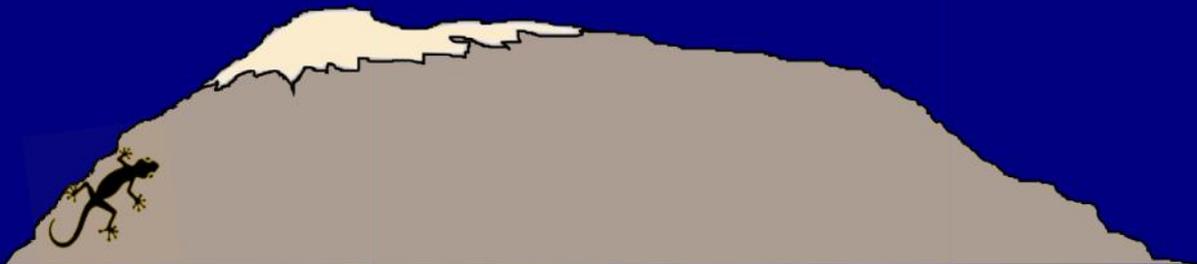


# Expedition report



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## KILIMANJARO CAVING



## Expedition 2011



# Kilimanjaro Caving 2011

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## Expedition Report

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Further copies of this report can be downloaded from our website:

<http://www.speleo.nl/kilimanjaro/>

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In alphabetical order:

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A special word of thanks goes to *Gadiel Majevu*, our professional Mountain Guide who not only guided us and guarded our safety during our stay on Mount Kilimanjaro but also helped us finding, measuring and digging many of the caves mentioned in this report.

*The Dutch Embassy* in Dar es Salaam and especially *Theresia Mcha* who helped us find our way in the sometimes unpredictable Tanzanian bureaucracy.

*Jean Marie Stroobants* for his advice about prices, hotels, transport, etc. .. and organising our safari after we returned from the mountain.

*Kim van der Schuit* for updating our website during our stay on the mountain.

And last but not least all those friends and relatives that had to stay at home. Many thanks for their patience and understanding.

## Participants

The participants on this expedition who actually did research on the mountain are:

*From 19 September 2011 – 6 October 2011:*

**Sjoerd van der Schuit NL** (Expedition leader)

**Arjan van Waardenburg NL** (Logistics and equipment)

**Bert Tindemans NL** (Transport and training)

*During this expedition and several trips of Clive Ward:*

**Gadiel Majevu TZ** (Professional mountain guide)

*During several visits in the period from 1996 -2011:*

**Clive Ward UK** (Advice)

In the past three years there was a substantial list of people from around the world willing to join this expedition. But mainly due to high costs to participate most of them had to withdraw. We made contact with Professor Sospeter Muhongo from the department of geology of the University of Dar es Salaam and asked him to participate in our expedition. Some of his colleagues tried to join us but unfortunately due to the high costs and short notice this also didn't work out. So finding participants was not easy at all. Doubts about physical condition in this exciting but hazardous and strenuous environment might also be a reason.



## Introduction

This report describes the result of the first official speleological expedition on Mount Kilimanjaro in Tanzania ever. The expedition's main goal is surveying and mapping lava tubes on the slopes of Kilimanjaro. Clive Ward has performed several short explorations from 1996 up until 2011 at Mawenzi and found 9 lava tubes that were presented on several occasions in past years<sup>1</sup>.

These explorations gave us the confidence that there should also be lava tubes on the biggest volcano, Kibo. However besides some short reports about shelter like caves we didn't find any documented discoveries of lava tubes at Kibo.

Many non-speleologists have asked us: "why is it important to find those tubes or caves?" The answer is simple. Lava caves are special. Often the biological, geological and even cultural features are very rare and at the same time very vulnerable. These places need protection! But you can only protect if you are aware of their presence. Thus the awareness of these features forms the core of this research.

## Research questions

The main purpose of this expedition is to locate, explore and map lava tubes on Kibo, the main volcano on Mount Kilimanjaro.

Furthermore we wanted to locate and explore other volcanic caves on Kibo and survey them if they are relevant from an environmental or ecological point of view.

## Kilimanjaro

Situated in North Eastern Tanzania, Kilimanjaro is situated about 3 degrees south of the equator on the border of Tanzania and Kenya. The mountain is the highest landmark in Africa and the highest free standing mountain in the world. The mountain actually consists of three volcanoes: Kibo (the youngest and highest), Mawenzi and the eldest Shira.

About one million years ago molten lava burst through the fractured surface of the Rift Valley at the location of Kilimanjaro. The Rift Valley is a giant fault in the earth's crust that runs through East Africa, where the African continent is literally pulling itself apart.

Initially, fast flowing (low viscosity) lavas emerged. This lava formed a very gentle sloping base for Kilimanjaro. As the volcano matured, different, cooler and more viscous lavas emerged. The huge pressures behind this eruption pushed part of the Earth's crust upwards, creating the Shira volcano, the oldest of the volcanoes forming the Kilimanjaro massif. Shira eventually ceased erupting around 500,000 years ago, collapsed and subsequently formed a huge caldera many times the size of its original crater.

Soon after Shira's extinction, Mawenzi started to form following a further eruption within the Shira caldera. Though much eroded, Mawenzi has at least kept some of its volcanic shape to this day.

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<sup>1</sup> International Journal of Speleology; Volume 27 B (1/4); 1998; p 53-55 and Guide to the volcanic caves of Kilimanjaro, Tanzania (report on the lava tubes of Mawenzi); Jim W. Simons and Clive Ward; Nairobi Kenya, June 2011.

Blanco regels weghalen

Then, 460,000 years ago, an enormous eruption just west of Mawenzi caused the formation of Kibo. Continuous subterranean pressure forced Kibo to erupt several times more, forcing the summit ever higher until it reached a maximum height of 5.895m. 100.000 years later another huge eruption from Kibo led to the formation of Kilimanjaro's characteristic shiny black stone, which in reality is just solidified black lava, or obsidian. This spilled over from Kibo's crater into the Shira caldera and around the base of the Mawenzi peak, forming the so-called Saddle. Later eruptions created a series of distinctive mini-cones, or parasitic craters, that run in a chain south-east and north-west across the mountain, as well as the smaller Reusch Crater inside the main Kibo caldera. The last important volcanic activity, just over 200 years ago, left a symmetrical inverted cone of ash in the Reusch Crater, known as the Ash Pit, still visible today.

During the progress of time glaciers, advancing and retreating across the summit, created a series of concentric rings like terraces near the top of Kibo on the western side. The Kibo peak has also subsided slightly over time, and about 100.000 years ago a landslide removed part of the external crater, creating the Barranco Valley. The glaciers also caused the formation of the valleys and canyons, eroding and smoothing the earth into gentle undulations around the mountain, though less so on the northern side where the glaciers never grew to the same extent, leaving the valleys sharper and more defined.

## Lava tubes

Lava flows are streams of molten rock that erupt from a volcano and move slowly downhill. The distance traveled by a lava flow depends on variables such as the erupted volume, steepness of the slope, obstructions in the path of the flow, and the viscosity of the lava.

Lava streams that flow steadily through a confined channel for many hours to days may develop a solid crust or roof and thus change gradually into streams within lava tubes. Because the walls and roofs of such tubes are good thermal insulators, lava flowing through them can remain hot and fluid much longer than surface flows.

Not all basaltic lava flows can form tubes. Mainly there are two types of basalt flows: aa (pronounced "ah-ah") and pahoehoe (pronounced "pah-hoy-hoy"). Aa means in Hawaiian stony rough lava. This type of lava is characterized by a rough or rubbly surface composed of broken lava blocks. The loose, broken, and sharp, spiny surface makes hiking difficult and slow. Lava tubes are seldom found in aa. Aa is usually of higher viscosity than pahoehoe.

