

2010

MULU CAVES 2010



expedition report

An Anglo-Malaysian Expedition to the
Gunung Mulu National Park, Sarawak



REPORT
on the findings of
THE MULU CAVES 2010
EXPEDITION
to the
SOUTHERN HILLS AREA
of the
GUNUNG MULU
NATIONAL PARK
SARAWAK

Between 1st and 26th May 2010

Edited by Matt Kirby FRGS.



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Water spout in Racer Cave

Photo: Robbie Shone

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ABSTRACT

Between 1st and 26th of May 2010 a team of seven British cavers, with the close support of National Park staff and a representative of the Sarawak Forestry Corporation, set up a base camp at Park headquarters. The expedition had three major objectives, Surveying, Science and Photography. Although exploration was low on the agenda, as with all Mulu expeditions 'caves are where you find them'.

Surveying

The caves of the Southern Hills were explored between 1978 and 1984. During that time some of the most impressive caves in the world were surveyed and documented. However, apart from a small scale area map, there was little else to position them geographically. With the advent of the survex dataset and its need for global coordinates some means of precisely fixing the position their entrances was required. GPS fixes were notoriously difficult to obtain under the forest canopy so surface traverses were seen to be the only answer. During the expedition 14.6 km of surface surveying was carried out which has allowed all the caves in the Southern Hills to be linked together and included in survex master dataset. This also provided altitude information which can be used in the scientific programme.

Science

Since the last expedition visited the Southern Hills in 1984 a great deal of scientific dating work had been carried out in the main blocks of Api and Benarat. This expedition provided the opportunity to sample caves in the Southern Hills in order to include this block in the ongoing study. Samples of sediments, quartz and speleothems were collected for analysis by various modern techniques. In addition, a review of the morphology of the area added to the understanding of the development of Mulu's Caves.

Photography

Although some of the caves in this block were well documented they had not been visited by an expedition for many years and the only photographic records had been made using film. The major caves in the vicinity of Park headquarters were visited to gain modern digital photographs using high quality camera equipment. These included Deer, Racer, Green and Stone Horse caves. In addition to this, record shots were made of the various new discoveries and the storey of the expedition.

Exploration

As with all Mulu expeditions new discoveries are almost inevitable, especially when searching through unexplored areas of limestone. Twelve previously undocumented entrances were located and extensions were made in Paris Cave yielding a total of 2.4km of surveyed cave.



Leaf

Photo: Hugh St Lawrence

INTRODUCTION

LOCATION

The Gunung Mulu National Park is situated in north-eastern Sarawak, with its northern boundary forming part of the border with Brunei, (Figs. 1 & 2). It was officially constituted in 1974 and opened to visitors in 1985. Lying 4° N. of the equator it covers an area of 528sq km.

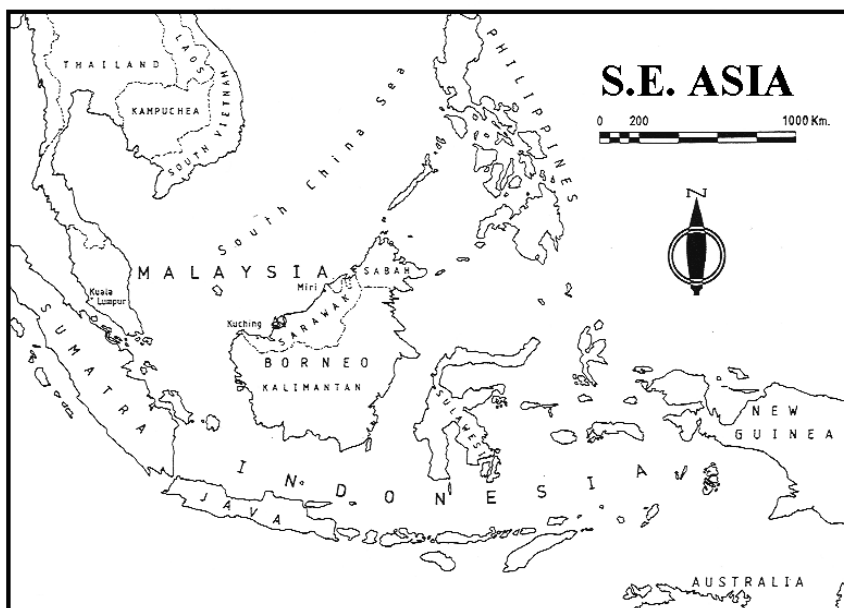


Figure 1: SE Asia

The Park is dominated by the sandstone mass of Gunung Mulu, which rises to 2376m. To the west of Mulu, and on its flank, lies a band of 'Melinau' limestone, which forms the lesser peaks of Gunung Api and Gunung Benarat. The lower slopes are covered in dense tropical rainforest, which rises to meet the montane forest of Mulu's upper slopes. Mulu is a rich mixture of plant and wildlife and in the limestones, beneath the forest canopy, lie some of the world's most impressive caves.

HISTORY of EXPLORATION in MULU

The existence of large caves in the Gunung Mulu area of Northern Sarawak has been documented for over 150 years. In 1858 reference was made to "Detached masses of limestone, much water-worn, with caverns and natural tunnels" around the base of Mulu by Spenser St. John in his book *'Life in the Forests of the Far East'*, (St. John, 1862).

St. John was 'Consul General in the Great Island of Borneo' and made some of the earliest exploratory journeys of any European into the interior of Sarawak. His attempts to reach the summit of Mulu were thwarted by limestone cliffs, dense forest and sharp pinnacles of rock and he says, "It is almost impossible to conceive the difficulty of ascending this mountain". Mulu was to keep the secrets of its summit for a further 74 years until Edward Shackleton successfully climbed the mountain during the Oxford University Expedition of 1932, (Harrison, 1938).

In 1961 G.E. Wilford, of the Malaysian Geological Survey, visited the area to explore its caves. His work included the surveying of Deer Cave and parts of Cave of the Winds (Wind Cave). He predicted that Mulu would yield many more caves in the future, (Wilford, 1964).

During 1977-8 the *'Royal Geographical Society Mulu Expedition'* spent 15 months in the area studying many aspects of the rainforest. This was the largest scientific expedition ever to leave the

UK. Included in the team were six speleologists who, in three months, explored and surveyed 50kms. of cave passages including parts of Clearwater Cave, Green Cave and others, (Brook & Waltham, 1978).

During the expedition a forest camp was established in Hidden Valley from where two major caves were explored. 'Wonder Cave' on the north side of the valley was found to have some of the largest passages in Mulu. 'Prediction Cave' on the south side also contained enormous passages which were almost filled with river sediments, (Meredith, Wooldridge & Lyon, 1992, p.10).

It was obvious from these findings that Mulu ranked as one of the world's foremost caving regions.

As a result of the RGS expedition two large scale caving expeditions were mounted in the early '80s. The '**Mulu '80**' expedition explored and surveyed a further 50km of cave passages including the largest

underground cavity, in the world, 'Sarawak Chamber', which forms the final chamber of 'Lubang Nasib Bagus' or 'Good Luck Cave', (Eavis, 1981). The end of this chamber lies very close to the end of Prediction Cave in Hidden Valley and tantalising draughts at the end of each cave suggested a connection.

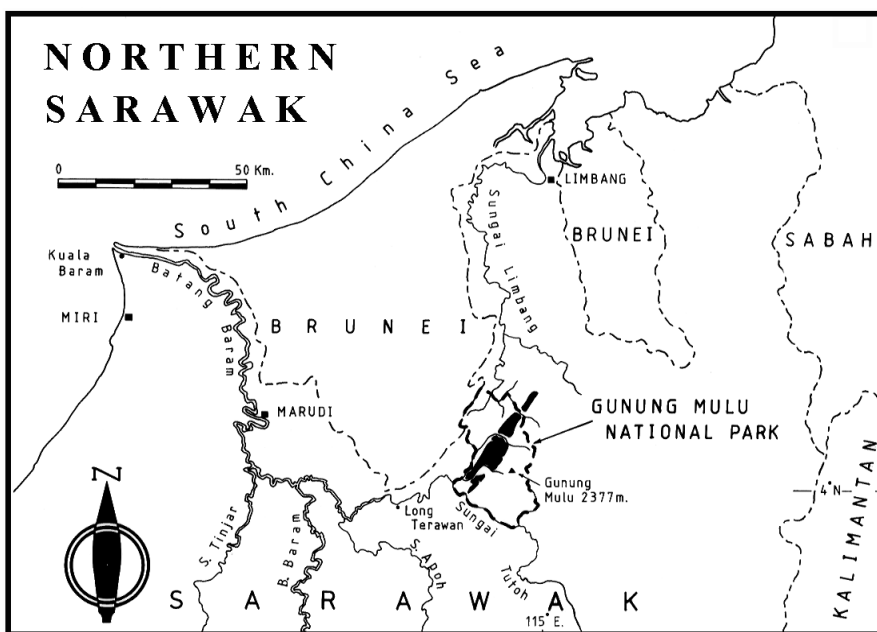


Figure 2: Northern Sarawak

In 1984 the '**Sarawak '84**' expedition spent one month in the field and explored 54km of caves. Clearwater Cave was extended by 14km but a great deal of work was carried out in Benarat where Cobweb Cave was discovered, adding a further 15km of passages to the Benarat total.

These two expeditions carried out a great deal of scientific research associated with the caves including dye tracing, geology, geomorphology, ecology, cave mineralogy, etc. However, although 150km of some of the largest caves in the world had been surveyed, some very significant areas of limestone remained totally unexplored presenting enormous potential for further exploration, (Fig 3).

During late '87 and early '88 plans were made to mount another caving expedition to the area. This would be the first expedition to visit the park since its opening to the public in 1985 and was primarily aimed at exploration, surveying and photography. Unlike the previous expeditions this was to be a lightweight venture with only six team members. The '**Mulu Caves '88**', expedition once again proved the potential of Mulu with a further 16km of passages explored. It was also shown that exploration in Mulu using a small team was both feasible and successful. The major discovery of this expedition was Blackrock Cave lying to the north of Clearwater and almost certainly part of the same system, (Kirby 1989, p.28).

As a direct result of this discovery, an eight strong group, including five of the 1988 team, returned to the Park exactly one year later as the '*Mulu Caves '89*' expedition. Once again a lightweight venture proved to be successful with over 24km of passages explored and surveyed in only one month. Major extensions were found in Clearwater Cave totalling 15km and the gap between it and Blackrock Cave was brought to within 90m. The Clearwater 5 streamway was discovered and explored for over 1km.

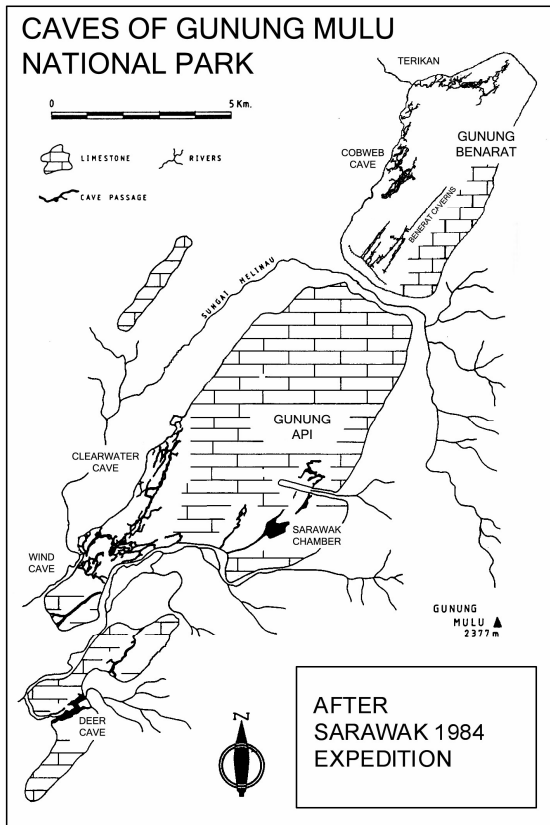


Figure 3: Exploration up to 1984

In 1991 a group of nine explorers, five of whom were from the '88 and '89 expeditions, returned to the Park to continue exploration in the Blackrock/Clearwater area. A connecting passage was discovered which linked the two caves. This discovery made the Clearwater System the seventh longest cave in the world at over 102km. This was the '*Mulu Caves '91*' expedition, (Fig 4).

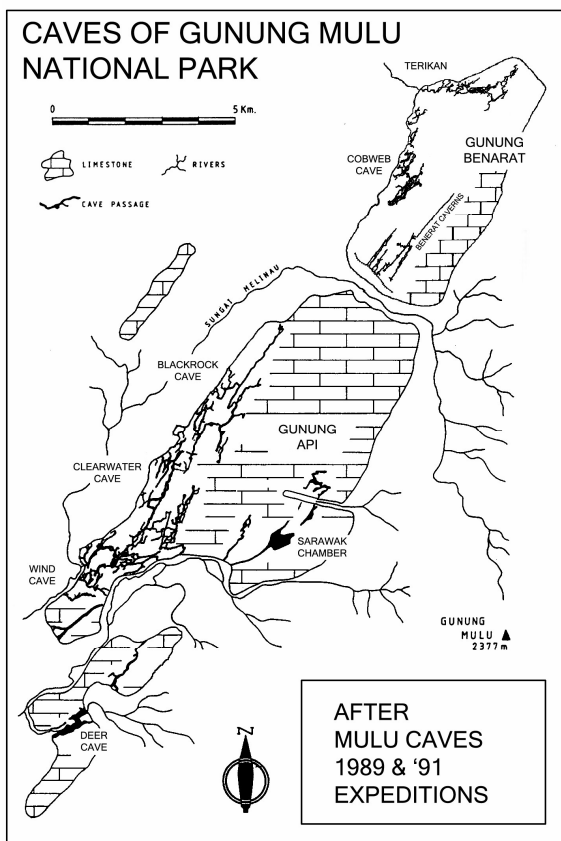
A vast amount of work had, by this time, been carried out on the western flanks of Gunung Api and although discoveries were by no means exhausted it was becoming increasingly difficult to find major objectives which would justify another expedition to that side of the mountain. The remaining significant lead, the Clearwater 6 Streamway, was weather dependent and, therefore, could not be relied on as a sole objective.

Attention now focused on the more challenging eastern flank of Gunung Api with Hidden Valley as the first objective. This area was less accessible than the west as there were no major rivers which could be used for transport of stores and equipment.

A new cave, provisionally named 'Simon's Cave', but later named 'Racer Cave', was discovered and explored and water tracing experiments proved a hydrological link from the Melinau Gorge through Blackrock and into Clearwater Cave, (Kirby, 1990). The discoveries made by these two expeditions had greatly altered the map of Gunung Api's caves.

During 1990 another British team visited the Park and continued the exploration of Racer Cave. The Clearwater 5 streamway was explored to an upstream sump. Although a sump bypass was found to lead into Clearwater 6, rain caused the bypass to sump which prevented further exploration (Weight, 1990). A physical link was established between Drunken Forest Cave and Alexandra Palace in Clearwater.

During February 1991 a Korean Team visited the Park. Some minor discoveries were made. Unfortunately these findings were not published.



Tentative enquiries were made in 1990 to see whether it would be possible to visit the Valley during the '91 expedition. A positive response was received and this became one of the secondary aims of that expedition. Unfortunately this was not achieved as other discoveries closer to park headquarters took priority. Instead, part of the '91 team returned approximately one year later in January 1993 as the *'Hidden Valley '93'* reconnaissance expedition with the sole objective of carrying out a lightweight reconnaissance of Hidden Valley.

The reconnaissance expedition proved a success with potential for further discoveries to be made in the two known caves within the Valley and a new cave discovered in the dolines to the west. Other entrances were noted for further investigation and surface reconnaissance suggested even greater potential further south in the deeper 'Third Doline', which was not entered.

