of the action.

Following the discovery of the enormously decorated cave Jörundur in 1979 there was an ongoing debate about necessary efforts to protect the cave. In 1985 the cave Jörundur was legally declared a natural monument and subsequently the cave was closed by a steel-gate on the surface, leaving it only open for scientific purpose, and managed by the Nature Conservation Agency. The lock on the gate was broken several times, but no serious damage was done to the cave, except a few specks of candle wax were left on some of the stalagmites. The gate was removed by ISS in September 1999 and a new chain-gate installed in a narrow passage.

The cave Árnahellir is another specific cave-conservation issue the be mentioned. The cave was discovered in 1985 and an escalating number of visitors was experienced in due time from the day of the discovery. In 1995 the ISS took a radical step in cave conservation when after some negotiation time a treaty was signed with the land-owner giving the ISS the sole right to take necessary steps to protect the cave, including the installation of a gate. The treaty was notarized at the sheriff's office in Þorlákshöfn. Immediately, or when the action was legally binding, the ISS prepared for gating the cave. The cave has been closed since and access controlled by the ISS. This privatized conservation has been a little disturbing and irritating for the authorities but the latest development is very satisfying and encouraging for the ISS. In 2001 the ISS board signed a contract with the Nature Conservation Agency granting the ISS the right to maintain and manage all protected caves and caves enclosed on areas where specific conservation effort or actions have been taken, i.e. natural parks, recreations areas, protected lava – or volcanic fields and other reserves. This action of forwarding the authority to the ISS is a milestone for the ISS´s efforts toward cave conservation in Iceland and the Minister of Environmental Affairs authenticated the arrangement in July 2002. The ISS/land-owner treaty wassubsequently abandoned and Árnahellir legally declared a Natural Monument.

In the future the ISS will propose new specific cave conservation projects to the Nature Conservation Agency or if the matter allows, take the necessary steps unaided in power of the treaty made with the Nature Conservation Agency and Ministry of Environmental Affairs.

Vulcanospeleology as Tourism: Case Study of Samoa

Ruth E Lawrence
Outdoor Education & Nature Tourism, La Trobe University,
PO Box 199 Bendigo 3550, Australia.
r.lawrence@bendigo.latrobe.edu.au

The Independent State of Samoa is located in the South Pacific region immediately east of the International Date Line. Located to the north of the Tonga Trench, the country of Samoa comprises several small volcanic islands as part of a 1200 linear volcanic chain extending 550 km from Rose Atoll in the east to the Samoan island of Savaii in the west. The Samoan islands are composed almost wholly of basic volcanic rocks such as olivine basalt, picric basalt and olivine dolerite of the alkaline basalt suite. Although the age of the rocks is poorly known, it is thought that the oldest Fagaloa Volcanics erupted in the Pliocene period. The islands are still volcanically active, with the last eruptions in Savaii of Mauga Afi in 1760, Mauga Mu in 1902 and Matavanu in 1905.

There are an unknown number of caves located within the volcanic landscape of Samoa. Most caves appear to be of subcrustal forms that have been modified by subsurface river systems. The Samoan Visitors Center advertise tours through several caves including the Peapea Cave in the Le Pupu-Pue National Park, and the Paia Dwarf's Cave below the summit of Mt Matavanu. Other caves, such as the Piula Cave Pool between the Piula Theological College and the coast, are available for visitor exploration.

This study aimed to identify as many vulcanospeleological features in Samoa as possible and to relate the location of the caves to geology and land tenure. A short inventory of the caves was undertaken by identifying physical and cultural features of significance. The use of the popular and lesser known caves for tourism was examined, and the relationship between cave tourism and local village ownership was explored. The challenges and impediments to the expansion of vulcanospeleology as part of tourism in Western Samoa was also examined.