Pahoehoe means smooth, unbroken lava in Hawaiian. This type of lava has a smooth, undulating, or roping surface. These features are due to the movement of very fluid lava under a congealing surface crust. A pahoehoe flow typically advances as a series of small lobes that continually break out from a cooled crust. It also forms lava tubes where the minimal heat loss maintains low viscosity. Most tubes are found in Pahoehoe lava.

Within lava tubes one can find various speleothems some of which also can be found in limestone caves: stalactites and stalagmites. The only difference is that these formations are mostly made of lava instead of limestone. Lava stalactites are formed by dripping; stalagmites are similar in shape and are formed on the floor of the tube by the accumulation of drips from the ceiling. Lava tubes may also contain mineral deposits that most commonly take the form of crusts or small crystals, and

less commonly, as stalactites and stalagmites. Lava tubes generally have pahoehoe floors, although this may often be covered in rubble from the ceiling.

## Research methods

### Where to look

Mount Kilimanjaro covers an area of about 60 by 80 square kilometres. The lava from Kibo covers about 2000 square kilometres Figure 1 gives an overview of the geology of Kilimanjaro and the size of the area.

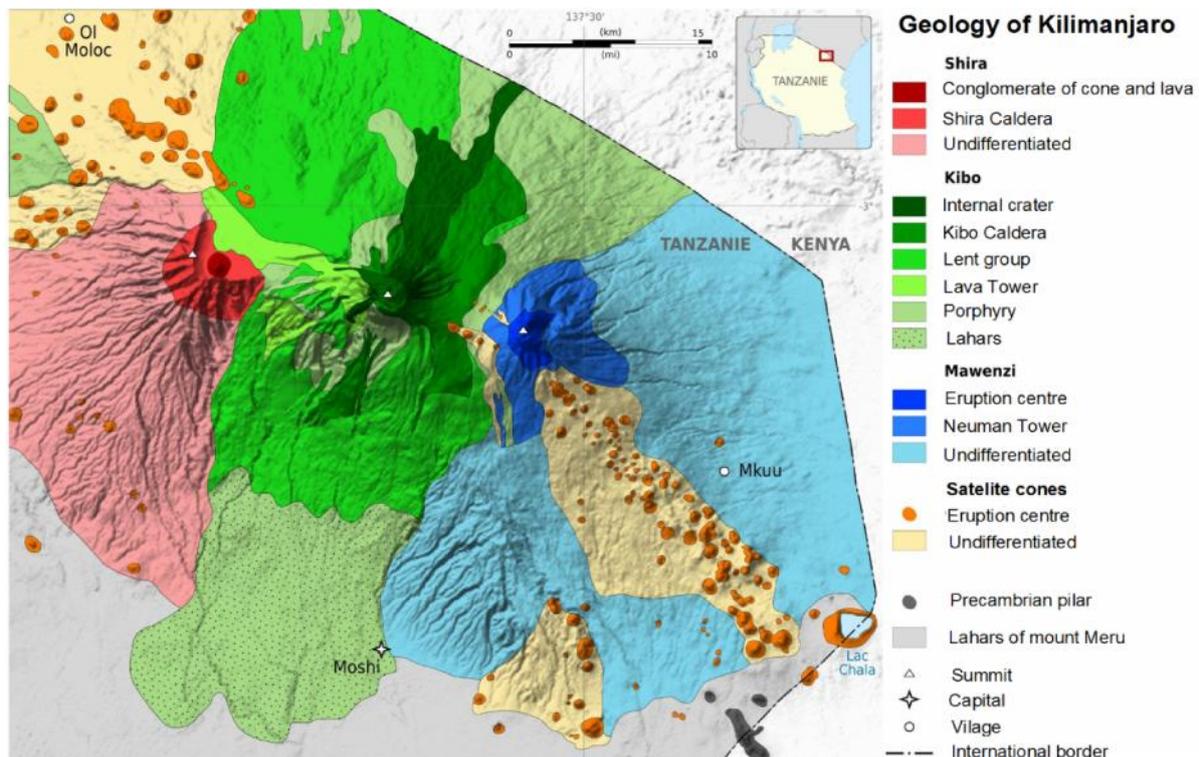


Figure 1 Geological map of Kilimanjaro<sup>2</sup>

Almost all routes to the summit of Kilimanjaro approach from the south or east side of Kibo. Because there weren't any reports of tubes seen on this side our main focus was on the northern side of Kibo. Our second consideration was at what altitude to perform our research. At the lower parts of the slopes you find rainforest and the vegetation diminishes the higher you get. At approximately 3.000 meters you will hardly find any trees and above 4.000 meters most vegetation has disappeared. Struggling our way through forest or dense vegetation is very difficult and therefore we aimed at higher altitudes. But with higher altitudes other problems arise. The air pressure is lower, which means less oxygen, so you will need a good physical condition and time to acclimatize. Mainly due to the presence of a good camp site with water we decided to choose Moir Camp on the Northwest side of Kibo as our base camp and to start our research from there. A research area of about 40 square kilometres was defined at the border of the lava flow around Lent Group and Lava Tower.

<sup>2</sup> Translation of [http://fr.wikipedia.org/wiki/Fichier:Mount\\_Kilimanjaro\\_Geology\\_map-fr.svg](http://fr.wikipedia.org/wiki/Fichier:Mount_Kilimanjaro_Geology_map-fr.svg)

Our group was small and we decided to split up in three groups assisted by one of the porters or by our guide. Mainly armed with binoculars we searched this area for about 10 days. During our stay we heard of caves at the east side of Kilimanjaro near Kibo hut at about 4700 m. Therefore we decided to extend our research for some days to locate and map those caves too.

## General principles

We follow the caving and speleological guidelines of the UIS (International Union of Speleology)<sup>3</sup> in particular the **UIS Mapping Grades** Version 1: 13 Aug 2010 and the **UIS Code of Ethics for Cave Exploration and Science in Foreign Countries** version 2001<sup>4</sup>.

## Infra-red photography

As a small scale side experiment was investigated: the use of IR photography as an instrument for detecting cave entrances. Relatively warm (or cold) air frequently flows out of an entrance. Being able to detect such airflow at a distance, say several hundreds of meters, would be a great help in systematically prospecting large areas. As our planned research site lies above the tree-line, giving an unobstructed view, it seems a good venue for a quick try-out.

However, there are also a few problems to overcome. First of all air will not show up on the picture because it radiates a very low amount of energy that will be lost in the background radiation. Therefore an indirect measurement is necessary: the airflow will heat or cool the surrounding rock, which makes a much better radiator.

Another problem is that the radiation measured consists of four components: reflection, radiation, absorption and emission. All objects will reflect part of the IR radiation from other objects, most notably the sun, which will give false readings. This was avoided by experimenting at night. On its way from the rock to the camera, part of the IR-radiation will be absorbed by the air it travels through; also that air will emit some radiation itself. These absorption and emission effects are stronger if the air is moist, and act like fog in visible light. As the photo of Mount Kilimanjaro, taken from a distance of 7,1 km, shows, these effects are negligible on clear nights. By the way: this is presumably the first IR-picture of Kilimanjaro ever.