Figure 4: Exploration up to 1991

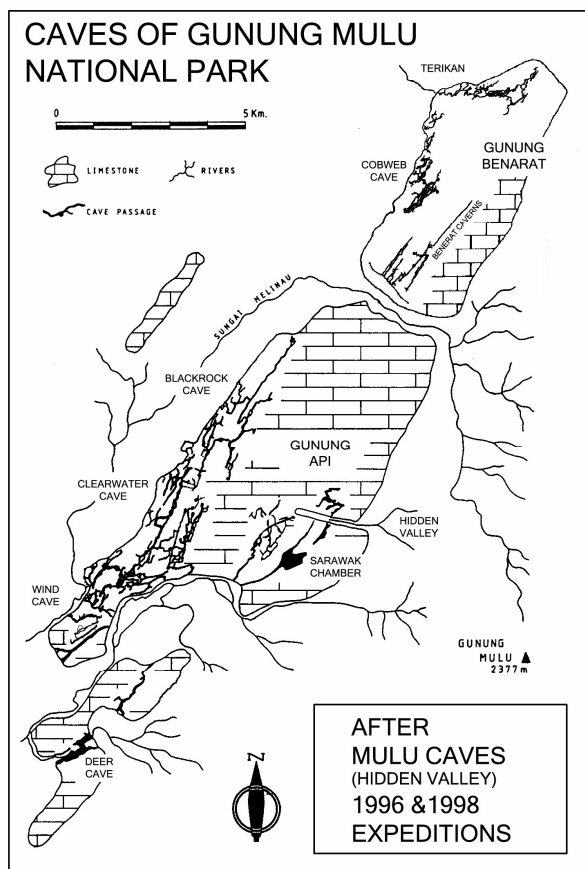
With the Hidden Valley reconnaissance expedition indicating potential for further discoveries in Hidden Valley a full exploratory expedition, *'Mulu Caves '96'*, was mounted and returned to the Park in October 1996. A base camp was established within the Hidden Valley gorge between the entrances of Prediction and Wonder Caves. Although very little was found within the main gorge exciting discoveries were made in the dolines to the south west. Arch Cave was explored in the second doline. Prediction and Bridge Caves were found within the third doline and the fourth doline revealed Cloud Cave which matched Deer Cave in scale. During the last few days of the expedition a descending boulder ramp was followed which led into the far reaches of Cobra Cave. This established a through route to the Melinau Paku valley.

During 1997 an American expedition, which was exploring Gunung Buda, carried out surface searching on the northern slopes of Benarat. This led to the discovery of Deliverance Cave on the north east corner of the mountain. 3.5km of passages were explored which were heading in the general direction of Cobweb Cave.

With the success of the '96 expedition a second Hidden Valley expedition, *'Mulu Caves '98'*, was mounted which returned to the Park in February 1998. As the centre of exploration was to be in the dolines it was known that this would not be best served by a camp within the Hidden Valley gorge. Not only would a camp in Hidden Valley be remote from the caves, it would also be almost impossible to supply without helicopter backup, which would be very expensive and could not be relied upon.

With this in mind, a gamble was taken on being able to reach the 4th Doline from the Melinau Paku Valley via a route, over the surface, which had never been explored. It was thought that the route through the caves would be used only as a back up, however, the severity of the climb up from

Nasib Bagus, together with the surface terrain proved to be far more difficult than the underground route via Cobra Cave, which soon became the main thoroughfare.



This expedition proved a great success with further extensions in Perseverance Cave and a connection established between Cloud and Bridge Caves establishing the Cobra – Cloud – Bridge system at 16.1km. with a vertical range of 459m, the greatest vertical range of any cave in the Park.

Owing to the El Nino year river levels were exceptionally low so a further attempt was made to explore beyond the Clearwater 5 upstream sump into Clearwater 6. This led to another sump which was bypassed into Clearwater 7 and the inevitable upstream sump which was not passable. This expedition was the last to visit Hidden Valley.

Another American expedition visited Buda in 2000 and carried out further work in Deliverance Cave, bringing its total length to 4.3km.

Figure 5: Exploration up to 1998

With exploration in Api now without any significant leads attention of the British team was drawn to Gunung Benarat. It had been sixteen years since a British expedition had visited the mountain during the Sarawak '84 expedition. The **'Benarat 2000'** expedition continued the exploration of Cobweb Cave where a further 10.7km of passages were explored bringing the total length of the cave to 25.9km.

As a follow up to the 2000 expedition the **'Benarat 2003'** expedition returned to the park. A further 4.4km were explored in Cobweb Cave but the significant discovery of the expedition was made in Terikan Rising Cave where 12.5km of passages were explored. Included in the team were two Api veterans who were to use the expedition, based at Camp 5, as an opportunity to prospect the northern slopes of Api between the Melinau Gorge and Blackrock's Racer entrance. This revealed a significant entrance 2.8km south west of Camp 5. The cave was named Whiterock and within the remaining three days of the expedition it had revealed 3.7km of new discoveries. Owing to its proximity to Blackrock it was thought that it would soon connect and might be of little significance.

During 2005 the **'Benarat 2005'**, expedition, based at Camp 5, continued the exploration of Whiterock which exceeded all expectations when a further 17.2km of passages were discovered, mostly lying above Blackrock. Two connections were made between the two caves which linked Whiterock into the Clearwater System.

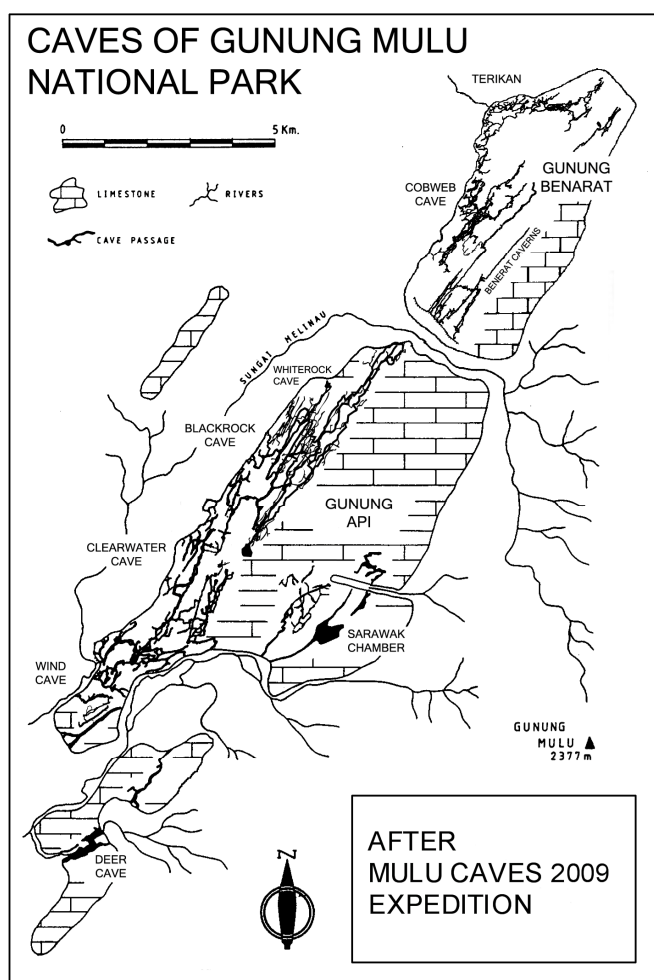
On the Benarat side of the gorge an attempt to climb up to an entrance high in the cliffs opposite Camp 5 was cut short when a small entrance was discovered only 60m above the ground. This cave

was named Moon Cave and was explored for 6.6km in an almost straight line into the mountain. A connection was also established with Benarat Caverns making the total length of this system 16.4km

Included in the expedition were two divers who investigated the sumps in the Terikan system. This proved connections between the individual elements of the system to make a total length of 32.5km. The total length of caves in Benarat was now 90.4km and in Api was 172.6km. During January and February of 2007 the '*Mulu Caves '07*' expedition continued the exploration of Whiterock and Moon Caves. Significant discoveries were made in the northern section of Whiterock where two major passages were discovered both of which came to within 400m of Camp 5 with no apparent entrances/exits found. These two passages, the Northern Line and the 1954 Series, ran northwards in parallel with 60m of vertical separation.

A great deal of in-filling was carried out, with new passages providing short cuts between previously discovered trunk routes. This reduced considerably the travel times to the northern reaches of the system. These discoveries extended the known cave to 42.9km. A major success of the expedition was the connection of Moon and Cobweb caves via an unexplored passage in Moon Cave. This connection linked Benarat Caverns, Moon Cave and Cobweb Cave to produce the Benarat Caverns System which ranks as the second longest system in the Park at 50.7km. In the Melinau Gorge considerable surface survey work was carried out to tie together all the known caves on the Api side of the river and link these back to the datum at Camp 5 which allowed them to be

linked into the Survox master dataset. Some minor entrances were explored in this area.



During January to March of 2009 the '*Mulu Caves 2009*' expedition continued to explore Whiterock Cave and discovered a further 24km of passages. Owing to the proximity of the northern passages to the cliff in the Melinau Gorge a considerable amount of effort was given to establishing a northern entrance and five days were spent attempting to gain entry via a small cave to the east of Camp 5. Unfortunately this ended in a boulder choke with a draught emitting, within 100m of Whiterock. A significant discovery in Whiterock brought its northern passages to a point underneath the Pinnacles track and even closer to Camp 5. Late in the expedition a steeply descending ramp off 1954 led into the Whiterock River, the upstream continuation of Clearwater streamway. Although not fully explored this streamway was left at a point 60m beneath Camp 5 with potential for further discoveries.

Figure 6: Exploration status following the 2009 expedition

THE SOUTHERN HILLS

TOPOGRAPHY

The Southern Hills consist of two isolated blocks of limestone which lie to the south of Gunung Api and the Melinau Paku river valley.

By far the largest block is the Deer Cave Massif which in itself is two main blocks linked together by a narrow ridge forming the north-western flank. The southern part of this massif contains the world famous Deer Cave which passes right through the mountain. This cave is one of the main show caves of the Park which is visited by thousands of tourists who are awe inspired by its vast proportions. From the northern entrance of Deer Cave the massive wall opposite contains the southern entrances to Green Cave. This is thought to have been the northerly continuation of the Deer Cave conduit in geological times. Between the two caves lies the Garden of Eden a large, closed valley. This feature is believed to have formed by surface erosion and the subsequent breaching of the Deer Cave/Green Cave conduit which eventually captured all the drainage from the area and directed it through Deer Cave and onwards to the Melinau River. The capture of these waters prevented any further surface flows to the northwest which in turn left the narrow ridge in place forming the north-westerly wall of the valley. The only easy access to the Garden of Eden is through Deer Cave which gives an unspoilt and magical atmosphere to this wilderness area.

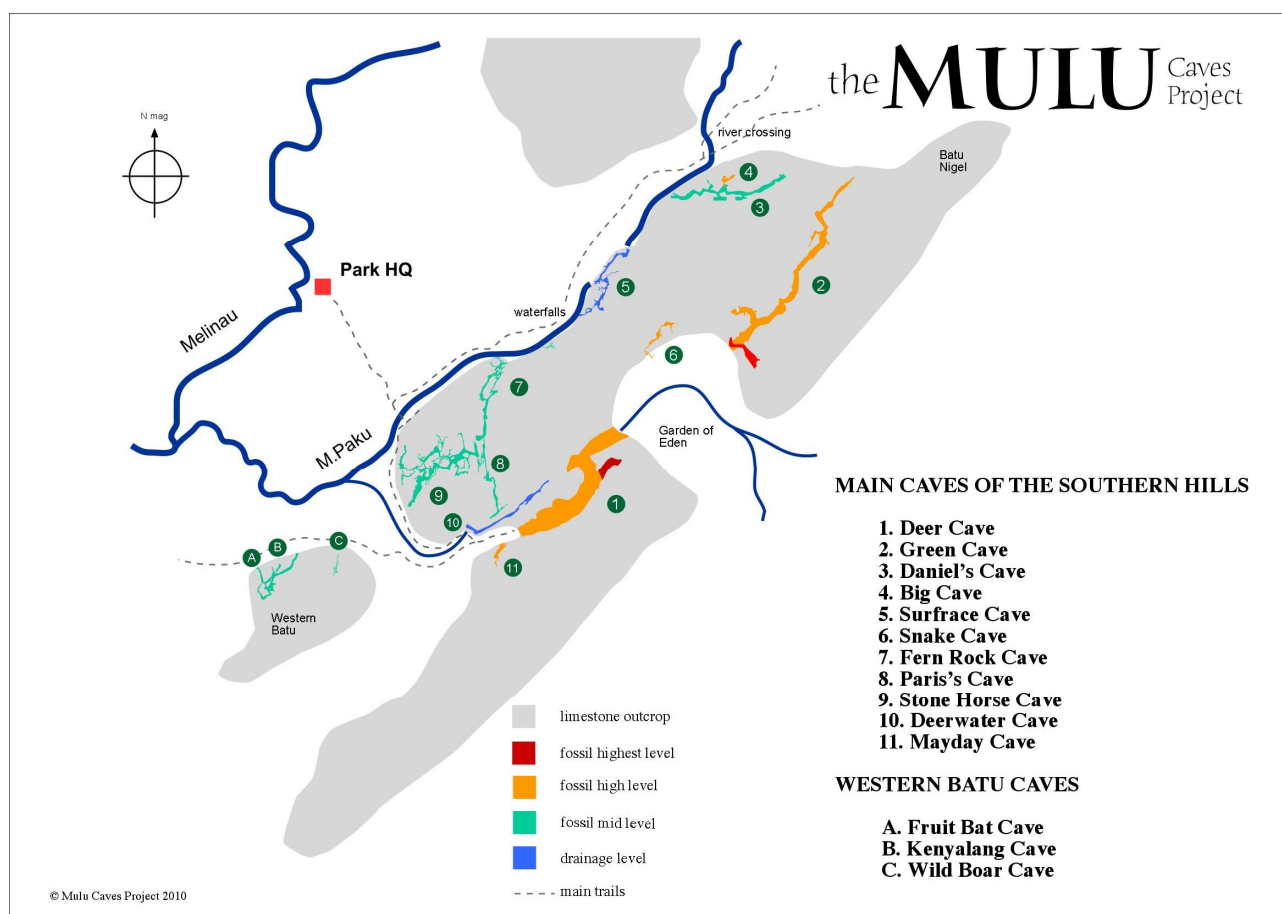


Figure 7: Main Caves of the Southern Hills

The Paku river runs along the north-western flanks of the Massif and has created numerous low level cave features, some of which remain active, such as Surface Cave where the river passes through the cave. Within the Garden of Eden a small cave entrance, Snake Cave, lies to the west of Green Cave. This takes local alluvial drainage which passes through the narrow north-western ridge to resurge as a splendid cascade of waterfalls into the Paku river close to Surface Cave. To the northwest of Deer Cave is the Stone Horse/Paris/Fern Rock System which cuts through the mountain. Stone Horse Cave entrance is situated above the Deer Cave plankwalk and passes eastwards through the hill to emerge in a deep doline. In the same doline is the entrance to Paris Cave which follows the strike to drop into Fern Rock Cave and emerge as multiple entrances in the cliff face high above the Paku river.

The northern flanks of the Massif overlook the Paku Valley and Camp 1. High on these slopes is the northern entrance to Green Cave. This tiny portal on a narrow ledge provides commanding views over the Paku valley towards Api. Apart from the powerful draught which emits, its size gives no indication of the massive passages beyond. To the west of Green Cave is Daniels Cave, a significant, well decorated conduit which cuts the northwest corner of the mountain to emerge high above the Camp 1 river crossing. At this point the Paku river is channelled through the narrow gap between Gunung Api and the Deer Cave Massif which is only 250m wide at the narrowest point.

The southern extremity of the Massif forms a long, strike-controlled ridge running southward from Deer Cave in which there are no known caves.

To the west of Deer Cave lies a much smaller block of limestone past which the Deer Cave to Long Pala boardwalk runs. This block (the Western Batu) has seen much less attention over the years and only recently have caves been discovered in its lower slopes.



Deer Cave's southern entrance from the Bat Observatory

Photo: Gina Moseley

THE MULU CAVES 2010 EXPEDITION

INTRODUCTION

As a break from the norm, this expedition was to be based at Park headquarters and would concentrate on the Southern Hills and the slopes around the Paku Valley. These areas had not been visited by an expedition since 1984. Although the known caves were well documented these had not been linked by surface traverses so their global positions were not fixed. With the advent of the survex dataset this represented a missing link which, with the concentrated effort of a mini expedition, could be overcome. In addition to this aim it was seen as an ideal opportunity to extend the scientific research programme, and its modern dating techniques, to the Southern Hills by collecting samples from various horizons and reassessing the morphology of the area in the context of the more recent discoveries made in Gunung Api.

Although the known caves had been photographed during the early expeditions most images were on film and were over 25 years old. It was seen as an ideal opportunity to re-visit the major caves close to Park headquarters and to re-photograph them using modern digital techniques and with advanced lighting. Primary exploration was to be a secondary aim of the expedition and would only be carried out if and when entrances or leads were discovered during the course of other activities.

In order to minimise the impact on the normal running of the Park, the venture was to be small scale. A team of seven members were in the field for three weeks and were joined by a representative from Sarawak Forestry Corporation to make an eight man team.