Patterns of Lava Tube Development on the North Flank of Mauna Loa, Hawaii

Douglas Medville and Hazel Medville
Hawaii Speleological Survey

Mauna Loa is a shield volcano on the island of Hawaii with a surface area of about 5,500 sq. km and rising to an elevation of 4,170 meters above sea level. The U. S. Geological Survey estimates that about 40 percent of its surface area is covered by lava flows that are less than 1,000 years old. In the time period 1992-2001, members of the Hawaii Speleological Survey have surveyed 55 km of passage in 107 lava tubes within a 60 square km area on the north side of Mauna Loa's northeast rift zone. The tubes are found in flows ranging in age from 5,000 years BP to as recent as the historic 1935 flow. These tubes exhibit several distinct configurations. The most commonly observed tube pattern consists of a single sinuous conduit containing occasional loops and short branches. Other, more complex tube patterns are also observed in the Mauna Loa lava flows and include:

(a) *Unitary, multi-level tubes*. Some of the thicker flows are up to 20 meters deep and contain multilevel tubes in canyon like passages. These tubes appear to result from stable lava levels that partially filled the tubes. Crusting took place on the top of the lava in the tubes with molten lava flowing below. Subsequent lowering of the level of flow in the tube and crusting of the tops of the lower lava flow levels resulted in evacuated multi-level tubes with the crusted upper surfaces of the partially filled tubes remaining as intermediate ceilings when flow through the tubes ceased.

(b) *Shallow complex tubes*. The 1935 flow is only 7-8 meters thick but contains a grid-like tube complex having 4,500 meters of surveyed passages in an area that is 700 meters long and 250 meters wide. This tube appears to have been developed by multiple flow lobes advancing along the distal end of a sheet flow with the lobes diverging and converging as inflation occurred, resulting in a tubes having a maze-like pattern.

(c) *Single level tube complexes in broad flows*. Over 8 km of parallel tubes have been surveyed in the historic 1855 flow. The tubes extend across the flow in at least three parallel lines. The tubes are at about the same depth beneath the surface, appear to be in the same flow unit, and are not branches of large loops.

(d) *Giant tubes*. Emesine Cave in the historic 1881 flow is the largest surveyed tube on Mauna Loa. With a linear extent of over 8 km, a vertical extent of 436 meters, and having a surveyed length of 20.72 km, this single tube contains almost 40 percent of the total surveyed passage found in the northeast rift zone tubes. Although much of Emesine Cave consists of a unitary tube, some parts of the cave are a complex braided network of passages on more than one level.

Carvão Cave (S. Miguel Island, Azores, Portugal: An Educational Experience

João Carlos Nunes[1,2], Teófilo Braga[2], and João Paulo Constância[2]
[1] Azores University – Geosciences Department. Rua da Mãe de Deus. P.O. Box 1422. 9501-801 Ponta Delgada. Azores. Portugal. jcnunes@notes.uac.pt
[2] "Amigos dos Açores" Environmental NG. P.O. Box 29. 9500 Ponta Delgada. Azores. Portugal.
teobraga@hotmail.com, constancia@mail.telepac.pt

"Gruta do Carvão" (meaning "Coal Cave") is the biggest lava cave in S. Miguel Island, and one of the most impressive underground structures in the archipelago. It is a well-known cave, reported in old manuscripts since the sixteenth century, and visited by many national and international explorers.

Carvão Cave has nowadays a total acknowledged length of about 1650 m, with a general NNW-SSE trend and along three different sections, most of it more than five meters wide. However, the original path of the main channel can be traced for about 2400 m from the coastline, and it might be able to have reached more than 5 km long. This cave develops in a basaltic *s.s.* lava flow (SiO_2=45.6%; Na_2O=2.53%, K_2O=1.19%) probably extruded from the Serra Gorda scoria cone area. This strombolian cone is one of the about 200 volcanic cones pertaining to the "Picos Volcanic Complex", an area of basaltic nature that extends in the western sector of S. Miguel Island as a shallow platform, built by lava flows of *aa* and *pahoehoe* type. The lava flow of Carvão Cave is covering a pumice layer and a paleosoil, in witch some charcoal remains were found and dated by ^{14}C conventional gas counting technique, at Geochron Laboratory (USA). The ages determined were 11,880 years BP (±80y) and 12,100 years BP (±140y), pointing a Holocene age to Carvão Cave.

Owing to its size, a great variety of microstructures can be found inside the cave, which are undoubtedly an eloquent sample of the creative force of the Azorean volcanism. Among those are flow marks, lava tree molds, *pahoehoe* slabs, ropy and spongy lavas, burst bubbles of lava, branching galleries, superimposed channels and long extensions with benches at several steps. On the roof there are many fusion lava stalactites and other irregular deposition-type stalactites, sometimes over the former. Some sectors of the cave, mostly the flatter ones, were affected by sand and clay deposition, which silt them up and block the cave in some places. Thus, it was needed some removing work in recent times to allow a permanent and easy walk inside the lava tube. Carvão Cave has been used for many years as warehouse of the local tobacco factory.