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<sup>3</sup> <http://www.uis-speleo.org/guides.html>

<sup>4</sup> UIS Mapping grades version 1: 13 August 2010

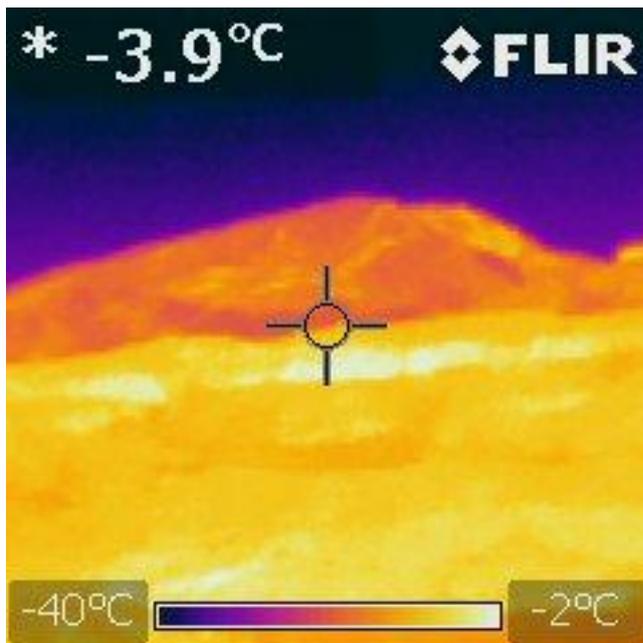


Figure 2 IR picture of Kilimanjaro

As can also be seen, resolution of the IR photos is much less than of the visible light photos. In fact it is insufficient to do analysis on IR photos taken from a useful distance. Thermal resolution of the camera used (100mK) is quite sufficient to obtain a useful image, spatial resolution (3,7mrad) should be two orders of magnitude better. Also a method to distinguish between rock heated or cooled by other sources than air would be very useful.

As we did not find (by conventional prospection) any cave that breathed, those where not experimented on and no final conclusions can be drawn. Furthermore the caves we saw on the IR pictures could also easily been seen at daylight (see figure 3 of Moir Cave). So for us the use of IR pictures proved to be of less importance.



Figure 3 IR picture compared to daylight of Moir Cave (KS 010)

## Results

### General

During the first two days we examined the northern parts of our research area Northwest of the Lent group. This area is mainly covered with porphyry lava and proved to be of less importance at this altitude. We found some remains of lava tubes and at the riffs of the mountain the erosion has formed many shelter like caves in the weaker layers. Furthermore we could see that great parts of this area have been covered with glaciers. Moir camp itself for instance lies in between two moraines. The slowly descending ice mass eroded many of the tubes in the higher parts of Kibo, and many caves are clearly eroded by ice and weather. We therefore decided to extend our research area a bit more to the south to the area mostly covered by the lava from Lava Tower (see figure 1).



Figure 4 Moraine at Moir Camp

The caves are often used by animals for shelter and due to the more stable temperature in the caves you can find vegetation near the entrance that wouldn't survive in the hard and rough climate outside these caves.



Figure 5 Vegetation near cave entrance

## Techniques

For this expedition we used professional equipment:

- Suunto Clinometer PM-5/ 360PC
- Suunto Compas KB-14/360R
- Measuring tape synthetic 30 meter

And to calibrate the compasses we made a compass base at Moir Camp. The angle between magnetic north (mN) and geographic north (gN) we found is  $+2^\circ$ . The declination is positive when the magnetic north is east of geographic north. This gives our maps the maximum expected accuracy of 2% or grade 5 in accordance with the UIS mapping grades.

To calculate the length and depth of the cave we used the result given us by the program On Station 3.0a. This software application is designed and distributed as shareware by Taco van Ieperen<sup>5</sup>.

For the infrared pictures we used a FLIR i7.

---

<sup>5</sup> Freeware mapping program by Taco van Ieperen (Canada) that isn't supported anymore.

## Secondary caves: shelters

At 4.200 meter the temperature varies between -5°C and 20°C almost daily. The influence of freezing and melting ice can clearly be seen at the many faults and ridges at the mountain. At those places we found many secondary caves, merely shelters that differ in size from less than a meter to sometimes 60 meters or more. We only took the coordinates of the ones larger than 10 meters.

We found 19 shelters that comply with these figures and listed them in supplement A.

Most people don't know that some of these shelters are used by buffalos to eat the soda salt (sodium bicarbonate) in the rock. The soda salt helps to prevent stomach problems and is mainly used for this purpose by farmers as food supplement for their cattle.

It is often the case that buffalo tracks on mount Kilimanjaro indicate the trail to one of these buffalo caves. These caves can be found at altitudes of up till 4.500 meters. One of the shelters (KS 015) at 4.086 meter we named Buffalo cave for this reason.



Figure 6 Buffalo cave KS 015

Furthermore we made a topographical map of the shelter at the northern moraine near Moir Camp. We called this cave Moir Cave (KS 010).

# Kilimanjaro Caving

## Moir Cave (KS 010)

*UISV1 4-3-BC*

Lenght: 88 m

Altitude: 4184 m

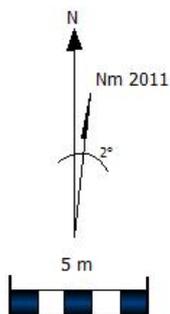
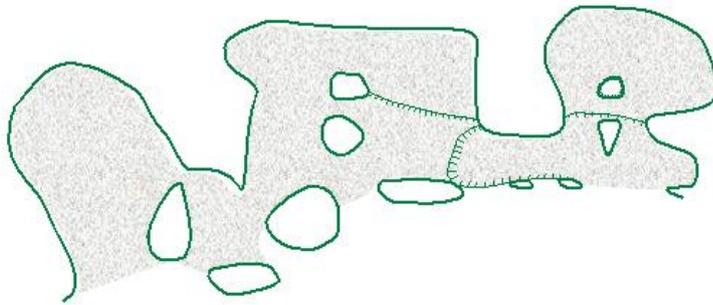
S 03° 02.322 E 037° 17.931

*Discovered: 25 Sept 2011*

*By: Sjoerd van der Schuit*

*Bert Tindemans*

*Arjan van Waardenburg*



## Buffalo Cave (KS 015)

*UISV1 3-3-A*

Lenght: 50 m

Altitude: 4086 m

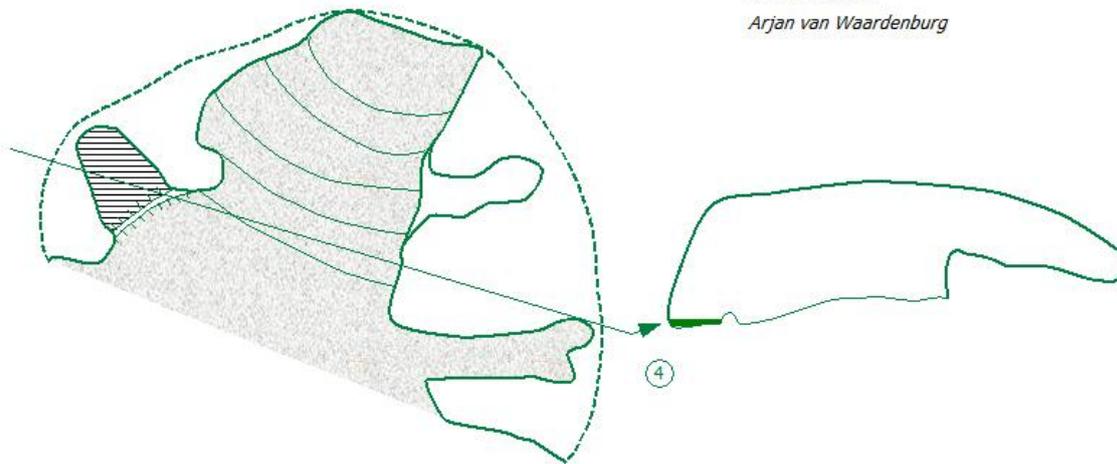
S 03° 03.858 E 037° 17.546

*Discovered: 27 Sept 2011*

*By: Sjoerd van der Schuit*

*Bert Tindemans*

*Arjan van Waardenburg*



## Primary Caves: blisters

Our main goals are the caves. One type of primary lava cave is the blister. This is a surface swelling of a lava flow crust in response to the puffing up of gas or vapour from beneath the flow. Blisters may also form through hydrostatic or artesian forces within the lava. They are usually 1–150 meters in diameter, with a maximum height of 30 m.