Deer Cave Main Passage Photo: Robbie Shone

OBJECTIVES

Primary objectives of the Expedition were:

Surveying

- Surface survey to link up as many of the known entrances in the Southern Hills. This should assist the scientists, add to the survey data base and form the basis of a 'Southern Hill's graphic' survey.
- Surface survey in the Melinau Paku valley to tie up entrances from Nasib Bagus to Berang's entrance.
- Put a number of survey lines through Clearwater, particularly up through the high levels and down into CW3 and linking to Berang's entrance. This continues the work started in 2009 to check the validity of the fake (reconstructed) data.
- Attempt laser scanning survey of Deer Cave and Sarawak Chamber.
- Set permanent accurate survey stations around the Park.
- Other survey task to improve the data set.

Science

- To collect samples of quartz, sediment and speleothem, predominantly from the high levels, to continue the research into the speleogenesis of the cave systems using independent dating analysis.
- To observe and record details of passage morphology.
- To assist the National Park where possible.

Photography

- To take modern digital images of the caves close Park HQ and not generally visited by the group in recent times. The aim being to update the Project's photo data base with images of caves which tourists and other interested parties will either see or hear about. Also to obtain photographs most likely to be required for the new visitor centre. Suggested locations include; Deer, Green, Daniels, Nasib, Drunken, Clearwater, Wind, Lagans, Racer etc.
- To take panoramic painted shots of Sarawak Chamber or at least a new type of photograph to show off its immense size.
- To take lots of digital video clips of all the different aspects of the trip with the aim to start a Project video collection for use in lectures and promotions.

Exploration

- To explore anything new which is found during the course of our other activities.
- To check out the Clearwater high levels with a view to either discovering the fourth major level or at least get a better understanding of its likely existence.
- Check out the small sump at end of Racer Cave for a possible connection, by diving, to Wind Cave.

SUMMARY OF EXPEDITION ACHIEVEMENTS

SURVEYING

Background to the Survey Dataset

Since the very first caving expedition to Mulu in 1978 new cave discoveries have been surveyed and published in the expedition reports. Over the years the totals of surveyed cave has been collated and by the end of the 2009 expedition over 345km of passage had been recorded within the Gunung Mulu National Park. During this 31 year period, methods of data management have advanced immeasurably, from discarded boxes of survey notes to modern computerised survey management systems. Managing this lengthy process has been beset with historical and technical difficulties which have no doubt been mirrored in other caving areas of the world. Using the best techniques the Mulu Caves Project has overcome these problems to produce, what we believe to be, one of the finest large scale datasets of historical cave survey data in the world.

In the early days, when slide rules, cosine tables and Chartwell semi-waterproof note books were the tools of the cave surveyor's trade, databases were mostly unheard of. The early Mulu expedition cavers went about their business with the best intentions. Notes were taken underground, field drawings produced on graph paper and finished inked surveys drafted on return to the UK. These were then published in the expedition report at that was it, an independent expedition completed until the next time. No great value was given to the raw data at the time. Survey notes were held by various members, stored in garages and attics until some became lost. On the 1978 expedition they had so much to survey that it is rumoured that the surveyors recycled the waterproof paper, wiping it clean once the data had been processed! It is very unfortunate that the raw data from the late seventies and early eighties, nearly one hundred kilometres of survey, was mostly lost.

It was in the mid to late nineties that the first meaningful attempt at building a Mulu dataset got underway. Dave Gill was employed at the National Park as the development officer and had a major influence on the expeditions of that decade. He began to contact all the key members of the early expeditions and pull together what data was still available. This period coincided with the development of computerised survey programmes and Dave eventually settled on the Compass software developed by the American, Larry Fish. All the data from the 1988 expedition onwards was readily obtainable. Certain discoveries, such as Cobweb Cave, was available from the 1984 expedition but very little remained from 1978 & 1980. To make matters worse Dave left Sarawak in 2000 and his well collected dataset suffered as a result.

2003 saw the start of the fledgling idea to pull all the independent expeditions under one banner – the Mulu Caves Project. This was to be driven by veterans Matt Kirby, Dick Willis and Tim Allen. It was also the year that Wookey, a caver with serious cave survey computing skills, joined the expedition. Wookey's preference for data processing and visualisation software was Survex as it was very good for the sort of multi cave dataset we had in mind for Mulu. He persuaded the team to adopt the programme as he was heavily involved in the development of the software. During the course of the expedition Dave Gill's Compass files were converted into Survex. Some further work was also done after the expedition returned to the UK as a case-insensitivity between the two programmes needed fixing.

The 2003 expedition focused its attention on Gunung Benarat and was eager to complete as much of the dataset for this mountain as possible. All the real data that existed had been converted to

Survex but that still left caves such as Blue Moonlight Bay Cave, Terikan River Cave, Benarat Caverns, Sakai's Cave and Tiger Cave with either part data or no data at all. We wanted to be able to visualise all the caves on the computer so that we could view them in relation to one another. This would help to better understand the geology and help us to find the connections. Fortunately the surveys in the expedition reports were high quality and contained both plans and elevations. This enabled us to reconstruct fairly plausible data using a method designed by Wookey, which created a set of three dimensional coordinates which were then entered into the dataset as if they were the raw data. By the end of the expedition a fairly comprehensive survey of all the known caves in Benarat was available.

2005 saw the rapid expansion of Whiterock Cave across the northern part of Gunung Api and its inevitable connection into the Clearwater System. Following that expedition a huge amount of work took place to bring the Gunung Api dataset up to, and beyond, the standard of Benarat. The Whiterock data had been entered as the cave was surveyed but in a somewhat unstructured manner. During the winter of 2005/6 Matt Kirby, who was new to Survex, decided to learn to use the system by re-entering the recently entered Whiterock data. Matt decided to standardise the way in which data was entered and stored in order to simplify the existing model and make it as user-friendly as possible. This resulted in a new Survex model for Whiterock. With the new structure for Whiterock in place Matt proceeded to enter all the available raw data from expeditions as far back as 1988, to create a model for the whole mountain. This include Blackrock and the Armistice series of Clearwater together with the 1996/98 discoveries in the Hidden Valley. Unfortunately data from expeditions pre '88 was not available so Tim Allen went through the laborious process of reconstructing the missing data from the original surveys. This included some fifty kilometers of the original Clearwater survey together with Lagans Cave, Cobra Cave and Nasib Bagus. This set the format for the current Mulu dataset.

With a working model in place for the Api side of the river Matt decided to re-work the Benarat dataset to bring the structure in line with that of Api. This was a laborious task as the data had been entered by various people over the course of several expeditions which had resulted in some complex links and commands that would make interrogation very complicated at a later date. When the Benarat data had been re-worked, the two datasets were joined together to produce an Api/Benarat dataset.

It was a fantastic achievement to be able to visualise all the Mulu caves in 3D and in relation to one another. It would be even better to be able to visualise the caves in relation to the mountains as well. Thus the idea of constructing a surface topography connected to Survex was born. A number of methods were considered where the surface topography could be represented by Google Earth or NASA imagery, but these were found to be either too technical to display or unsuitable for our needs. In 2006, Tim Allen built a simple wireframe using a 250m grid for the area covering the Southern Hills, Gunung Api and Gunung Benarat. Spot heights were taken from the 1:50,000 topographical map and the grid converted to a Survex file and incorporated into the dataset. This was a laborious task which required many hours of painstaking work but allowed the wireframe to be viewed in its entirety or split into the three major hills. At this time Survex data could only be viewed as either 'cave' or 'surface survey' and a new image type was required for the terrain data. Eventually, Phil Underwood of the Survex Group provided an amended version of Survex with a third option for surface terrain.

Between the 2007 and 2009 expeditions Tim Allen and Matt Kirby continued to update the Survex dataset. All the available survey data for the Southern Hills was added and, where this was not available, reconstructed data was generated from the original surveys. This highlighted a

problem with the Southern Hills caves. It was impossible to position the caves in relation to each other especially in terms of elevation. No work had been done by our group since the 1980's and many of the new caves had been surveyed by other visiting cavers in the 1990's. If surface survey and positioning work had been done in the past, it was now lost. It seemed an obvious objective for the 2010 expedition, locate all the caves in the southern hills and complete a surface survey between them. This would assist the scientists in their dating programme and enable graphic illustrations of the area to be produced. Completing the Southern Hills dataset would be a major task although highly practicable for our small team based at Park HQ.

Surface surveying

One of the main aims of the expedition was to carry out surface surveying between all known entrances in the Southern Hills in order to fix them on the main survey dataset. Previously entrances had been placed approximately by using the positions shown in the '84 report and giving the entrances fake GPR coordinates. Unfortunately this did not provide any vertical position data and only a rough fix for the cave.

During 2008 Dave Clucas established a GPS fix for the Deer Cave gate and this was used as the fixed datum from which the surface traverses radiated. Dave had also gained a GPS fix for the Deer Cave heli pad, which is situated to the west of the Bat Observatory, and the Park HQ heli pad. These two additional fixes were used as a check of the accuracy of the surveys.

A boardwalk exists for tourists to visit Deer Cave and this formed the central spine for all the interconnected traverses. The main traverses were as follows:

- Park HQ Heli Pad to Melinau Paku Bridge
- Melinau Paku Bridge to Deer Cave Gate
- Deer Cave Gate to Kenyalang Cave
- Deer Cave Gate to Deer Cave Northern Entrance
- Deer Cave Northern Entrance to Green Cave
- Deer Cave Northern Entrance to Snake Cave
- Melinau Paku Bridge to Fern Rock Area
- Fern Rock Area to the Waterfall
- Fern Rock Area to Pendant & Corner Caves
- Waterfall to Camp 1 Trail Paku Crossing
- Camp 1 Paku Crossing to Daniels and Big Caves



Surface surveying Photo: Robbie Shone

In total 14.7km of surface traverses were logged and, with these, all the known cave entrances were tied into the master dataset. This has enhanced the Mulu dataset and fulfilled a major objective of the expedition.

The Survox Wireframe

The wireframe terrain model provides a valuable enhancement to the survex dataset. However, its 250m grid squares provide no recognisable fixed feature by which to connect it accurately to the UTM grid and the cave data. The Api wireframe contains the only connection between cave data and wireframe data. This is achieved by means of a false leg down from the wireframe grid to the Wind Cave entrance (Clearwater Cave Fake station 0) which is known to be at 22masl. By virtue of the fact that the grid connects to the cave data, so the grid becomes attached to whatever GPS fixed point the cave data is attached to. The whole Clearwater system is positioned by a GPS fix at the 'Whiterock Junction' and an interconnecting surface traverse back to the original entrance. In order to fine-tune the position of the wireframe to the cave data the interconnecting leg between it and Wind Cave entrance is adjusted.

The Hidden Valley system is connected to the dataset by means of a fake GPS fix at the entrance to Cobra Cave and Nasib Bagus is likewise fixed at its entrance. The positions of these are best attempts based on the surrounding terrain features.

Although the Api wireframe covers the Southern Hills a separate Southern Hills wireframe was constructed to allow this area to be viewed on its own. This wireframe is fixed by matching the UTM coordinates for its southwestern point to the same point the Api wireframe and this fixed point is found in the Southern Hills wireframe svx file. The same principal applies for the Benarat wireframe.

In the Southern Hills, Fern Rock Cave's entrances appeared to be sticking out of the side of the mountain and the track to Deer Cave was inside the hill. Clearly some adjustment was required. Further study of the caves in relation to the surface overlay revealed that the track from the Bat Observatory to Deer Cave appeared to run along the hillside, clearly this was incorrect. In an attempt to correct this, the whole terrain overlay was moved 175m northwards and 50m eastwards. This appears to have improved the situation but the establishment of accurate GPS fixed points around the Park will provide more accuracy.

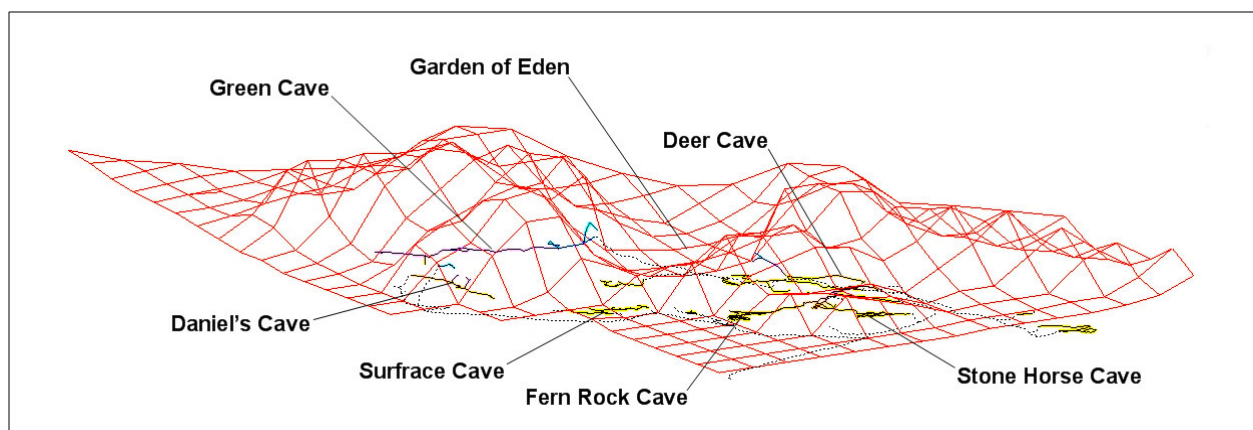


Figure 8: Southern Hills Survex image

SCIENCE

LONG TERM REGIONAL LANDSCAPE EVOLUTION determined from MULTIPLE DATING of CAVE DEPOSITS in the GUNUNG MULU NATIONAL PARK, SARAWAK, MALAYSIA

Summary

The expeditions of 2009 and 2010 contained an element of scientific research. The aim of the study was to obtain a Plio-Pleistocene chronology for cave development in the Gunung Mulu National Park, using two developing radiometric dating techniques; uranium-lead (U-Pb) dating of speleothem calcite, and cosmogenic aluminium-26/beryllium-10 (^{26}Al - ^{10}Be) burial dating of quartz gravels, plus the established method of palaeomagnetic analysis of sediments. The multi-geochronological approach is to be used to indicate the reliability of the chronology and allow inter-comparison of suitability of the methods for dating long-term landscape evolution. In addition, the cave elevation/age data permits determination of rates of fluvial incision over extended timescales which are equal to uplift in this tectonically active region. Variation of rates with time will be considered in relation to intensity of the Asian monsoon and basin sediment data, which indicate constancy of rates over the last 17 million years (Ma). This research will thus provide important information for landscape evolution studies on tropical long-term denudation rates in response to climatic changes and tectonic forcing.

Introduction

Scientific research has been a key element of the expeditions to Mulu over the past 32 years (Smart and Willis 1982; Farrant *et al.* 2007), providing understanding into the geomorphic and chronological evolution of the caves. In 2009, the Mulu Caves Project began a new chapter in research and welcomed Gina Moseley onto the expedition. The 2010 expedition also saw the return of Pete Smart, who after several decades working in caves elsewhere in the world, thought it a good time to revisit the caves of Mulu.

Background

Caves are useful in landscape evolution studies because they often mark the level of previous water tables and when dated, yield estimates of fluvial incision and tectonic uplift rates. Entrenchment of the Melinau and Melinau Paku Rivers within the National Park has created a base level for cave development thus, as incision has proceeded over the Quaternary, a stacked vertical sequence of cave passages extending up to 500 m above the present Clearwater resurgence has formed. During wet interglacial periods, increased landslips and sediment production result in aggradation of the Melinau and Melinau Paku Rivers and the development of large alluvial fans of which remnants are present as terraces (Rose 1982). Large volumes of coarse gravels derived from the adjacent sandstone uplands are also transported into the caves and deposited at resurgence level, preventing incision and focusing erosion laterally on the cave walls to create morphologically distinctive notches (Smart *et al.* 1985). If the alluvial fan extends so far as to block the resurgence, ponding occurs within the passages and finely laminated sediments are deposited. During drier glacial climates, incision of the Melinau and Melinau Paku rivers dominates processes and the local water table drops. If the base level falls faster than the rate of incision, upper cave passages are abandoned and groundwaters are diverted to new lower phreatic routes. Once abandoned, the passages become suitable for formation of speleothems (stalagmites

and stalactites) thus cave deposits typically comprise coarse gravels overlain by finely laminated sediments (Photo 1) and a capping speleothem layer (Smart *et al.* 1985).