Given its size and location, right in the urban area of Ponta Delgada city, close to the downtown, airport, schools and tourist facilities, the cave is the perfect spot for visitors interested in the speleological thematic, or in a wider sense, to all who want to know the natural volcanic underground landscape of the S. Miguel Island. Therefore, a project to open Carvão Cave to the general public is in progress, taking profit of the many potentialities of that cave, namely in terms of its scientific, educational and touristy value.

That project is based on well-sustained museum programme and the dynamics of several activities associated, including an exhibition area nearby the main entrance. In fact, it is believed that Carvão Cave is the perfect place to enhance the importance of the volcanic phenomena (specially of the basaltic volcanism) to the genesis and evolution of the Azores archipelago, and its influence in the Azorean way of life. This cave is also an excellent scenario for educational approaches, namely in terms of Environment Education, owing for a better knowledge of Man and Nature, calling attention to Environmental problems and creating a new behaviour. With these ideas in mind, a special attention is given to schools (with the appropriate connection with their teachers and school programmes) allowing that many students visited Carvão Cave, in what it's expected to be a fruitfully educational experience.

The Grotta dei Rotoli (Mount Etna, Italy)

F. Petralia[1,2]*, R. Bonaccorso[1], A. Marino[1], and B. Sgarlata[1]
[1] Centro Speleologico Etneo, Via Cagliari 15,
95127 Catania, Italy
[2] Università di Catania, Dip. di Scienze Geologiche,
Corso Italia 55, 95129 Catania, Italy
* Corresponding author. University of Catania,
Dip. Sc. Geologiche, Corso Italia 55, 95123 Catania, Italy.
fpetrali@mbox.unict.it

Only few years ago discovered, the Grotta dei Rotoli (*cave of rolls*) develops in the flow field who was generated during the eruption of 1865. This basaltic effusion shows both pahoehoe and 'a'a flows but it is in the former morphology that the studied lava tube develops. Plan view, longitudinal and transverse sections of the cave are presented in this work.

This lava tube has a length of only 260 meters but its importance is given by big rolling-over structures drapping the walls of the cave. In his short lenght the cave bifurcates twice, in general agreement with the observation that many lava tubes show an increase in size with increasing distance from the vent (Calvari and Pinkerton, 1999).

Is supposed that the enlargement of the lava tube, join to a fast draining of lava (probably due to the opening of an ephemeral vent), promotes a slow longitudinal collapse of the still not self-supporting roof. This kind of collapse generates a downward directed bulge: because this bulge touches the floor it create the splitting of the lava tube. This partition of the transverse section works as a stoppage for the new following flow. Is in fact assumed that only a new re-filling of the tube with fresh lava can lock the collapse of the roof, giving to it more time to cool and solidificate. The successive rapid draining gives eventually rise to rolling-over structures that embrace the bifurcation.

Thanks to thin sections studying, substantial differences in porphyritic indexes are detected between rolls and roof samples, giving force to the theory of the second flow injection.

Key words: lava flow; lava tube; rolling-over structures; Etna volcano.

Growth of a Submarine Lava Tube at Ustica Island (South Tyrrhenian Sea)

F. Petralia[1,2]*, C. Ferlito[1], and R. Cristofolini[1,2]
[1] Università di Catania, Dip. di Scienze Geologiche,
Corso Italia 55, 95129 Catania, Italy
[2] Centro Speleologico Etneo, Via Cagliari 15,
95127 Catania, Italy
* Corresponding author. University of Catania,
Dip. Sc. Geologiche, Corso Italia 55, 95123 Catania, Italy.
fpetrali@mbox.unict.it

The island of Ustica is a small (8 km^2) volcanic island, located in the Tyrrhenian Sea, 60 km north of Sicily. The island rises from the bottom of the sea of 2.000 m and reaches the elevation of 248 m a.s.l..