At Kibo we found many blisters some very small and some as big as 11 meters wide and 2,5 meters high (KB 019). We also found many blisters that have been eroded over the years. We decided to skip those narrower than 5 meters and the ones with less than 50% roof cover. We recorded 19 lava blisters and listed them in supplement A. Interesting to mention is that the Shira cave that is on many touristic maps and has been used for overnight stay by many climbers during the last decades, actually is a lava blister in Kibo lava.



Figure 7 Blisters: Clockwise KB 008, KB 001, KB 019, KB 009

## Primary Caves: Lava tubes

Back to the main purpose of our expedition: lava tubes. Harter has defined tubes on their stratification patterns. Although some scientists don't agree on the process that Harter describes how these tubes have been formed; the classification is useful and adequate for our purpose.<sup>6</sup>

Harter defines:

### A: Surface Tube

There are two strata: a flat floor stratum which extends well to both sides of the tube, and a roof stratum that forms an arch.

### B : True Trench Tube

The walls join the floor at right angles and curve to overhang the passage. The roof is a separate stratum and there is a single wall stratum

### C: Semitrench Tube

The wall consists of the edges of lamina. The roof is separate stratum.

### D: Rift Cave Tube

Rift caves form in volcanic rifts. The structural walls are the side of the fracture.

### E: Interior Tube

The theoretical interior tube would lie entirely within a single stratum of lava.

And to complete these classification Harter writes that "since the classification system is derived from theory, examples of the pure types are relatively rare."

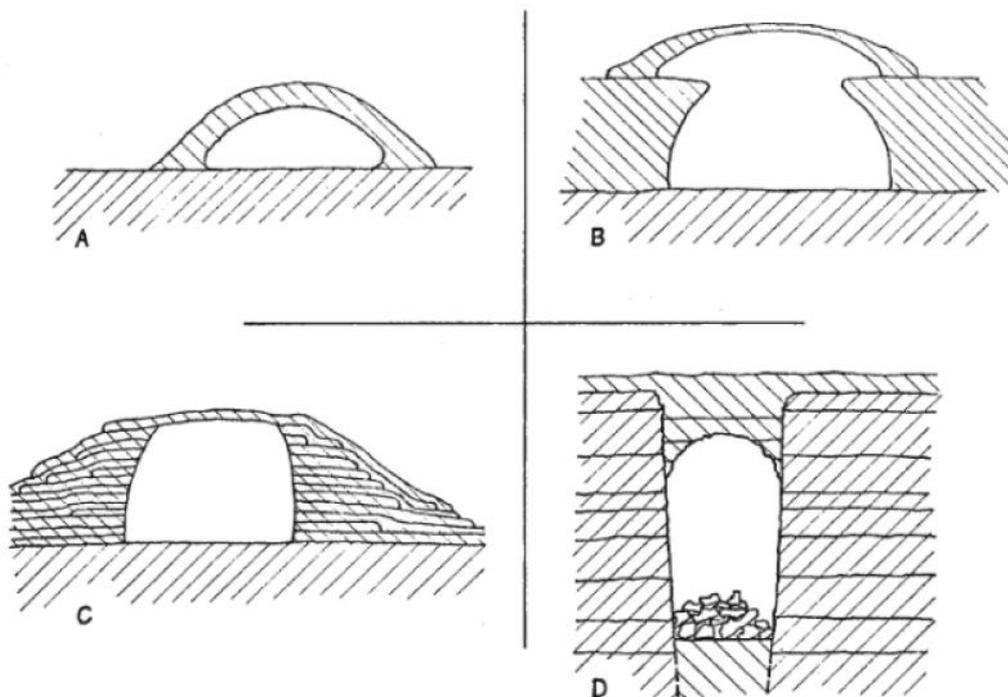


Figure 8 Classification of lava tubes by Harter

<sup>6</sup> Morphological Classification of lava tubes, J.W.Harter; International Symposium on Vulcanospeleology; Washington, August 1972

The thickness of the roof stratum of surface tubes varies from a few centimetres up to half a meter. Trench roofs and rift roofs tend to be thicker than those of surface tubes.

The tubes that Clive Ward found on Mawenzi are of the type “surface tube” and most of the tubes we found on Kibo are of the same type. Without any exception they are formed in pahoehoe lava and the structure of the terrain with many basalt lobes support this classification.

We have found three more complex caves near Kibo Hut that puzzle us. The roof consists of many lamina and big pieces of strata have broken and fallen down. The entrance of KT 016 for instance is pretty unstable due to this phenomena. But no doubt these are primary caves. We classified them as Trench Tubes most likely of the Semitrench type. The main reason for this classification are the many lamina and the internal shape of the cave. A plausible assumption is that these three caves were formed in a later development stage of Kibo. Near Moir Camp the tubes were most likely formed at the initial stage of the forming of Kibo and the lobes where we found the tubes are of pahoehoe lava. The fact that many tubes are eroded due to the rough conditions and the moraine during the last 500.000 years leads to this assumption. Near Kibo hut the lava higher on the mountain is of a different composition, more porphyry like, and possible formed at a later stage. This assumption is supported by the more instable formation of the tubes at this side of the volcano.

Except for the more or less completely eroded tubes we made topographical maps you can find in this report.

### ***Kibo Tube 001***

This is an exit of a surface tube at 3.955 meter. It lies in the valley where a glacier has destroyed many tubes on the higher parts. But this nice tube survived the elements. Its length is 5,5 meters and at the end even some mosses survive. Outside you can see some remains of the original length of the tube.



**Figure 9 KT 001**

### ***Kibo Tube 002, 003, 004, 005 and 009***

These are remains of former surface tubes. They are almost completely eroded or destroyed by the glacier and the tough environmental conditions. Only 1 to 2 meter is left with a roof on top. Outside you can sometimes see a nice track of the original tube. KT 002 for instance has a track of almost 19 meters where you can see both side of the original tube. We merely added these tubes to be complete in our inventory.

### ***Kibo Tube 006***

KT 006 lies at 4.313 meter. The tube makes a right angle to the left after 3 meter. Its floor is covered with mosses, sand and mud. At the end the roof meets the floor.



Figure 10 KT 006

### ***Kibo Tube 007***

This tube at 4.320 meter actually consists of two tubes close together. Outside you can follow the track along the wall for more than 18 meters. The inside length of the tubes is about 4 meters but the left tube with its height of approximately 30 cm is only accessible for the small ones.



Figure 11 KT007

### ***Kibo Tube 008***

KT 008 is a nice surface exit situated at the side of a big lava lobe at 4.489 meter. At the end the tube is closed by a boulder choke. Outside you can see a track of about 4 meters.



Figure 12 KT 008

### ***Kibo Tube 010***

Kibo Tube 010 has a man's height exit quite close to the Shira trail at 4.381 meters. The floor of KT 010 is flat with some rocks. Its shape is not as symmetrical as most surface tubes we found so far, but the top stratum is an evident clue for its classification.



Figure 13 The expedition team in front of KT 010

### *Kibo Tube 011*

KT 011 at 4.598 meters is the highest known surface tube in the world and with its length of 17 meters it is the longest one we have found. At the end of the tube we found some siliceous stalactites of about 4 cm . Halfway there is a step of 25 cm .



Figure 14 At 4598 meters KT 011

### *Kibo Tube 012*

Most tubes we found are exits but KT 012 is man's height entrance of a surface tube at 4.222 meters. Almost until the end it keeps its height. It has a flat stony floor, and lies in a basalt lobe where we also found KT 013 and KT 014.



Figure 15 Gadiel in KT 012

### *Kibo Tube 013*

This surface tube is one of the bigger ones we found. After 7 meters the tube is blocked with a sand dune up to the roof and needs further exploration. The tube is situated quite near the Shira trail and had some litter in the entrance, which we removed.