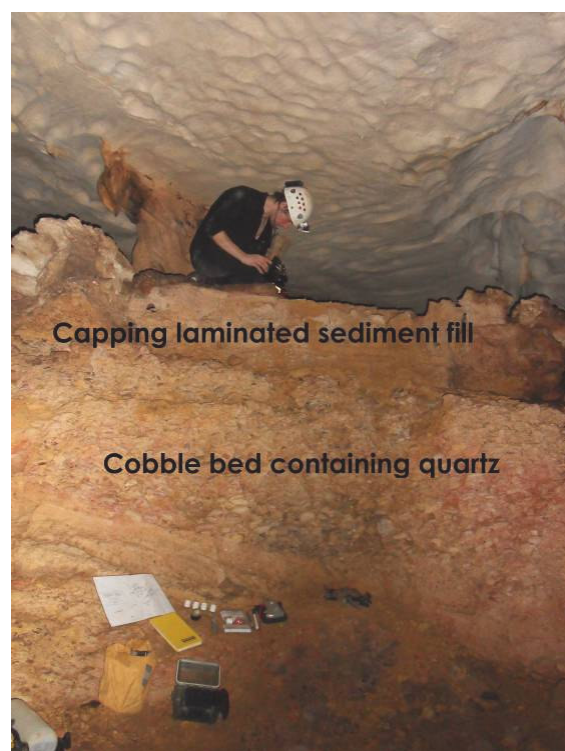


Photo 1: Cobble bed containing quartz capped by finely laminated sediment; Stone Horse Cave
Photo: Gina Moseley

Farrant *et al.* (1995) were successful in obtaining a chronology for the development of the lower 120 m of cave passage using alpha spectrometric dating of speleothems which has an upper age limit of ~350 thousand years (ka). Above 120 m, the speleothems were too old to be dated using the methods available at the time. Farrant *et al.* (1995) thus used the record of palaeomagnetic reversals preserved within cave sediments to develop a chronology extending back to 850 ka however above 186 m the record was too sparse for reliable interpretation. The upper ~300 m of cave development from the early Quaternary therefore remained undated. In addition, Farrant *et al.* (1995) demonstrated that in the 0-700 ka range, the chronology for formation of cave wall notches and thus aggradational events is closely associated with 11 major interglacial peaks. Palaeoclimatic fluctuations and associated changes in hydrology are thus considered a major driving force for karst evolution and speleogenesis.

The discovery of Whiterock Cave in recent years opened up a new avenue for research in the higher levels of the Clearwater System which, when combined with newly available dating techniques offered promise to establish a complete chronological framework for cave development within the Park. Sampling in Whiterock was the main scientific focus of the 2009 expedition. However, basing the 2010 expedition at Park Headquarters provided an ideal opportunity to revisit the sites of the 'early' science with modern dating techniques and thus gain a fuller understanding into Mulu cave development.

Methodology

This research aims to extend the sediment palaeomagnetic record and apply two newly available techniques: uranium-lead (U-Pb) dating of speleothems and aluminium-26/beryllium-10 (^{26}Al - ^{10}Be) cosmogenic burial dating of quartz gravels. Intercomparison of the three methods will allow confirmation of the reliability of the derived chronology.

Cosmogenic ^{26}Al - ^{10}Be burial dating of quartz gravels has proven successful in the New River valley caves, Virginia (Granger *et al.* 1997) and Mammoth Cave, Kentucky (Granger *et al.* 2001), for dating caves over an extended (5 Ma) timescale (Granger and Muzikar 2001). Quartz accumulates ^{26}Al and ^{10}Be from secondary cosmic rays within the top few metres of the earth's surface as it is exhumed within hill slopes and transported through river systems. Subsequent burial of the quartz deep (>25 m) within cave systems ceases nuclide production, and the ^{26}Al and ^{10}Be products decay exponentially. Because ^{26}Al decays roughly twice as fast as ^{10}Be , the

inherited nuclide ratio (N_{26}/N_{10}) decreases exponentially over time and the ratio of $^{26}\text{Al}/^{10}\text{Be}$ in buried gravels may be used to determine burial ages.

Uranium(U)-238 is the parent isotope of a radioactive decay chain encompassing uranium-234, thorium(Th)-230 and ending with the stable isotope lead(Pb)-206. In the hydrological environment, Th is primarily present as ThO_2 and is adsorbed onto the surface of organic or inorganic particles and clay minerals. U however, forms soluble complex ions such as UO_2^{2+} and is transported through the epikarst to percolating dripwaters in the cave environment. During speleothem deposition, U in solution in the dripwater is co-precipitated into the calcite crystal lattice. Th concentrations in dripwater and the deposited calcite are, however, typically negligible creating a state of extreme fractionation between the parent and intermediate nuclides. The date of deposition may thus be determined by U-Th dating from the ingrowth or decay of intermediate nuclides. U-Pb dating relies on the measurement of cumulative amount of radiogenic lead. The technique has been shown to be applicable in areas with uraniferous groundwaters (and thus speleothems) and low levels of natural Pb (Richards *et al.* 1998). In this study, speleothems have been initially screened to assess their suitability for U-Pb dating using the conventional U-Th technique.



Photo 2: Gina Moseley collecting sediment for palaeomagnetic analysis

Photo: Robbie Shone

In general, the scientific assault occurred in conjunction with the other objectives for the expedition, apart from a two day camp in Clearwater which targeted the higher levels from which Farrant *et al.* (1995) had only a few samples.

Samples suitable for palaeomagnetic analysis were obtained from clean, vertical, finely laminated, undisturbed sedimentary sequences and duplicated six times within a horizon to test for reliability. Each sample was orientated using a spirit level and compass (Photo 2). Using the procedure of Granger *et al.* (2001), 100 to 200 g of clear white quartz gravel were sampled from distinctive former river beds. Though it is possible to analyse sands, these were avoided because of the ease in which they can be remobilised. Previously broken speleothems were abundant throughout the caves and thus were easily sampled. The quartz, sediment and speleothem samples collected in 2010 are shown in table 1. Permission to collect samples was granted by the Forestry Department, Sarawak.

Preliminary Results

Quartz

The Natural Environment Research Council Cosmogenic Isotope Facility (NERC CIAF) granted support for a pilot analysis of six quartz samples collected in 2009 (Project 9064.0409). The aim of the pilot study was simply to determine whether the buried sediment samples would produce measureable levels of cosmogenic isotopes. Results of this initial study (Table 2) were reported

in August 2010 and were shown to be successful. Burial ages (Table 2) from the pilot study have thus been calculated to a first approximation using the modern $^{26}\text{Al}/^{10}\text{Be}$ ratio as measured in surface sample MR092. Because production rate variations affect ^{26}Al and ^{10}Be alike, the effect on the initial $^{26}\text{Al}/^{10}\text{Be}$ ratio is minimal and has little effect on burial dating however, a future development of this project shall be to calculate an initial $^{26}\text{Al}/^{10}\text{Be}$ ratio based on the probability of exhumation from different elevations. Final calculations for burial ages may thus differ slightly from those reported here which should be considered preliminary results only.

A full application for analysis of the remaining 21 samples has been submitted to NERC CIAF. Figure 9 shows the preliminary burial ages relative to the steady-state denudation curves of Farrant *et al.* (1995). Preliminary results in the lower elevations are in agreement with Farrant *et al.* (1995) 0.15 m ka^{-1} rate of base level lowering for which a comprehensive suite of palaeomagnetic samples were analysed. The one pilot burial age from a high elevation (255 m ar) deviates from the steady-state erosion curve. Whilst it is premature to make conclusions based on three data points, one can speculate that after analysis of the remaining 21 samples (Fig. 9) in this study, it will be possible to estimate variable rates of base level lowering over Plio-Pleistocene timescales.

Figure 9 shows $^{26}\text{Al}/^{10}\text{Be}$ burial ages for three underground samples from the pilot study relative to elevation above resurgence (grey). Constant rates of base level lowering are shown from the previous study of Farrant *et al.* (1995) (green dashed line). The elevation of the remaining samples to be analysed are shown at X=0 (crosses).

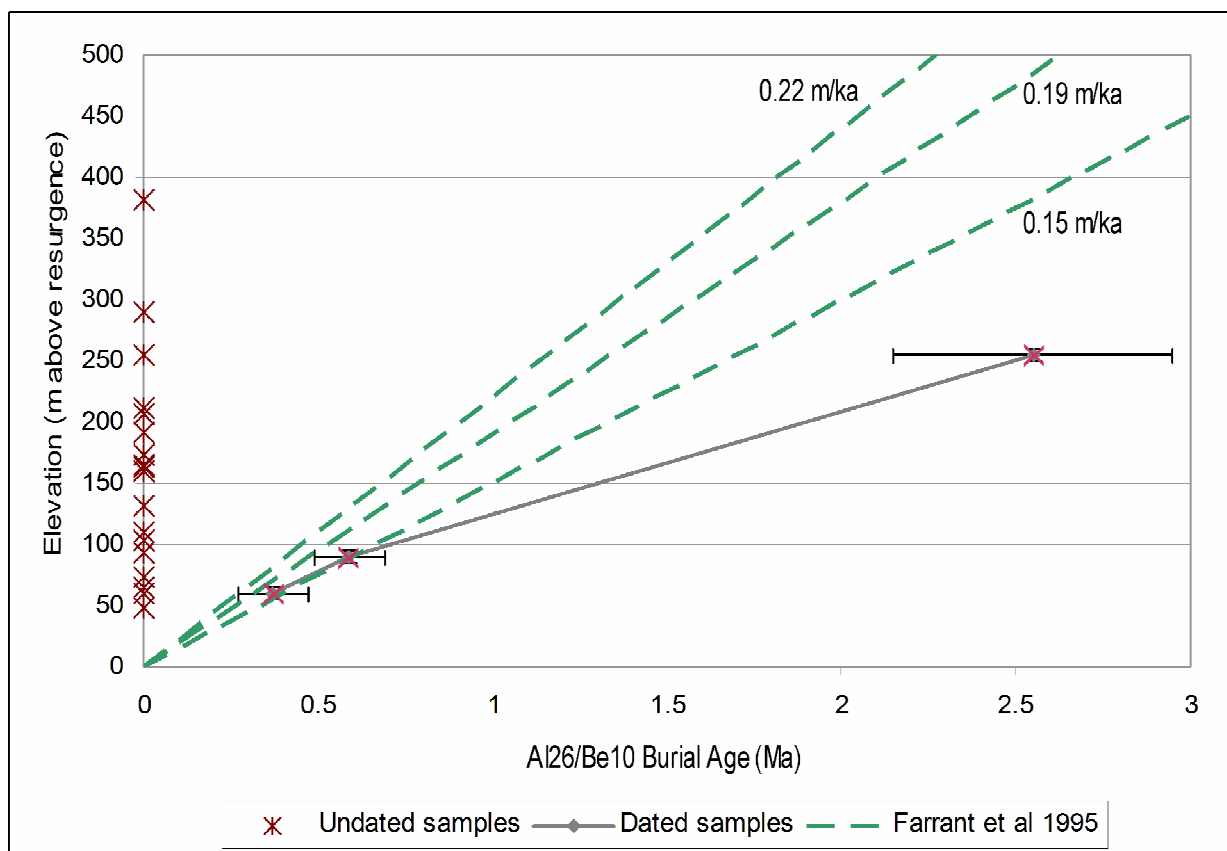


Figure 9: $^{26}\text{Al}/^{10}\text{Be}$ Burial Age Results

Sample Code	Type	Cave	Location	Elevation (m ar)
MP-10-6-1	Quartz	Melinau Paku	Surface	
PC-10-10-1	Quartz	Paris Cave	Main passage	132
PC-10-11-1	Quartz	Paris Cave	Main passage	132
PC-10-11-2	STM	Paris Cave	Main passage	132
PC-10-11-3	Sediment	Paris Cave	Main passage	132
SH-10-12-1	Sediment	Stone Horse Cave	Main passage	103
SH-10-12-2	Sediment	Stone Horse Cave	Main passage	103
SH-10-12-3	Quartz	Stone Horse Cave	Main passage	103
13/05/2010	Quartz	Deer Cave	Antler Passage	206
LC-10-14-1	Sediment	Lagans Cave	Main passage	39
LC-10-14-2	STM	Lagans Cave	Main passage	39
LC-10-14-3	STM	Lagans Cave	Main passage	39
LC-10-14-4	Sediment	Lagans Cave	Main passage	39
GOE-10-15-1	Quartz	Garden of Eden	Surface	
GC-10-15-1	Quartz	Green Cave	Top of arête	211
GC-10-15-2	Sediment	Green Cave	Top of arête	211
GC-1-15-1	Quartz	Green Cave	Upper entrance	381
RC-10-16-1	Quartz	Racer Cave	Main passage	65
RC-10-16-2	Sediment	Racer Cave	Main passage	65
RC-10-16-3	Quartz	Racer Cave	Main passage	60
CW-10-23-1	Quartz	Clearwater	Armistice	218
CW-10-23-2	Red crust	Clearwater	Armistice	218
CW-10-23-3	Sediment	Clearwater	Armistice	218
1/25/10	FST	Clearwater	Armistice	218
CW-10-23-4	STM	Clearwater	Armistice	218
CW-10-23-5	FST	Clearwater	Armistice	208
CW-10-23-6	Sediment	Clearwater	Armistice	208
CW-10-23-7	Sediment	Clearwater	Armistice	208
CW-10-23-8	Sediment	Clearwater	Scumring/Snowslopes	154
CW-10-24-1	Quartz	Clearwater	Hyperspace Bypass	74
CW-10-24-2	Sediment	Clearwater	Between Infinite Improbability and Leap in Time	170
CW-10-24-3	Sediment	Clearwater	Leap in Time	192
CW-10-24-4	Sediment	Clearwater	Leap in Time	192
CW-10-24-5	Quartz	Clearwater	Leap in Time	192
CW-10-24-6	Quartz	Clearwater	Heaven's Gate	290
CW-10-24-7	Quartz	Clearwater	Not Before Time	49

Table 1: Quartz, sediment and speleothem collection record. Elevation in m above resurgence (m ar)

Sample	Elevation (m ar)	^{26}Al (10^5 at g^{-1})	^{10}Be (10^4 at g^{-1})	$^{26}\text{Al}/^{10}\text{Be}$	Burial age Ma
MR091	92(surface)	0.347 ± 0.0361	0.6504 ± 0.04236	5.34 ± 0.65	0.002 ± 0.59
MR092	92(surface)	0.907 ± 0.0710	1.253 ± 0.06009	7.23 ± 0.66	-0.002 ± 0.18
LC09122	60	2.01 ± 0.0912	3.379 ± 0.01152	5.94 ± 0.34	0.37 ± 0.11
WR09021	90	0.577 ± 0.0358	1.088 ± 0.04356	5.30 ± 0.38	0.59 ± 0.14
WR09181	255	0.0850 ± 0.0172	0.4450 ± 0.02564	1.91 ± 0.39	2.55 ± 0.40
HOTM092	515	≤ 0.0478	0.2070 ± 0.01762	≤ 2.31	

Table 2: Burial ages calculated from equation 3, Granger et al. 2001 using the modern $^{26}\text{Al}/^{10}\text{Be}$ ratio as measured in surface sample MR092

Speleothem

Funding for analytical costs associated with U-series dating has been granted by the British Cave Research Association and Quaternary Research Association. All 24 speleothems collected as part of this project have been sawn and polished in preparation for sub-sampling and are currently being screened to assess their suitability for U-Pb dating using conventional U-Th techniques. In general, the majority of samples display good, dense macrocrystalline calcite suitable for dating (Fig. 10a). However, two samples display either needle like aragonitic texture (Fig. 10b) or a punky porous fabric (Fig. 10c), neither of which are suitable for dating.