Several authors have recognised in the island an articulated volcanic succession, with different eruptive centers, the last of wich has been active 147 ky b.p. (Cinque et al., 1988; De Vita et al., 1998; Romano & Sturiale, 1971). The morphologies of lavas cropping in the island vary from pahoehoe to pillow. Explosive activity produced large amounts of tephra, going from hydromagmatic breccias to pumice. All existing geochemical data comes from subaerial outcrops, they indicate for the volcanics of Ustica a mostly alkaline and subordinately subalkaline character.

Due to the reduced dimension of the island all subaerial lava flows reached the sea. This produced a great amount of morphologies of the transition from subaerial to submarine lava flows. The tectonic uplift wich has affected the island after its last period of activity allows us to see the submarine lavas, and the transition from pahoehoe flows to pillow breccias.

In this work we want to point out the existence of a little lava tube (14x2 m) found in one of these submarine pillow-breccia levels. Such lava tubes are considered to be very rare occurrences in submarine lavas.

The origin of this lava tube can be explained considering the formation of a mega-pillow in an advancing submarine lava flow. Its outer layer solidified protecting the inner part of the tube from the water. Inside the tube the gas expanded, probably part of this gas was provided by the vaporization of small volumes of sea water that entered the tube. The expansion of the gas caused an inflation of the walls of the tube wich were still in a plastic state. Such an inflation left a space in the tube so that liquid lava inside could develop tipically pahoehoe ropy morphologies.

Key words: lava flow; lava tube; pillow-lava; Ustica; Tyrrhenian Sea.

Lava Tubes of Harrat Kishb, Saudi Arabia

John J. Pint
Cave Unit Consultant, Saudi Geological Survey

This presentation features a Powerpoint slide show on the discovery and exploration of several lava tubes located in Harrat Kishb, a lava field located 300 kilometers Northeast of Jeddah, Saudi Arabia.

The first visit to Harrat Kishb had two goals. One was to investigate a series of collapse holes, visible in air photos, extending from an extinct volcano named Jebel Hil and suggesting the presence of a lava tube at least three kilometers long. The second goal was to try locating several shorter lava tubes seen in this area by a hunter.

A hair-raising, nearly impossible climb up Jebel Hil revealed an opening in the side of the crater, presumed to be the upper end of the long lava tube. A ground reconnaissance then gave the coordinates of most of the collapses and indicated the floor of the tube was from 26 to 42 meters below the surface.

Two days of searching the stark landscape of Harrat Kishb failed to reveal the location of the smaller lava tubes, but these were finally found with the help of Bedouins living at the edge of the lava field. One of the tubes, Kahf Al Mut'eb, was surveyed to a length of 165.8 meters and was found to contain lava levees, stalactites and animal bones. A brief look at a nearby lava tube revealed that it was "populated" by tall, shadowy figures which turned out to be stalagmites of rockdove guano, giving this hole the name Ghostly Cave.

During a second visit to Harrat Kishb, a survey of Ghostly Cave was undertaken. Samples were taken of the basalt and mineral coatings found on the walls and of the thick layer of choking, potassium-rich dust on the floor. The "guanomites" were photographed and sampled. During the survey, two L-shaped throwing sticks were found inside the cave. These are similar to sticks seen in the hands of figures in Arabian Neolithic rock art and may be five to eight thousand years old.

A photography session held in Kahf Al Mut'eb resulted in the discovery of a plant-fiber rope which may also be of Neolithic age.

Finally, a visit was made to a lava tube located much farther north in Harrat Kishb. Its entrance is unusual in that it is not a collapse, but apparently the result of surface air being sucked into the tube as the lava was draining from it. This cave, named Dahl Faisal, also features a "dust volcano" produced by the release of air trapped in mud during flooding.

Topographical Map of Lower Hallmundarhraun

Árni B. Stefánsson
Kambsvegi 10, 104 Reykjavík

Hallmundarhraun is morphologically and speleogenetically one of the most interesting lavas in Iceland. Hallmundarhraun is in the authors opinion at least two different lavas. An older one, probably coming from southern main crater in Jökulkrókur and a younger one around 1200 years old, coming from the northen crater. It totally covers the older lava, except where the lavas meet east of Þrístapafell and in Laski south and south east of Þorvaldsháls. There are other separate lavas in Jökulkrókur south of the southern crater coming from craters covered by Langjökull.