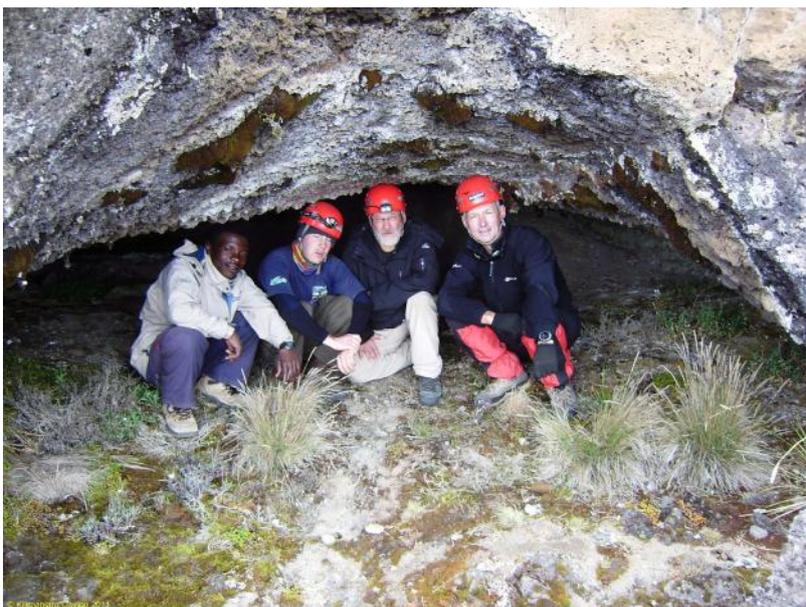
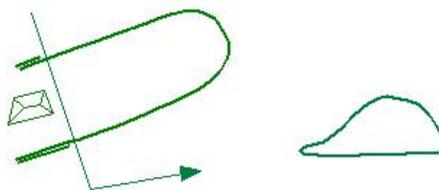


Figure 16 The expedition team inside KT 013

# Kilimanjaro Caving

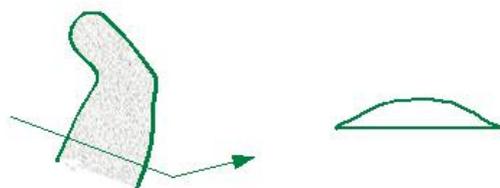
## KT 001

Lenght: 5,5 m  
 Altitude: 3955 m  
 S 03° 02.581 E 037° 16.830



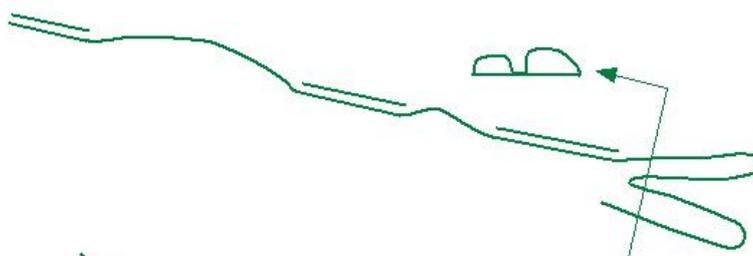
## KT 006

Lenght: 6,9 m  
 Altitude: 4313 m  
 S 03° 02.559 E 037° 18.504



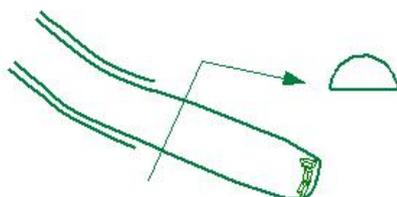
## KT 007

Lenght: 7,9 m  
 Altitude: 4320 m  
 S 03° 02.450 E 037° 18.475



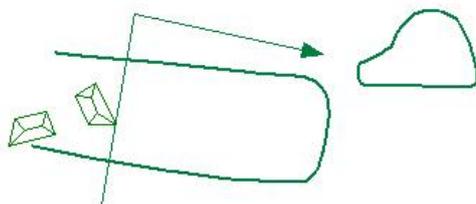
## KT 008

Lenght: 5,1 m  
 Altitude: 4489 m  
 S 03° 03.427 E 037° 19.028

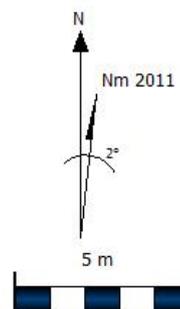


## KT 010

Lenght: 8 m  
 Altitude: 4381 m  
 S 03° 02.209 E 037° 18.306



*UISV1 4-2-A*  
 Discovered: 22 - 27 Sept 2011  
 By: Sjoerd van der Schuit  
 Bert Tindemans  
 Arjan van Waardenburg



### ***Kibo Tube 014***

KT 014 at 4.232 meters has two parallel tubes filled with sand. After about 5 meters the tube was not accessible without digging. Altogether the three tubes we found here makes this basalt lobe flow very interesting and asks for closer exploration.



**Figure 17** The parallel tubes of KT 014

### ***Kibo Tube 015***

This tube at 4.480 meters is special in some ways. First of all, it's positioned in the middle and not at the side or top of the lava flow where most surface tubes were found. Secondly, it is formed almost entirely out of one stratum and therefore we classified it as an internal tube. After 4 meters it makes a 45° angle to the left. The floor is flat and stony.



**Figure 18** Gadiel in the entrance of KT 015

### ***Kibo Tube 016***

Kibo Tubes 016, 017 and 018 are found at the eastern side of Kibo near Kibo hut and are the highest tubes known so far. KT 016 is the highest tube and lies at an altitude of 4.763 meters. The total length is about 50 meters. The entrance is a little instable due to loosely stratum at the ceiling of the cave. Inside, many rocks that have fallen from the ceiling of the cave. Some silver mould is found at the roofs and walls of this cave. The instable construction of this cave prevented us from further exploration. No doubt these are primary tubes but to classify them by Harter was difficult. Due to the many stratums and shape of the cave we classified these tube as trench tubes.



**Figure 19 Bert at the entrance of KT 016**

### ***Kibo Tube 017***

KT 017 at 4.686 meters is another trench tube. Unlike KT 016 this tube is more stable and the entrance is filled with sand. The total length is about 40 meters. Inside we removed some sand to enter a side tube that didn't continued. The left tube is quite big and you can easily stand upright.