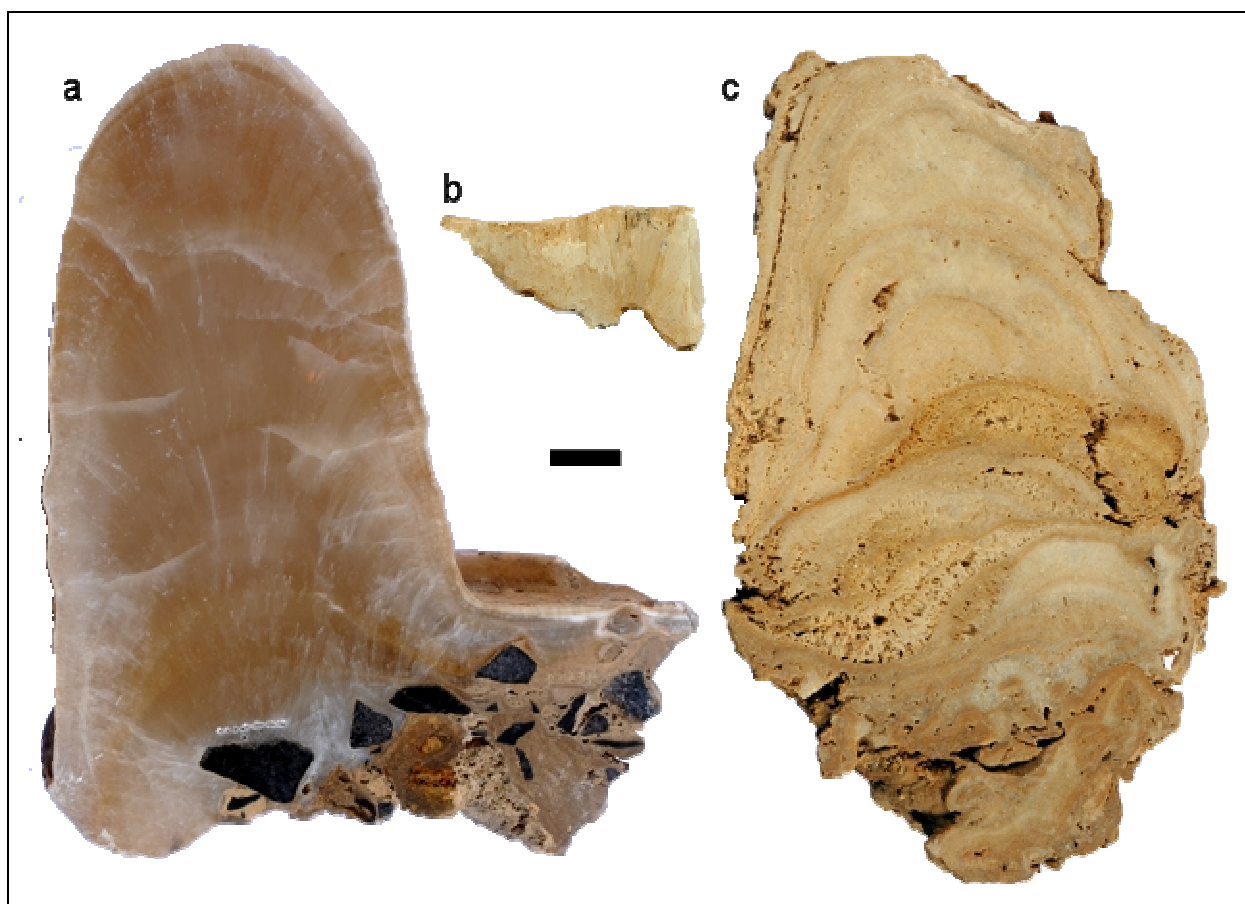


Figure 10: Selection of speleothems

A: clear dense macro-crystalline calcite,
B: needle aragonitic like fabric,
C: punky, porous fast growing calcite. Scale bar = 2cm

In total, 15 samples plus one procedural blank have undergone chemical separation and purification of U and Th in the laboratories of the Bristol Isotope Group. Seven of these and the procedural blank have been analysed on the Thermo-Finnigan Neptune multi-collector inductively coupled plasma mass spectrometer (MC-ICPMS). These results and images of the samples are shown in figures 11 (samples a- d) and 12 (samples e – g).

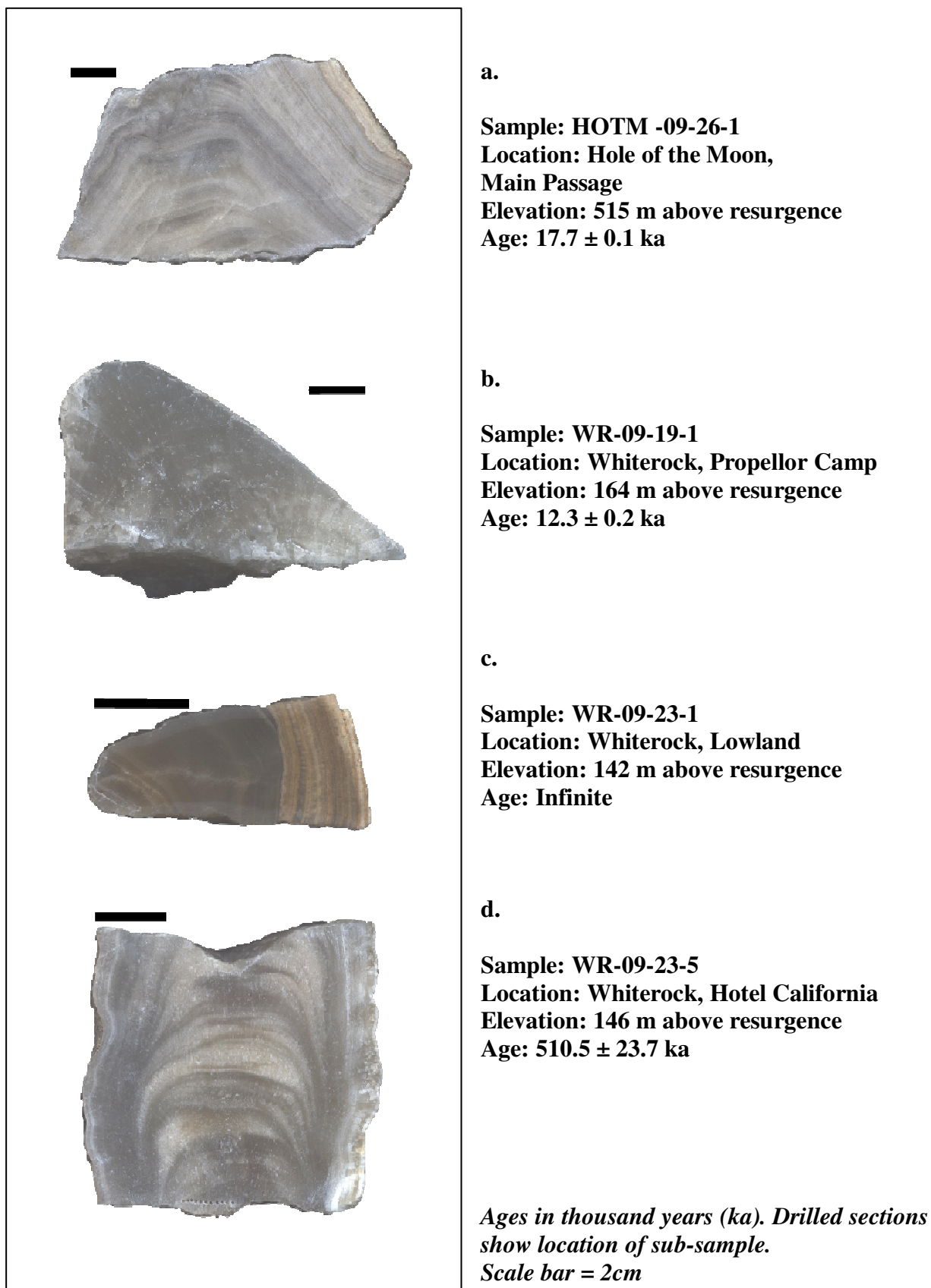


Figure 11: Samples a - d, speleothems analysed with U-Th dating



e.

Sample: LC-10-14-3
Location: Lagan's Cave,
Main Passage
Elevation: 39 m above resurgence
Age: 42.9 ± 0.6 ka

f.

Sample: WR-09-4-1
Location: Whiterock, Off Piste
Elevation: 100 m above resurgence
Age: 245.2 ± 15.1 ka

g.

Sample: WR-09-18-4
Location: Whiterock,
Strong Hint of Bigness
Elevation: 255 m above resurgence
Age: Infinite

Ages in thousand years (ka). Drilled sections show location of sub-sample. Scale bar = 2cm

Figure 12: Samples e - g, speleothems analysed with U-Th dating

At the time of writing, analysis of the remaining eight samples that have undergone chemistry has been delayed due to maintenance on the MC-ICPMS. It is anticipated that these samples shall be analysed by the end of December, 2010. The seven samples which remain to have U and Th extracted are scheduled to be analysed in the next few months. Five of the seven samples were successfully dated using U-Th techniques. However, two samples (WR-09-23-1 and WR-09-18-4) were beyond the limit of U-Th dating and are thus good candidates for U-Pb analysis. U-Pb analytical techniques are being set up at the University of Bristol by PhD student Chris Smith. Once the laboratory is ready for such work, it is hoped Chris shall begin working on the speleothems too old to be dated by U-Th methods.

Sediments

Pete Smart has analysed one sub-sample from each set of 2010 palaeomagnetic sediment samples on the magnetometer at the University of Plymouth. At present, the results of the data reduction have not been reported from the laboratory but are expected during 2011.

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PHOTOGRAPHY

As photography continues to advance in its more familiar genres, so does cave photography. Be it a new form of lighting, a new technique or style or be it the challenge of photographing a new cave. Every time is like the first with cave photography. There are always obstacles that you have to overcome. However, when you add 100% humidity and torrential rainforest conditions it gets a whole lot worse. Thankfully for this year's encounter into Gunung Mulu National Park we were based at the Park's Headquarters (along with the friendly tourists). This meant that we were able to dry out all of our photographic equipment in the air conditioned rooms, re-charge our batteries using the electricity provided and generally keep on top of all the maintenance that was occasionally needed.



View across the main passage of Deer Cave, four explorers stand on the ridge in the distance Photo: Robbie Shone

Our main photographic objectives were to offer our services to the Park's management. If there was a particular cave that they wanted photographing, for the 'new' Tourist Research Centre, then now was the time to ask. Secondly we were keen to get back into Sarawak Chamber following a 25 year-long wait for a more modern photograph of the world's largest underground void. Sadly due to time restraints high water conditions and resources we had to abandon this idea, leaving it for a later date, hopefully at the beginning of the 2011 expedition based at Camp 5.

The main photographers on this expedition were Robbie Shone, Andy Eavis, and Matt Kirby. All using Canon built digital SLR cameras ranging from early D60 to 20D and the latest 5D mkII bodies. The optics varied from camera to camera. Each photographer chose his preferred lens. Anything and everything from 16mm Sigma's on Andy's stereo D60's to 15mm fisheye and 16-35mm F/2.8 Canon's on the 5D mkII bodies. There was no shortage of lenses. For lighting once again, each photographer chose to run their familiar set-ups, occasionally sharing Robbie's lighting scenes in order to leave the cave with both 2D and 3D still imagery. Once the CF cards were back to HQ, people were able to immediately made back-ups onto a laptop computer or chose to run until the larger CF card was full to capacity. Both Andy and Robbie had brought out a good number of

large Edison screw fitting flashbulbs filled with magnesium wire wool. These bulbs burn at a considerably high temperature and emit a huge amount of light (approx GN 300 @ ISO100). The majority of these bulbs were not used as the big shoot in Sarawak Chamber was postponed to a later date and were thus left in the Project's 'secure box' at Park HQ until the next expedition. However, there were a few used to illuminate some of the large cave passages like Green Cave and Deer Cave. The other underground locations were much smaller and only really required a single small flashbulb or a strobe to illuminate the scenes.



Descending into Green Cave's vast southern entrance

Photo: Robbie Shone

Following the recent discovery of Hang Son Doong in Vietnam which claims to be the world's largest cave passage, the Mulu Caves Project took it upon themselves to photograph Deer Cave in a greater detail, focusing on the largest sections and those with the greatest cross-sectional areas. Deer Cave is a real contender for the world scale record, and with it being so close to the Park's HQ, it seemed an ideal opportunity to spend some quality time photographing the passage. We made several images late into the evening when the daylight dropped and there wasn't so much ambient light flooding into the two entrances. Here we were able to work with the big flashbulbs and the ambient light to create an image unaffected by the glare of the sun and the high contrast this creates. We also tried an evening scene looking out of the southern entrance, but due to a cloud filled sky, we will need to repeat this shot again next time, given enough time.

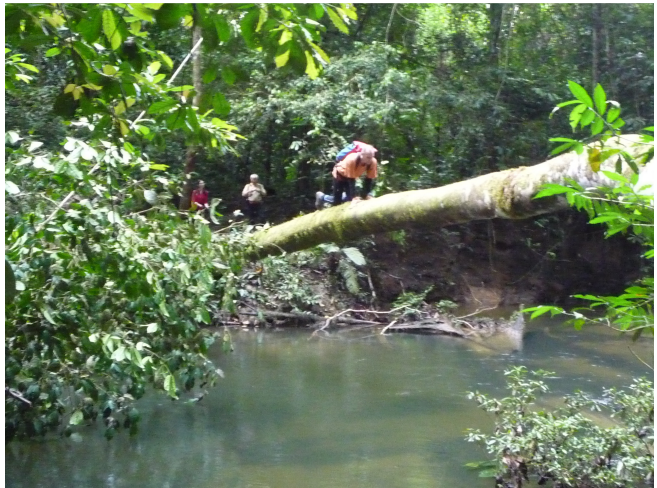
General photographic record shots were carried out by most team members, documenting various aspects of the expedition, although photographically less challenging these shots are equally important to the bigger picture and the Project's records. These were also backed up and a selection of everyone's best and relevant frames were put together in one folder for an end-of-expedition presentation, to the National Park's management team.

EXPLORATION

Although not a specific aim of the expedition a number of previously undocumented discoveries were made. It is accepted that we were possibly not the first to explore these, however, the following notes are the first to document them.

LOWER MELINAU PAKU CAVES

The entrances to Fern Rock Cave are situated in a cliff face on the east bank of the Melinau Paku River. Following the Camp 1 trail upstream from the Deer Cave boardwalk leads to a view of the Fern Rock cliff after about twenty minutes. Unfortunately the trail is on the opposite bank of the river so it is necessary to cross the river, which is too deep to wade across for most of its length. Fortunately, on this occasion, a well placed fallen tree had provided a perfect bridge over which to cross the river completely dry-shod. This bridge was approximately 80m upstream of the original entrance and allowed access to explore the river bank in both directions from here.



The log bridge

Photo: Hugh St. Lawrence

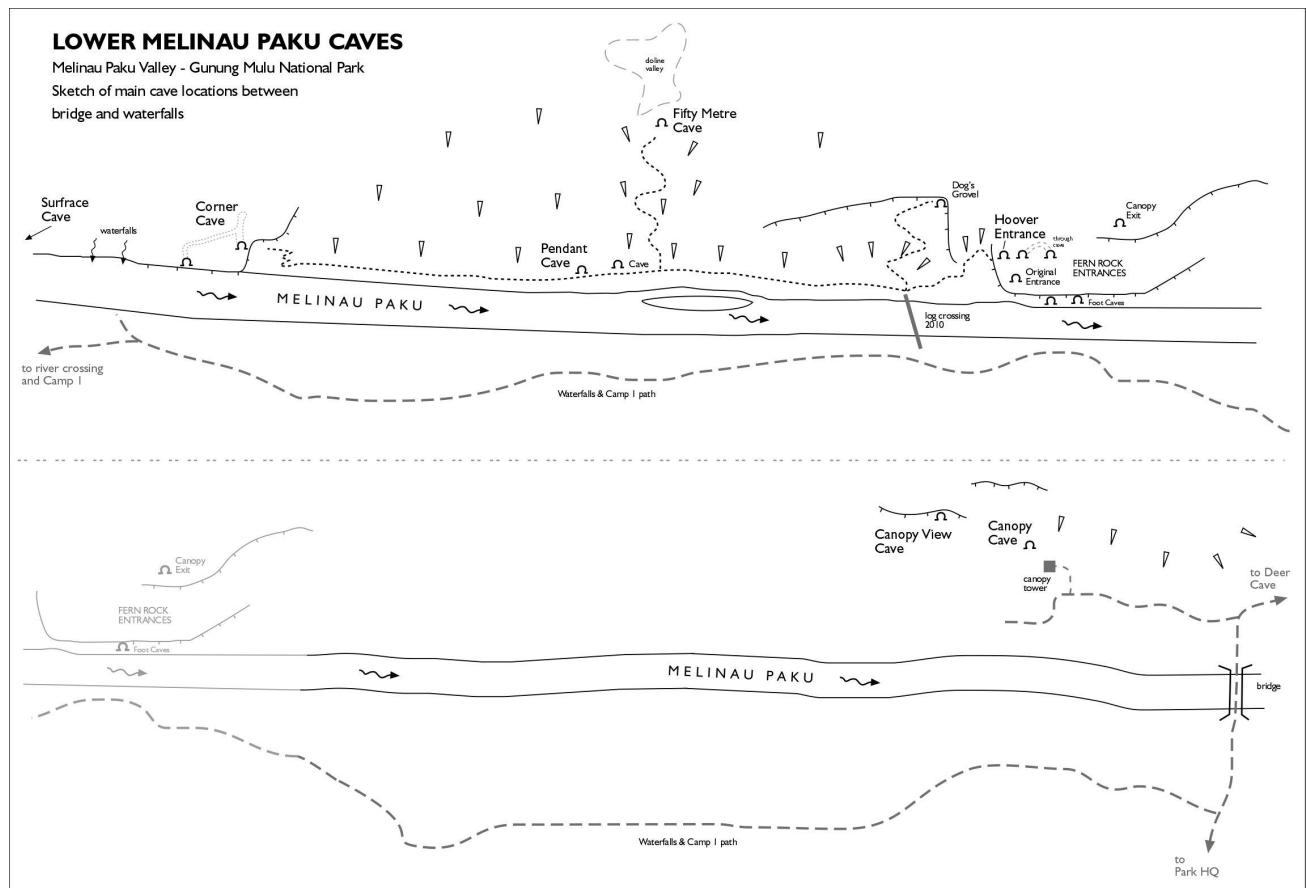


Figure 13: Caves of the Lower Melinau Paku Valley

Dog's Grovel – *Explored 7th May '10; Length 50m (Grade 1 survey only)*

Explored by Matt Kirby & Andy Eavis

Once across the bridge a short walk downstream leads to the base of the Fern Rock cliffs which form a tall buttress rising up from the river bank. The cliffs almost cut the riverside track so it is necessary to scramble along their base on rock ledges to continue downstream. Immediately before the cliffs a scramble up the slopes led to another cliff higher up and away from the river bank. This is overhanging and provided protection from a downpour which started as we arrived. In an alcove at the western end of this was a descending hole over rotting timber. This led into several small well decorated chambers with no draught and no way on. It is likely that this cave is a part of the complex entrance series of Fern Rock Cave but has been truncated by calcification. The cave was not surveyed.