A geomorhological map of the lower two quarters of the lava showing surface features and the underlying caves is presented and discussed.

The History of Lava Cave Preservation in Iceland

Árni B. Stefánsson
Kambsvegi 10, 104 Reykjavík

The author spent several summers as a child helping out at Kalmanstunga in the vicinity og the great caves in Hallmundarhraun in the fifties and sixties. Peoples interest in the caves and that new caves were found was very stimulating. But there was an other side, a black side that was only wispered about. The damage. The dwindling bone heap in Vígishellir in Surtshellir, deliberate breaking and taking of formations from all the caves. This had a deep effect on the author. The relationship became clearer as the years went by. Every find of a new cave had been presented in the newspapers and or the radio. This stimulated interest, interest traffic, traffic damage, intentional as well as unintentional, the well known evil cicle. All caves were easily accessible. By 1982 sensitive formations in all known Icelandic caves had been either severly or totally damaged. The papes describes the steps taken after 1982 in the preservation of lava cave features as seen by the author.

Five Vertical Conduits in Iceland

Árni B. Stefánsson
Kambsvegi 10, 104 Reykjavík

The paper describes five interesting vertical conduits in Iceland. First four are in the Gjábakka / Þjófahraun fissure system. The first three, Tintron, Pyttlur, Vambi are seen by the author as either as pure chimneys or chimneys with some overflow, on an otherwise closed vent / tube cave system. The fourth is a 24m deep very well preserved mineature volcano. A chamber with an inflow tube from below, chimney and a small outflow tube. At last the great pit crater Þríhnúkagígur is presented and discussed.

Complex Tree Mold Labyrinth found in Ken-Marubi Lava Flow in Mt. Fuji

Hiroshi Tachihara, Yumi Kuroishikawa, Tadato Makita, Nobuyoshi Watanabe, Haruko Hinata, Kisara Nakaue, Takanori Ogawa, and Tsutomu Honda
Mt.Fuji Volcano-Speleological Society

At the north-east flank of Mt.Fiji, the tree molds are often found in the lava flow erupted about 1000 years ago. During the field survey for tree mold in this lava flow, a very complex tree mold is found and observed (H. Tachihara,T. Makita,1998).

This tree mold is not a single tree mold, but combined labyrinth like tree molds which consist of 39 tree molds attached one after another and total lenght of the cavity (the maximum diameter is about 1.5m) penetrable by personnel is 204 m by excepting unpenetrable cavity of less than 50cm diameter. The longest tree mold cavity reported in US hitherto was 40.84m (D.G.Davis et al,1983).

The following table 1 shows length/depth and cross section of penetrables in the combined tree molds.

Combined 39 tree molds are, one vertical standing tree mold, fourteen horizontally inclined tree molds, and other unpenetrable twenty four samall tree molds of branches or creepers.

The inner surafece of some tree molds have a remelted layer of lava and lava stalactite are often observed. The remelting of the inner surface of the tree mold seems to be produced by gas burnig with oxygene by chemical reaction of carbon after carbonization of living tree or cellulose with water in the tree(T.Honda,1998). The tree molds located at the bottom area are laid down on a scoria layer and have no remelting surface.

As for details on the origin of the structure of tree mold and vegetation succession stage at the eruption time, extensive studies are still under going together with the historical dating investigation of this lava flow.

At the symposium poster session, the photos and drawings of this combined tree molds will be presented.

References:

H. Tachihara: The press interview document, Mt. Fuji Volcano-Speleological Society, 1998, p.1~3.

T. Makita: "Report on the lava tree mold of important memorial object no.102", The annual meeting of the Speleological

Table 1 (Tachihara et al. "Complex Tree Mold Labyrinth). Depth/length and cross section of combined tree molds.

Tree mold	Depth or Length	Cross section
Tree mold A	675 cm	160x120~140x110cm
Tree mold B	2420cm	360x140~90x90cm
Tree mold D	400cm	70x70cm
Tree mold E	940cm	45x50cm
Tree mold F	886cm	70x70cm
Tree mold G	2835cm	500x120~70x70cm
Tree mold H	160cm	420x120~100x65cm
Tree mold K	2760cm	110x80cm
Tree mold L	1800cm	100x120~90x40cm
Tree mold M	1800cm	70x60cm
Tree mold O	1770cm	150x110cm
Tree mold Q	300cm	70x70cm
Tree mold S	320cm	200x90~74x60cm
Tree mold T	900cm	50x35cm
Tree mold V	500cm	50x50cm

Society of Japan, 1998, July, p.21.