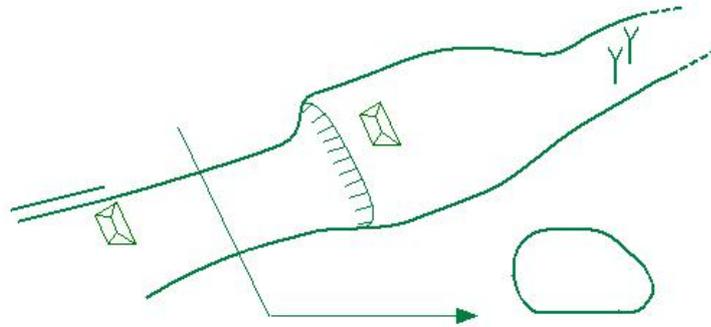


**Figure 20 Gadiel digging his way to a side tube in KT 017**

# Kilimanjaro Caving

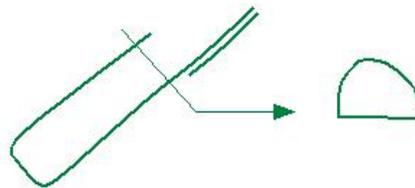
## KT 011

Lenght: 17 m  
 Altitude: 4598 m  
 S 03° 02.992 E 037° 19.193



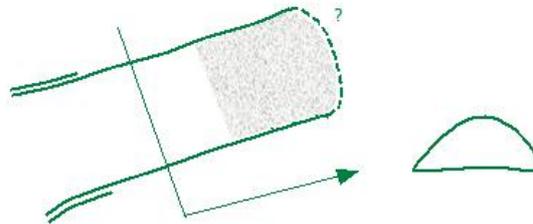
## KT 012

Lenght: 5 m  
 Altitude: 4222 m  
 S 03° 03.804 E 037° 17.979



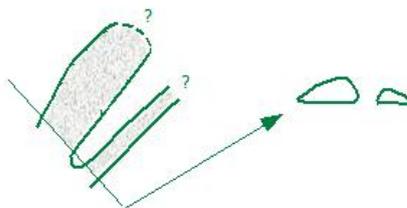
## KT 013

Lenght: 7 m  
 Altitude: 4231 m  
 S 03° 03.892 E 037° 17.965



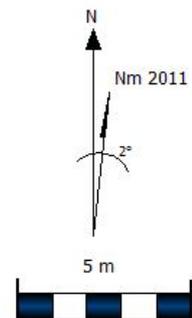
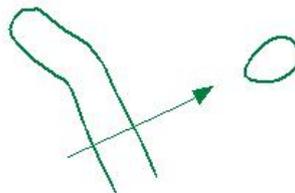
## KT 014

Lenght: 5 m  
 Altitude: 3232 m  
 S 03° 03.849 E 037° 17.962



## KT 015

Lenght: 6 m  
 Altitude: 4480 m  
 S 03° 03.405 E 037° 19.002



UISv1 4-2-A  
 Discovered: 22 - 27 Sept 2011  
 By: Sjoerd van der Schuit  
 Bert Tindemans  
 Arjan van Waardenburg

### *Kibo Tube 018*

This trench tube has an entrance and mainly consists of a chamber of 15 by 8 meters with a partly ice-covered floor, which even has a nice ice stalagmite in the middle of it.

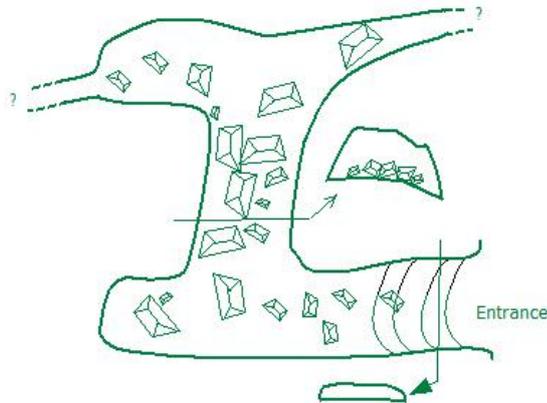


Figure 21 Samuel pointing at the ice stalagmite in KT 018

# Kilimanjaro Caving

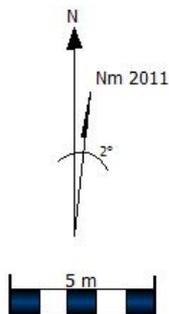
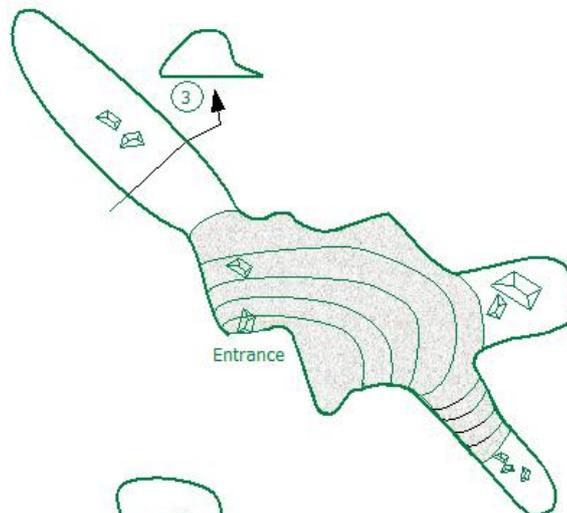
## KT 016

UISV1 3-3-A  
 Length: 50 m  
 Altitude: 4763 m  
 S 03° 05.156 E 037° 23.290  
 Discovered: 3 Oct 2011  
 By: Sjoerd van der Schuit  
 Bert Tindemans  
 Arjan van Waardenburg



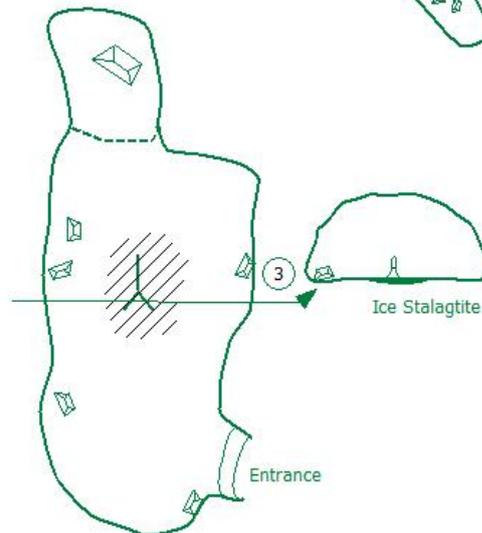
## KT 017

UISV1 5-3-BC  
 Length: 40 m  
 Altitude: 4686 m  
 S 03° 05.600 E 037° 23.347  
 Discovered: 4 Oct 2011  
 By: Sjoerd van der Schuit  
 Bert Tindemans  
 Arjan van Waardenburg



## KT 018

UISV1 2-3-A  
 Length: 30 m  
 Altitude: 4728 m  
 S 03° 05.444 E 037° 23.298  
 Discovered: 4 Oct 2011  
 By: Sjoerd van der Schuit  
 Bert Tindemans  
 Arjan van Waardenburg



### *Mawenzi Tube M*

On our way down the slopes of Mawenzi we visited two tubes that Clive Ward had pointed out. We continued the numbering of tubes that Clive had started. We found the entrance and exit of Tube M at 4.378 meters but weren't able to go through all the way. At the top the tube is more than a meter wide but after 19 meters the tube is too small to pass. However, outside we found the exit in line with this tube, so we have no doubt that both sections are part of the same tube.



Figure 22 Arjan at the top entrance of Tube M and GPS at the exit downhill.

### *Mawenzi Tube N*

The last tube we found on the slopes of Mawenzi is Tube N at 4.391 meters. This tube has a length of 50 meters and is relatively big compared to the other tubes we found. The roof is decorated with many primary stalactites.