Fern Rock Cave, Hoover Entrance – *Explored 18th & 23rd May '10; Length 160.97m*

Explored by Rambli Ahmad & Hugh St. Lawrence

Towards the end of the expedition Hugh and Rambli made a couple of brief exploratory forays to the cave. Initially the idea was to locate the climb up to the original entrance, based on the description in the '94 report. As the entrance cannot be seen from the approach it's all guesswork, and a vertical tree root traverse was abandoned in favour of a slightly easier ledge a few metres higher. This led onto a small ledge with a cave entrance that was mostly crawling for 30m to an exit a little further along the cliff. Backtracking through the cave we deduced we were too high for the main entrance and were about to get back into the forest for more investigation when a low entrance was spotted on the right. Sticking my head in this I was almost sucked into the mountain such was the inward (at that time) draught. We surveyed in and after about 60m of mostly small going reached an 8m pitch into a larger passage below. It was possible to climb down to a ledge at half height but the bottom was severely undercut and needed rope. The passage below seemed well trodden and looked likely to be the passage to the original entrance we had traversed on the previous visit.

We called our entrance the Hoover Entrance, but later reading of the '94 report made us think that this was probably what the '94 report calls the Hornbill Entrance and Ivy Passage. However, we only managed to survey 60m at most to the pitch head whereas the '94 report describes at least 100m of passage between the entrance and the pitch. That report also describes an offshoot passage to the left leading to a 3m drop into a larger passage which was not entered. We could find absolutely no trace of this offshoot passage, only a body size tube 10m long to a stal blockage. So there is a Hornbill/Hoover conundrum – are they one and the same? It would be useful to view the original survey data and compare with recent measurements.

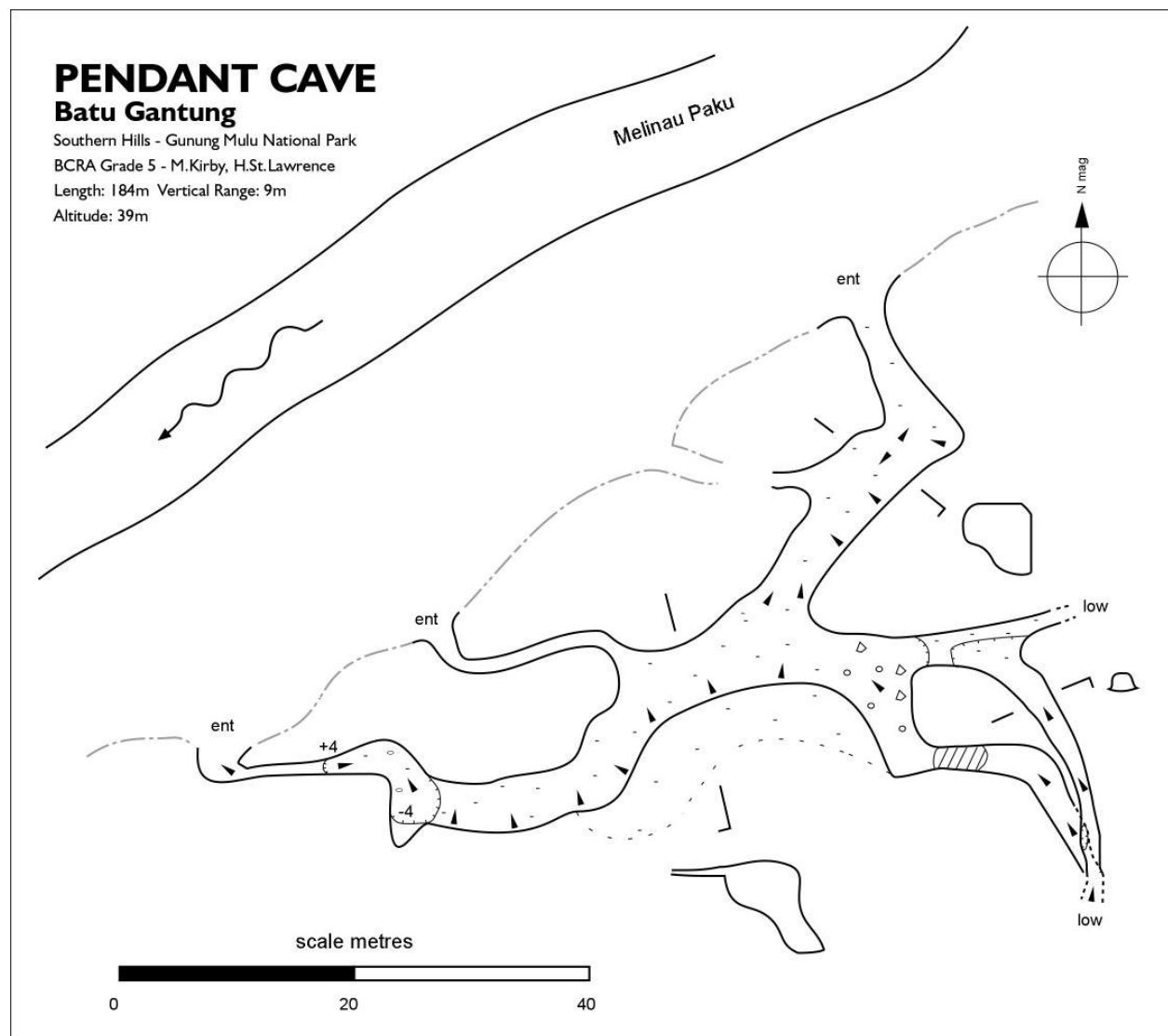
A couple of days later we returned with some rope and dropped the pitch into the main entrance passage. We then surveyed east down a passage which appeared unfollowed on the '94 survey – this was small and led to a T-junction, left going to calcited avens and right going down more muddy tubes to a pit. This pit was later reached from the other side by a small passage (which was on the old survey) from the 4-way junction, so we had closed a loop. The pit appears undescended still. Several other parts of the cave were visited; the top passage from the original entrance was followed, as per the original explorers (see '94 report) over holes in the floor to a final hole where the passage clearly continued beyond. This mirrors the '94 description and looks like a reasonable lead. We also visited the Roberts Highway area, particularly the big Z bend. The two 'dotted lines' on the old survey were inspected, one small and choking, the other a large descending tube to what appeared to be at least a 10m pitch, maybe more, into a lower level.

The latter is definitely worth a further look as the descending tube has big phreatic markings and the whole Z bend area is liberally coated in guano. A slight oddity of Fern Rock is that on three visits we experienced relatively little swift activity. There are indeed nests here and there, and the odd bird occasionally swooped past. But nowhere were swifts encountered in the kind of population which would lead nesters to brag in great scrawled graffiti, as they have done at the bottom of the pitch from Paris Cave, about hauls of 6kg or 10kg of nests. So, where are all the swifts? Does it suggest that there is a lot more cave in Fern Rock/Paris as yet unvisited by cavers?

Pendant Cave – *Explored 10th May '10; Length 183.59m*

Explored by Matt Kirby & Hugh St.Lawrence

Returning one evening from surface surveying, a dark opening was glimpsed on the south bank of the Paku half way between the waterfalls and the Fernrock entrances. The next day an easy walk up the south bank from the log crossing revealed several entrances. The first was 15m above the riverbank in an obvious rock promontory and was a descending 5m diameter tube to a choke. A couple of minutes beyond, back at river level, a rock bluff with large pendants contained several entrances to Pendant Cave.



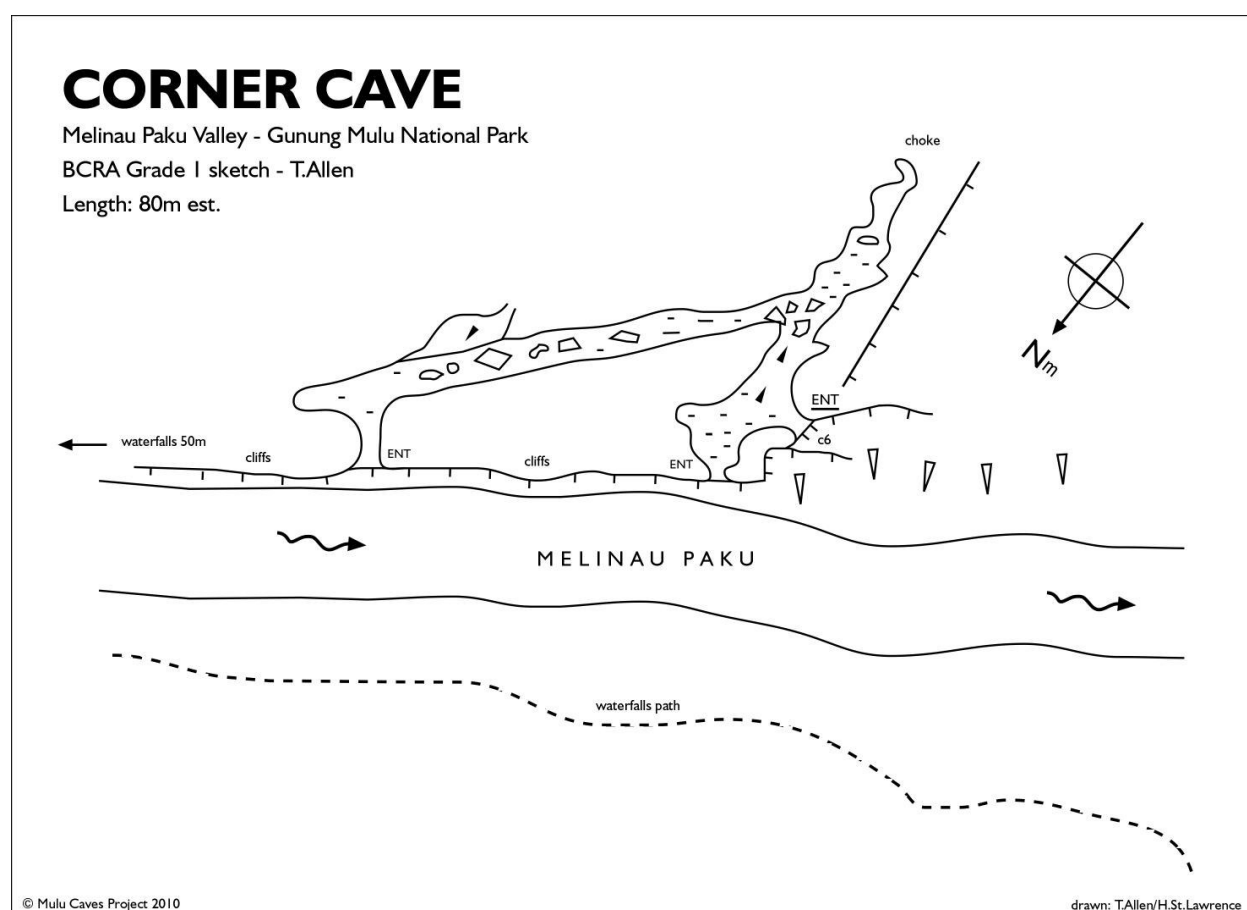
The largest entrance was the easternmost and led via easy walking in 3x8m passage to a junction with a larger passage parallel to the river and home to a large colony of bats. Turning left the easy passage passed a small passage on the left and degenerated into a crawl through pools until it got too tight just beyond a small shower from the roof. The source of the shower was reached via the earlier small passage on the left, a slide over a mudbank into an ascending phreatic tube which got too tight in a region of flowstone from which trickled a small stream which fell down a slot into the lower passage.

Back at the main junction the large passage was followed west, past a passage on the right (containing interesting flood marks on the wall) which led to the middle entrance, and continued to a 4m climb down into a pit. A scramble up the gravel wall on the far side led to a short flat out crawl and the third, westernmost entrance.

Corner Cave – Explored 17th May '10; Length 50m (Grade 1 survey only)

Explored by Tim Allen & Hugh St.Lawrence

Corner Cave had first been noted by Matt and Hugh about 100m downstream of the Paku waterfalls where the cliffs, which overhang the river, cut back into a corner. Approximately 30m up the cliff is a small cave entrance in the corner. The entrance could be approached on ledges from the west but the last 6m required bolting.



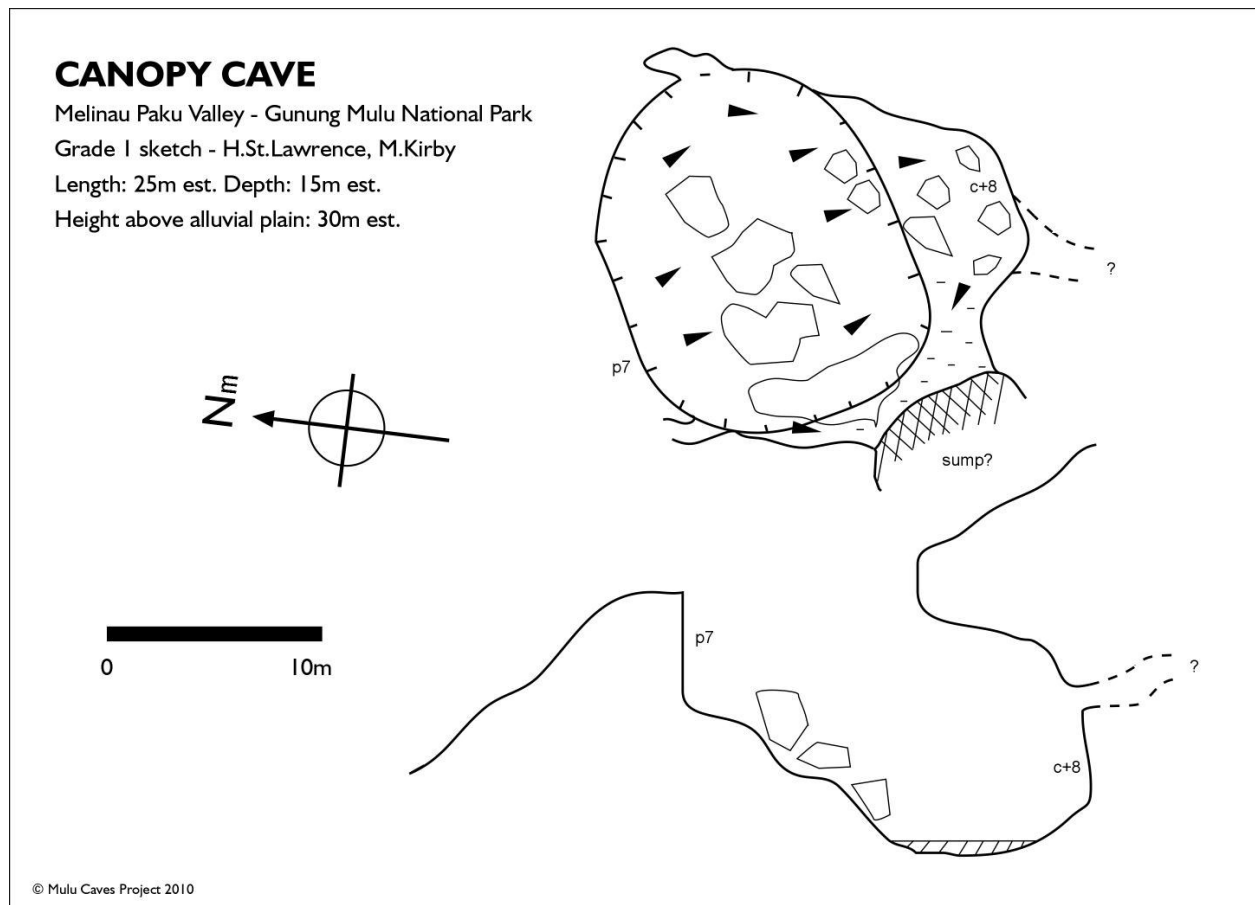
At a later date Tim joined Hugh to continue and gained access to the cave. This was larger than it looked due to the amount of speleothems blocking the passage. No footprints were evident in the main passage which quickly choked in mud and stal. A junction to the left followed a 2x5m

passage for approximately 40m to another entrance further along the cliff (in the direction of the waterfalls). It is thought likely that this entrance, just downstream of the waterfalls, is one which was entered, via a bold climb up vegetation, in 1990 by Park guide Robert Gani during a recce into the area with Matt and Liz Kirby. Due to the difficulties of re-rigging the climb for Hugh to ascend the cave was not surveyed.