D.G. Davis, R.B. Scoville: "Lost long Lava Labyrinth" NSS news,1983 July, p.196.

T. Honda: "Interpretantion of remelting layer of inner surface of tree mold.", The annual meeting of the Speleological Society of Japan, 1998, July, p.17.

T. Honda: "Physico-chemical explanation for remelting process of inner surface wall of Tainai-tree molds located on the flank of Mt. Fuji". Journal of the Speleological Society of Japan, vol.23, December,1998, p.29-38.

Recent Discoveries on the Laki Flow Field, S. Iceland

Chris Wood[1]* and Ed Waters[2]
[1] School of Conservation Sciences, Bournemouth University, UK
[2] Shepton Mallet Caving Club, Priddy, Somerset, UK
*Corresponding author

Speculative expeditions to the 1783/4 Laki flow field (Skaftáreldahraun) in 2000 and 2001 discovered significant caves in the upper part of the eastern arm of the flow field, known as the upper Eldhraun. In an area of approx. 12 km^2, northeast of Miklafell, approx. 12 km of cave passage were located, explored and mapped. Many of the caves were short, but 4 were over 500 m long, and the longest had a survey traverse length of 1.982 km. The caves had impressive volumes, varying forms and a diversity of internal features. Some had isolated locations in remote parts of the flow field, but others were members of complex cave groups. One group located on the eastern side of the flow field appeared to have an origin related to the formation of a large collapse trench. Another, larger and more complex, group of caves, lay on the western side of the flow field adjacent to the seasonal lake, Laufbalavatn. Here approx. 5.0 km of cave passage underlay and had a close association with a range of surface landforms, including short collapse trenches, lava rises and closed depressions. Accurate mapping of the caves and their relationship with the surface landforms in the study area has provided evidence on which to base an interpretation of the morphogenesis and nature of emplacement of the upper Eldhraun.

A Mega-Tube System in the Hallmundarhraun, W. Iceland

Chris Wood*, Paul Cheetham, and Rob Watts
School of Conservation Sciences,
Bournemouth University, UK
*Corresponding author

Experimental work to track and map lava tube caves remotely from the surface of a lava flow with geophysical methods was undertaken with great success on the Hallmundarhraun flow field in 2001. Using a caesium magnetometer and a survey method known as area survey, it was possible to accurately map the dimensions and route of an entranceless cave passage lying upflow from the terminal lava seal of Stefánshellir. The work proved the presence of 300m of open cave that trends upflow in an easterly direction. The length of cave discovered simply reflects the dimensions of survey block and it is probable that a future survey will be able to map a further length of this passage.

Farther east and extending over a distance of about 18 km upflow from Stefánshellir is a series of crater-like features, each made of a ring of large blocks of lava crust and sitting like a crown at the summit of a low lava shield. Similar features recently observed on Kilauea have been termed 'shatter rings'. The rings extend across the flow field in the manner of a sinuous necklace. Magnetic survey between three revealed that cavities exist beneath and between them. Interestingly, another shatter ring occurs in the lower part of the flow field, overlying the upflow end of Víðgelmir and demonstrating that shatter rings and lava tubes may be genetically related. A working proposal is that the long necklace of rings formed over the master lava tube that fed lava into the Norðlingafljót valley. It is believed that the newly discovered entranceless cave is also a part of this mega-system.

The Volcanic Landforms and Lava Tube Caves of Jeju Island, S. Korea: Candidates for World Heritage Site Status?

Chris Wood
School of Conservation Sciences,
Bournemouth University, UK

This paper will be a report-back on a visit to Jeju Island made by the author in mid-August, 2002. The purpose of the visit was to provide some advice to the S. Koreans on technical aspects of a bid to UNESCO seeking nomination of the lava tube caves and other volcanic landforms as a World Heritage Site. The island has over 100 caves, the three longest ranking 8, 10 and 18 on Bob Gulden's list of the world's longest lava tube caves.