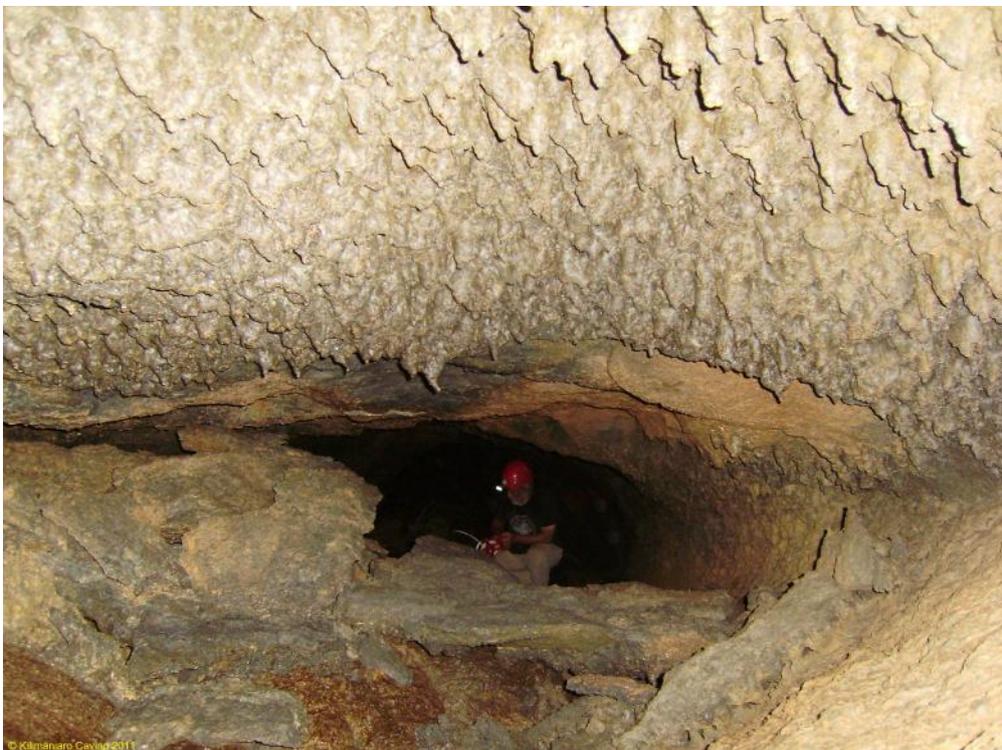


Figure 23 Arjan measuring in Tube N

# Kilimanjaro Caving

## Mawenzi Tube N

*UISv1 3-2-A*

Lenght: 50 m

Altitude: 4323 m

S 03° 06.407 E 037° 26.380

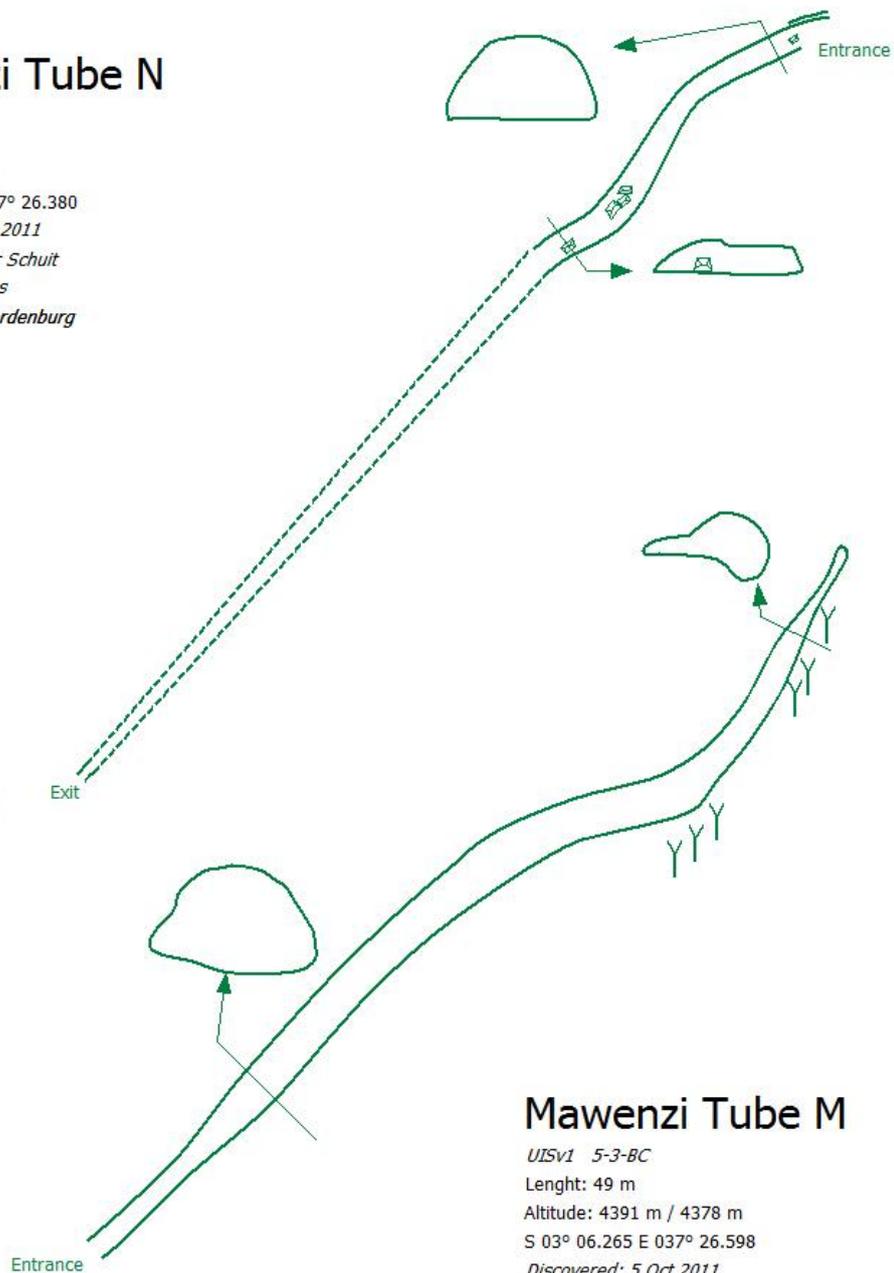
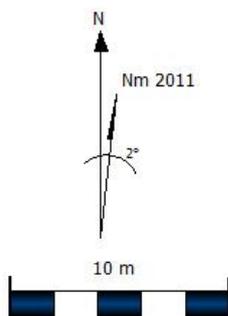
*Discovered: 5 Oct 2011*

*By: Sjoerd van der Schuit*

*Bert Tindemans*

*Arjan van Waardenburg*

*Clive Ward*



## Mawenzi Tube M

*UISv1 5-3-BC*

Lenght: 49 m

Altitude: 4391 m / 4378 m

S 03° 06.265 E 037° 26.598

*Discovered: 5 Oct 2011*

*By: Sjoerd van der Schuit*

*Bert Tindemans*

*Arjan van Waardenburg*

*Clive Ward*

## Volcanic cave features

Sometimes you can also find small secondary translucent stalactites in the blisters and tubes; we found some white rose samples. These stalactites are formed by a mineral which dissolves in water and are very fragile. In limestone caves these stalactites are very common and formed by calcium carbonate, but in this volcanic environment these stalactites are most likely siliceous.

Rheotites can also be found in many places. These are lava drips that remain from the initial separation of the roof crust from liquid lava below. As such drips can be expected any time that solid lava (above) separates from the liquid lava, they are conceptually the commonest form of rheotites<sup>7</sup>.

Unfortunately Clive Ward noticed that at Mawenzi some of the features in the recently discovered caves have been destroyed by visiting tourists or locals. This very special and fragile environment deserves protection. We estimate that there are more than 100 tubes at Kilimanjaro that deserve protection.

Guided tours are sometimes possible if the guide is trained for this fragile environment and if the most crucial parts of the cave are well protected.



Figure 24 Rheotites and stalactites in KT 011

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<sup>7</sup> Morphological Classification of lava tubes, J.W.Harter; International Symposium on Vulcanospeleology; Washington, August 1972



## Conclusions

The conclusions of our research questions are as follows:

The first, and maybe, most important question was: “Are there any tubes or caves in Kibo lava?” We can definitely answer this question affirmative (see figure 25) . We have covered roughly about 5% of the higher slopes of Kibo, the major volcano of Kilimanjaro, and found 20 tubes of different types, 19 lava blisters with a width of more than 5 meters and more than 50% covered with roof and 19 shelters with a width of more than 10 meters and a depth of more than 5 meters. This convinced us that there are many more lava caves to be found on the slopes of Kibo.

The tubes we found on the western side of the volcano differ from the three caves near Kibo Hut at east site of Kibo. The lava is different: where near Moir Camp the tubes are found in pahoehoe lobes, the trench tubes near Kibo Hut are formed in lava of a different composition, more porphyry like. This feeds the assumption that the tubes at the east side might be younger.