Canopy Cave – Explored 9th May '10; Length 50m (Grade 1 survey only)
Explored by Matt Kirby, Hugh St.Lawrence & Pete Smart

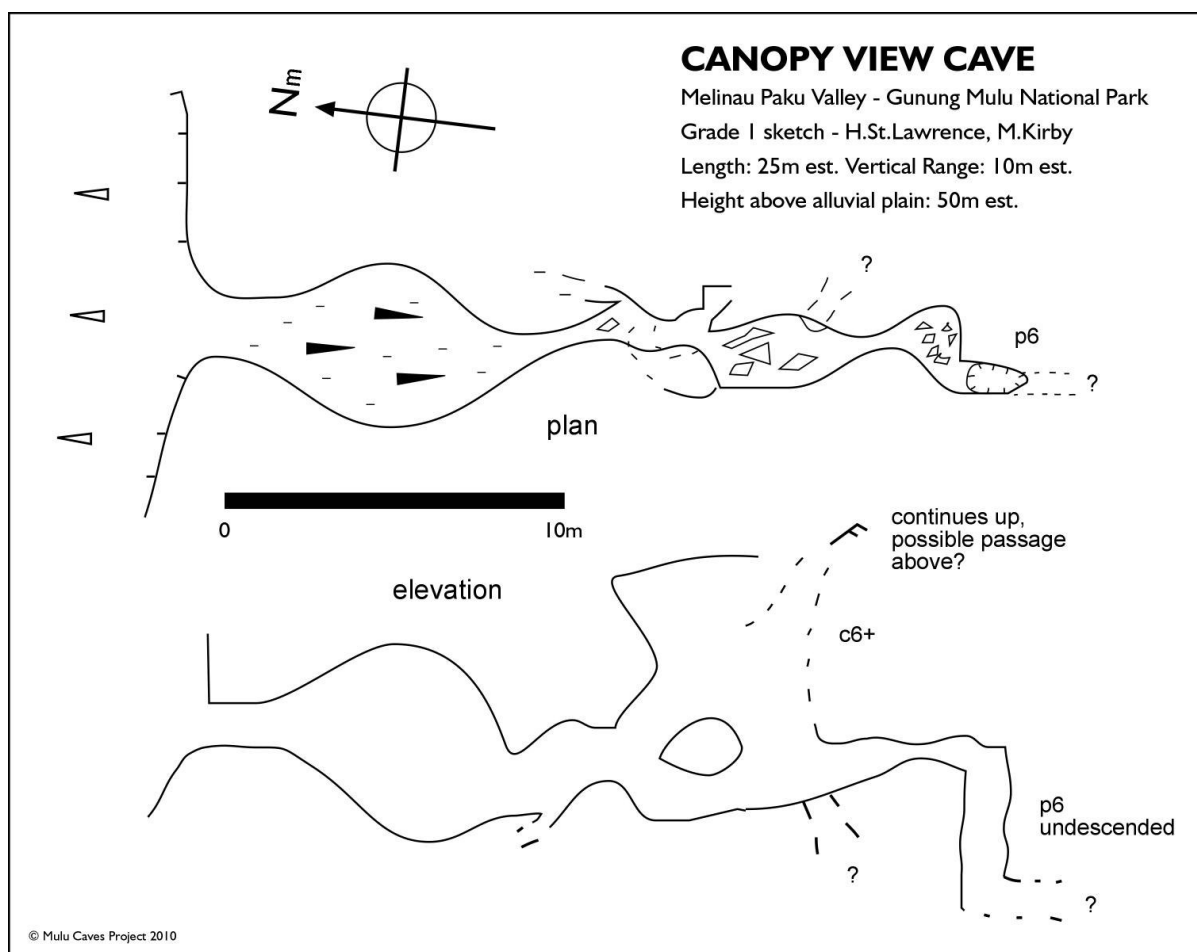
This cave was shown to us by park guide Syria Lejau and is just 20m uphill of the first 'tower' of the canopy walkway. Climbing the steps to the bottom of the wooden tower we then went uphill at 10 o'clock for just 20 metres or so to discover a large hole in the ground, entirely invisible from below or from the canopy walkway. An 8m pitch belayed to a handy fallen tree lands at the top of a slope of breakdown which can be descended on the left to where the way falls back right down a slippery mud slope to what appears to be a sump. The only way on appeared to be a possible passage at the top of a wall near the bottom which would require a 7m bolt climb to reach.

The sumps appears to be at river level and is probably a window into the extensive phreatic system which appears to run along this side of the hill and which resurges at various points between Deerwater Cave and the Paku bridge.



Canopy View Cave – Explored 8th May '10; Length 50m (Grade 1 survey only)
Explored by Matt Kirby & Hugh St.Lawrence

Straight uphill for 50m vertically from Canopy Cave is a large white cliff with some pits at its base but no caves. Descending northwards from the cliff, across the slope, a smaller cliff was reached with a small but strongly draughting entrance at its base. A mud floored portal chamber descends to a narrow rift which passes a small hole in the floor and enlarges slightly in a 1-2m wide rift aven. The draught appears to come down this rift and an attempt to climb it was made, but failed due to lack of holds and slippery walls. Several holes in the floor descend into loose rifts that were not fully explored, and an awkward flat out crawl at the end of the rift pops out above an undescended 6m pitch with a passage appearing to lead off the bottom.



Fifty Meter Cave – Explored 10th May '10; Length 50m (Grade 1 survey only)
Explored by Matt Kirby & Hugh St.Lawrence

Thinking that Pendant Cave might have larger 'parent' caves above it, we hacked up the slope above Pendant for a height of 100-150m. A shallow but steep gully routed us up through tree fall into a small doline valley beyond which was a col and a partial view down towards the Paris and Deer Cave areas. Just before the doline was reached a tiny cliff concealed an entrance. A 2x2m entrance passage led past tree roots and grew to 3x5m over rubbly breakdown and old stal. Just as the cave walls were becoming more solid the cave ended after approx 50m in a flowstone choke. A small hole in the flowstone was not passed and the cave may continue, but there was no noticeable draught.

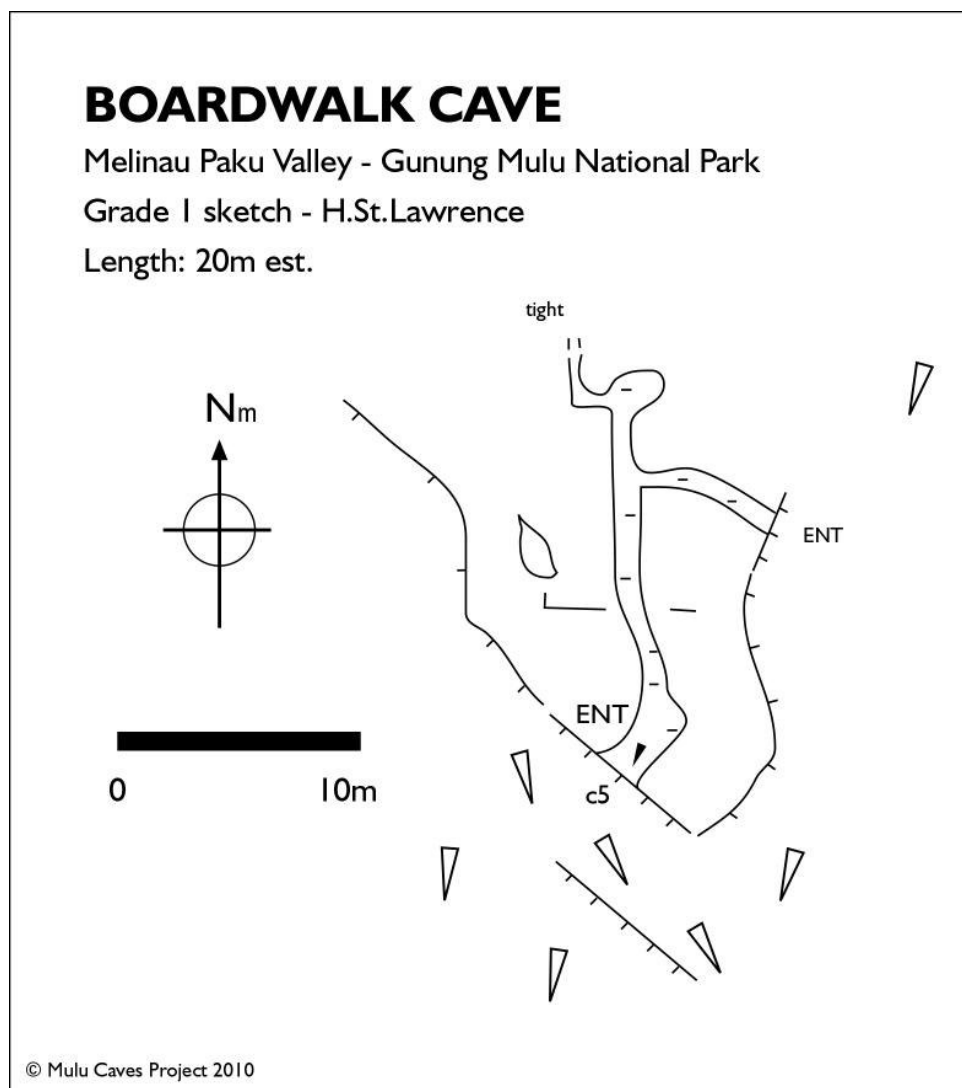
STONE HORSE AREA CAVES

After crossing the Melinau Paku bridge the Deer Cave boardwalk turns right and follows the foot-slopes of the Massif. Several small resurgences rise from the base of the slope and run under the boardwalk to flow into the main river. After five minutes a steep track leads up to Stone Horse Cave. The boardwalk continues round the northwest corner of the Massif, passing the dark entrance of Deerwater Cave, before arriving at the Bat Observatory.

Boardwalk Cave – *Explored 15th May '10; Length 20m (Grade 1 survey only)*

Explored by Hugh St.Lawrence

Nursing a not-fit-for-Green Cave ankle I returned through Deer Cave and set off back along the boardwalk. Halfway between Deerwater Cave and Stone Horse Cave, near the toe of the limestone block, a bluff of rock 15m above the boardwalk can be seen through the trees with a small entrance. Investigation via a slippery climb up revealed a second entrance and about 15m of stooping passage to where the way on became too narrow with no draught.



Black Hands Series; Paris Cave – Explored 11th May '10; Length 568.30m
Explored by Robbie Shone, Pete Smart & Gina Moseley

After passing through Stone Horse Cave, Andy and Pete exited via Entrance 4 which leads into a large doline. They then traversed the hillside trying to locate the entrance to Paris Cave. After dropping down into the doline following the obvious line, a steep climb up with a cliffed wall to the left led to a large cave entrance. Meanwhile Andy had apparently decided to search for high levels over Deer Cave, and was only called back with difficulty and after a frustratingly long time. An initial examination confirmed that this in all probability Paris Cave, but also revealed a passage to the right close to the entrance which was not marked, but had clearly been entered by nesters. Crawling along the right wall, over a sediment bank, led into a large passage with copious breakdown and with a further small entrance at the base of the same cliff.



Paris Cave entrance

Photo: Matt Kirby

The next day, Andy and Pete returned with Robbie and Gina to explore further and survey. Following the main passage to the left, a stalagmite blockage was avoided by traversing in the wall notch to the right. Thereafter, the passage continued with impressive dimensions and easy going to a junction.

To the right the passage continued large before terminating abruptly at a flowstone choke, probably close to the surface. At this point a small side passage behind stalagmite bosses along the right wall was later proven to loop back to the main passage prior to the junction. From the junction, the passage continued large and steeply down over breakdown before climbing a guano

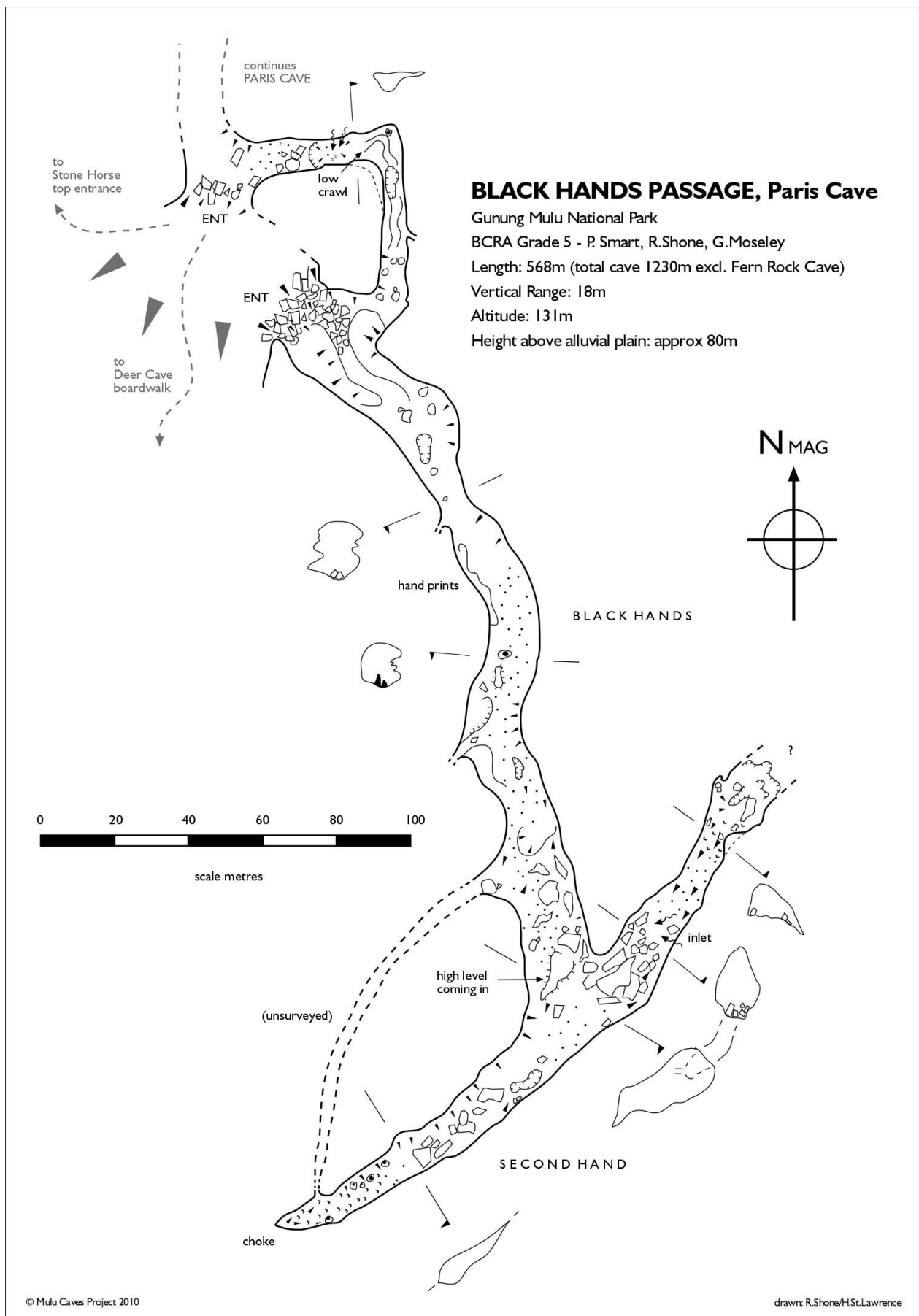
and breakdown slope to a col. At this point exploration was terminated, with Andy and Pete returning the next day. Above, and to the right, led to a 10 m shaft in the right hand wall of the passage. The initial approach is up a steep slope, but the vertical walls above offer no holds, and had previously been passed by nesters using poles, which now lay rotting, to a small (c 2 m diameter) tube clearly which offered a clear high level continuation. Climbing down to the left, and along the main passage from the col, Vadose flows left the cave through inaccessible boulder filled slots in the floor, but the passage continued up to the right to a small chamber at the base of an 8-10 m wall. Again, the phreatic passage roof could be seen to continue over the climb, with a large dark chamber beyond. Wading through knee deep wet guano to the base of the climb, a short pole was used to gain some height. Above there is a pocket which could be entered with aid (a jammed block and sling perhaps), followed by a couple of bold unprotected moves to easier ground beyond. The rock has, however, a quite friable crust. It is likely that the shaft also enters this chamber, and appears to have been the preferred access for the nesters. We spent some time watching swifts flying in the chamber, but differed as to whether what came in also went out the same way or whether they went elsewhere. This is a good lead with potential for large high level passage along the southern edge of the Deer Cave Massif.