Unfortunately at Mawenzi some of the features in the discovered caves have been destroyed by visiting tourists or locals. This very special and fragile environment deserves protection. Guided visits are possible at some caves but at the same time the regulation to enter caves should be changed. When entering the park you can read that “sleeping in caves has been abolished ...”. We strongly advise to change this rule in “Entering caves is strictly forbidden”.

Caves can only be protected if one is aware of their presence. We therefore advise the management of TANAPA (Tanzanian National Park ), TAWIRI (Tanzanian Wildlife Research Institute) and COSTECH (Tanzania Commission for Science and Technology) to allow a follow up to this first expedition.

## Postface

For three years I have prepared this expedition. The biggest struggle was to find our way in the sometimes unpredictable Tanzanian bureaucracy. Over 40.000 people visit Mount Kilimanjaro every year and I absolutely understand the dependence of the local and national economy on this very special mountain. However official requests to support this expedition and wave the fees were not rewarded. I truly hope that further speleological research on mount Kilimanjaro gets priority so that our research will be continued.

Sjoerd van der Schuit

Expedition leader

## Supplement A: List of found caves

<b>Kibo Shelters</b>							
Name	discovered	S-grid	E-grid	Altitude	Depth	Height	Width
KS 001	22-sep-11	03° 02,936	037° 17,590	4184 m	5 m	2 m	10 m
KS 002	23-sep-11	03° 02,514	037° 17,456	4086 m	5 m	2 m	14 m
KS 003	24-sep-11	03° 02,100	037° 19,116	4521 m	10 m	10 m	10 m
KS 004	25-sep-11	03° 02,320	037° 17,942	4194 m	5 m	1,3 m	60 m
KS 005	25-sep-11	03° 02,316	037° 17,953	4195 m	5 m	4,5 m	18 m
KS 006	25-sep-11	03° 02,313	037° 17,983	4203 m	7 m	6 m	25 m
KS 007	25-sep-11	03° 02,315	037° 18,005	4205 m	6 m	4,5 m	30 m
KS 008	25-sep-11	03° 02,317	037° 18,020	4205 m	5 m	3 m	15 m
KS 009	25-sep-11	03° 02,306	037° 18,045	4217 m	5 m	2,5 m	14 m
KS 010	25-sep-11	03° 02,322	037° 17,931	4184 m	10 m	3,1 m	88 m
KS 011	25-sep-11	03° 02,680	037° 18,299	4270 m	5 m	3,5 m	18 m
KS 012	25-sep-11	03° 02,771	037° 18,295	4312 m	7 m	1,5 m	35 m
KS 013	25-sep-11	03° 02,697	037° 18,366	4315 m	5 m	3 m	17 m
KS 014	25-sep-11	03° 02,562	037° 18,510	4330 m	6 m	5,5 m	14 m
KS 015	27-sep-11	03° 03,858	037° 17,546	4086 m	12 m	4 m	16 m
KS 016	27-sep-11	03° 03,202	037° 17,729	4218 m	5 m	1,4 m	12 m
KS 017	27-sep-11	03° 03,168	037° 18,217	4339 m	5 m	1,7 m	11 m
KS 018	27-sep-11	03° 03,157	037° 18,600	4440 m	7 m	1,2 m	15 m
KS 019	27-sep-11	03° 02,829	037° 19,296	4611 m	6 m	1 m	2 m
<b>Kibo Blisters</b>							
Name	discovered	S-grid	E-grid	Altitude	Height	Width	%
KB 001	23-sep-11	03° 01,883	037° 15,444	3639 m	1,5 m	10 m	50%
KB 002	23-sep-11	03° 01,927	037° 17,010	3961 m	3 m	6 m	50%
KB 003	23-sep-11	03° 02,585	037° 16,859	3968 m	2,5 m	5 m	50%
KB 004	23-sep-11	03° 02,556	037° 16,871	3973 m	3 m	10 m	70%
KB 005	23-sep-11	03° 01,967	037° 17,103	3985 m	2 m	6 m	60%
KB 006	23-sep-11	03° 01,920	037° 17,621	4113 m	4 m	8 m	75%
KB 007	23-sep-11	03° 01,846	037° 17,729	4157 m	3 m	8 m	50%
KB 008	25-sep-11	03° 02,329	037° 17,896	4179 m	1,7 m	12 m	50%
KB 009	25-sep-11	03° 02,705	037° 18,254	4253 m	1,3 m	52 m	50%
KB 010	25-sep-11	03° 02,679	037° 18,287	4262 m	1,2 m	5,5 m	70%
KB 011	25-sep-11	03° 02,637	037° 18,471	4292 m	1,8 m	8,5 m	70%
KB 012	25-sep-11	03° 02,789	037° 18,291	4310 m	1,5 m	5,6 m	80%
KB 013	25-sep-11	03° 03,157	037° 18,198	4338 m	2 m	6 m	75%
KB 014	25-sep-11	03° 03,164	037° 18,808	4343 m	1,5 m	5 m	50%
KB 015	25-sep-11	03° 02,713	037° 18,477	4345 m	2 m	6,5 m	90%
KB 016	26-sep-11	03° 03,159	037° 19,278	4596 m	2 m	8 m	60%
KB 017	27-sep-11	03° 03,881	037° 17,529	4069 m	2,5 m	11 m	50%
KB 018	27-sep-11	03° 03,126	037° 17,816	4236 m	0,8 m	25 m	50%
KB 019	27-sep-11	03° 03,162	037° 18,206	4335 m	1,3 m	4 m	80%

## Supplement B: List of found Tubes

<b>KIBO TUBES</b>						
<b>Name</b>	<b>Type</b>	<b>discovered</b>	<b>S-grid</b>	<b>E-grid</b>	<b>Altitude</b>	<b>Length</b>
KT 001	Surface	22-sep-11	03° 02,581	037° 16,830	3955 m	6 m
KT 002	Surface	23-sep-11	03° 01,947	037° 17,242	4020 m	1 m
KT 003	Surface	25-sep-11	03° 02,501	037° 18,174	4206 m	1 m
KT 004	Surface	25-sep-11	03° 02,686	037° 18,286	4262 m	3 m
KT 005	Surface	25-sep-11	03° 02,492	037° 18,386	4280 m	2 m
KT 006	Surface	25-sep-11	03° 02,559	037° 18,504	4313 m	7 m
KT 007	Surface	25-sep-11	03° 02,450	037° 18,475	4320 m	4 m
KT 008	Surface	25-sep-11	03° 03,427	037° 19,028	4489 m	5 m
KT 009	Surface	27-sep-11	03° 03,104	037° 17,829	4234 m	2 m
KT 010	Surface	27-sep-11	03° 03,209	037° 18,306	4381 m	8 m
KT 011	Surface	27-sep-11	03° 02,992	037° 19,193	4598 m	17 m
KT 012	Surface	28-sep-11	03° 03,804	037° 17,979	4222 m	5 m
KT 013	Surface	28-sep-11	03° 03,892	037° 17,965	4231 m	7 m
KT 014	Surface	28-sep-11	03° 03,849	037° 17,962	4232 m	5 m
KT 015	Internal	28-sep-11	03° 03,405	037° 19,002	4480 m	6 m
KT 016	Trench	3-okt-11	03° 05,156	037° 23,290	4763 m	50 m
KT 017	Trench	4-okt-11	03° 05,600	037° 23,347	4686 m	40 m
KT 018	Trench	4-okt-11	03° 05,444	037° 23,298	4728 m	30 m
<b>MAWENZI TUBES</b>						
Tube M	Surface	5-okt-11	03° 06,265	037° 26,598	4391 m	49 m
Tube M (1)	Surface	5-okt-11	03° 06,285	037° 26,577	4378 m	49 m
Tube N	Surface	5-okt-11	03° 06,407	037° 26,380	4323 m	50 m