The passage was named 'Black Hands' because the nesters have used black guano to make hand prints on the clean white limestone in the notch in the section of passage prior to the junction. These echo the glove hands sometimes encountered on the nester trails, and are I guess a warning: hands off! They have some affinities with Paleolithic art in the caves of northern Spain, where hands were stencilled on the rock walls by blowing coloured pigment through a straw.



Hand prints in Black Hands passage

Photo: Robbie Shone



UPPER PAKU VALLEY CAVES

Fourteen hundred meters upstream of the Waterfalls the Camp 1 trail crosses the Paku. The river crossing is a relatively open area which provides a clear view of part of the northern slopes of the Massif. The main trail heads northeast from here to Camp 1. The nature of the ground between the trail and the Massif is complex with dry stream beds, sinks and resurgences along the base of the slopes. Exploration attempted to unravel the complex nature of this area.

Big Cave – *Explored 17th May '10; Length 227.45m*

Explored by Pete Smart & Andy Eavis

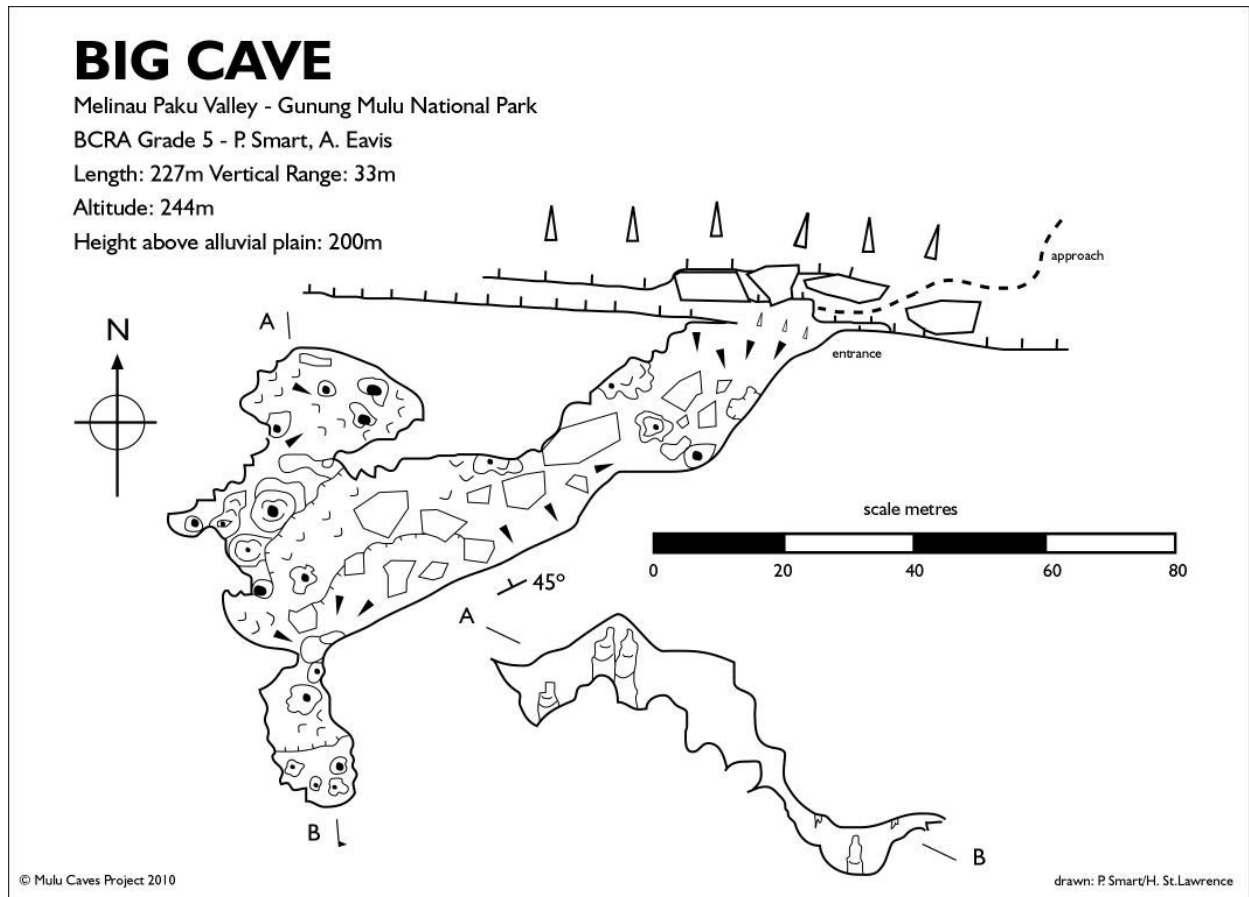
Andy and Pete started to search for caves on the northern flank of the Deer Cave massif at the prominent cliffed corner where the Melinau Paku swings in to the foot of the Deer Cave massif, just downstream of the Camp 1 trail crossing. The general objective was to relocate Daniel's Cave, but as entrances are known above the Melinau Paku immediately to the west of the corner, we kept an open mind on what we might find. Traversing at two different heights, Pete came across a cut track going steeply upslope, and whilst Andy continued to traverse along, Pete followed the track a considerable distance to easier ground on scree, with a white vertical rock face above, and also bounding to the right. Climbing detached blocks at the base of the cliff, an open entrance was found, low at first but increasing rapidly in size.



Big Cave entrance

Photo: Andy Eavis

The passage was explored steeply uphill over breakdown and rock to a speleothem barrier. On returning to the entrance, Andy was summoned, but found difficulty locating the track from his position, arriving after a considerable delay. Crawling through and then up inside the stalagmite barrier, a way into open passage was found at the eastern end of the cave, which appeared to by pass the stalagmite choke. However, next day after a short dog-leg to the north, this passage was also found to be sealed by speleothem. An additional way on down a hole in the floor of the main passage, lead down to a lower chamber, also stalagmite choked.



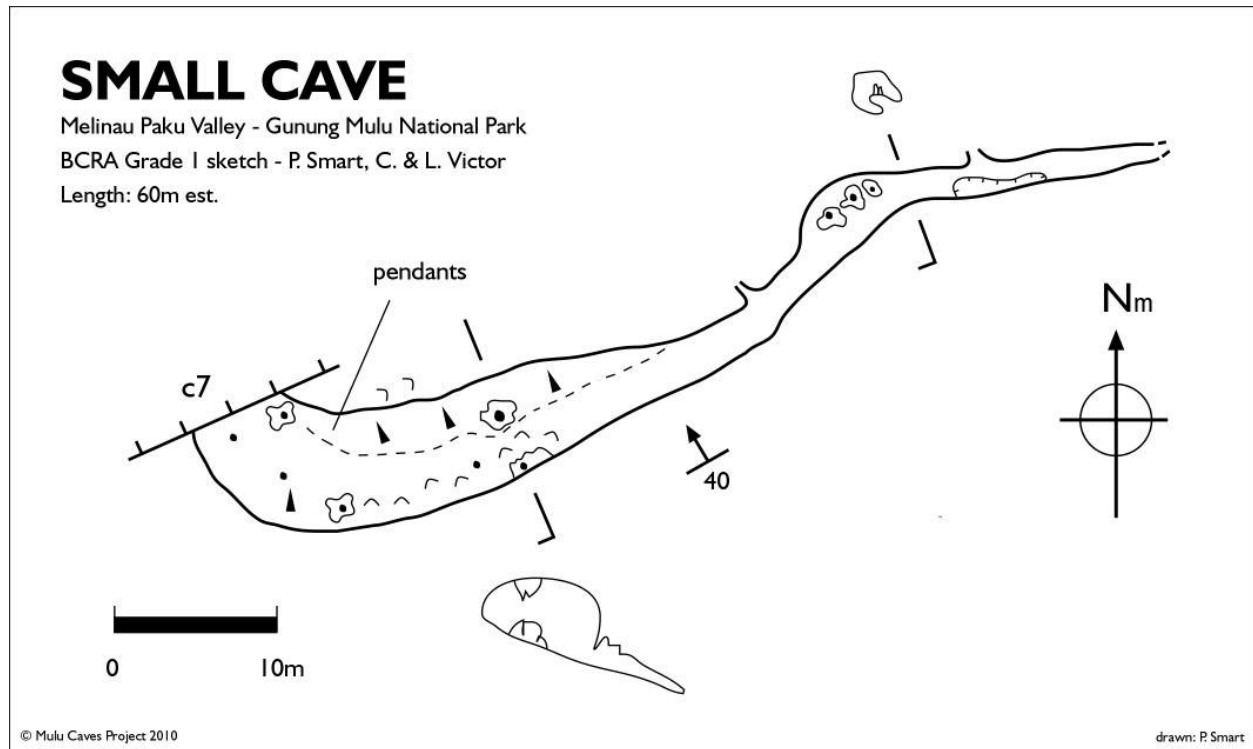
The cave is formed in the back wall of a rockslide on the slopes of the Deer Cave massif, which forms a prominent feature on some aerial photographs. The true size of the passage cannot be readily appreciated in the cave because it is in-filled by breakdown and huge volumes of speleothem. The section A-B is in fact a cross section through this single passage, which has a width of 60-70 m and a height of at least 40 m, the cave being truncated at an oblique angle by the cliff. There is only minor air movement in the cave, and no obvious howling drafts, so it's unlikely that an easy way over of through the speleothem choke will be found. The site has been extensively visited by nesters (hence the track and the warning glove adjacent to the river found later), but only a very few swifts were present and no evidence of nests when we visited.

The track may be relocated by following the tributary river along the basal slopes of the Deer Cave Massif for a distance of 210m. The track starts adjacent to a large buttress rooted tree on the slope-base alluvial plain where the river first swings away from the cliff foot. The first section of the track traverses obliquely and then steeply up on rocky slopes, and can be difficult to follow. Thereafter the gradient is easier on soil and scree to the base of the prominent cliff, the entrance being behind foundered blocks to the right.

Small Cave – Explored 20th May '10; Length 50m (Grade 1 survey only)

Explored by Pete Smart, Chris & Lucy Victor

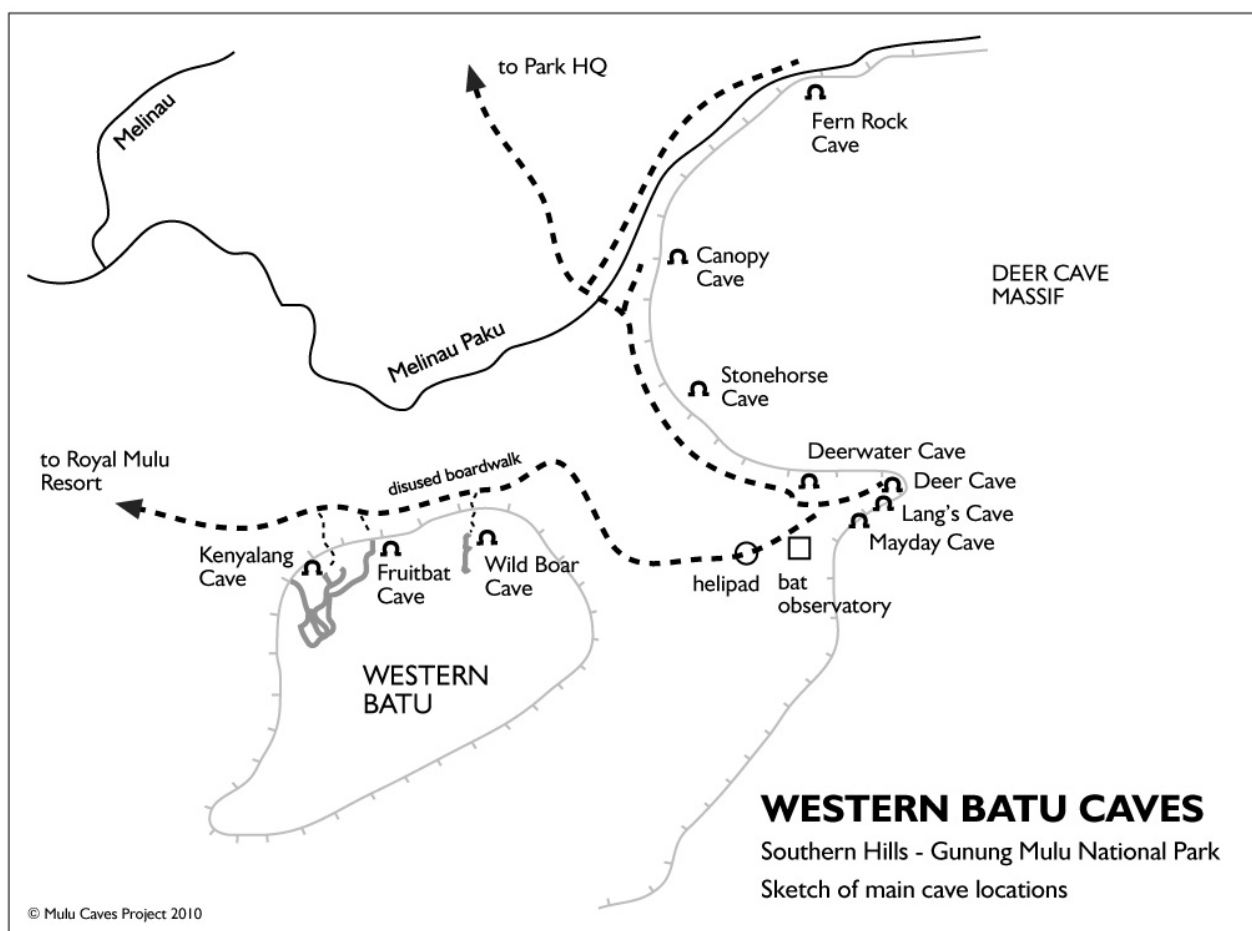
Directly below Batu Nigel a small but very steep marginal stream channel derived from the sandstone uplands is present. This can be followed along the limestone /terrace margin, with a series of tributaries flowing south off the terraces, to a choked stream sink with no underground access. The overflow channel continues along the flank of the hill. Three cave entrances are visible above the channel, the first can be entered after a 7 m climb.



It is a small hading predominantly strike oriented system with an under-storey of constricted down dip passages (not entered). The cave rises to a constricted termination with copious speleothem, and an increasingly alarmed flight of bats! This was not the ideal place to demonstrate the principles of cave survey. The second entrance is at the top of a c10 m cliff. It is small and would be difficult to enter safely, though Chris was keen to give it a go. The third entrance is obvious and some 8-10 m up a cliff face. Unlike the others it is not a simple phreatic opening, but appears to have some vertical vadose development. The cliff face is covered in a slimy grey green tufa, and all hold slope down dip towards the valley, not a pleasant prospect.

THE WESTERN BATU CAVES

As part of the surface survey project it was decided to tie in the isolated Batu to the south west of Deer Cave. Within the Batu are the known caves of Wild Boar, Fruit Bat and Kenyalang. These caves are well known locally and are used by the National Park for some types of adventure caving. As the Mulu Caves Project does not have any survey data on these caves it was decided to spend a day surveying the main route in each so that at least a portion of the caves could be represented on the master survey. A National Park guide kindly showed us the entrances as described below.

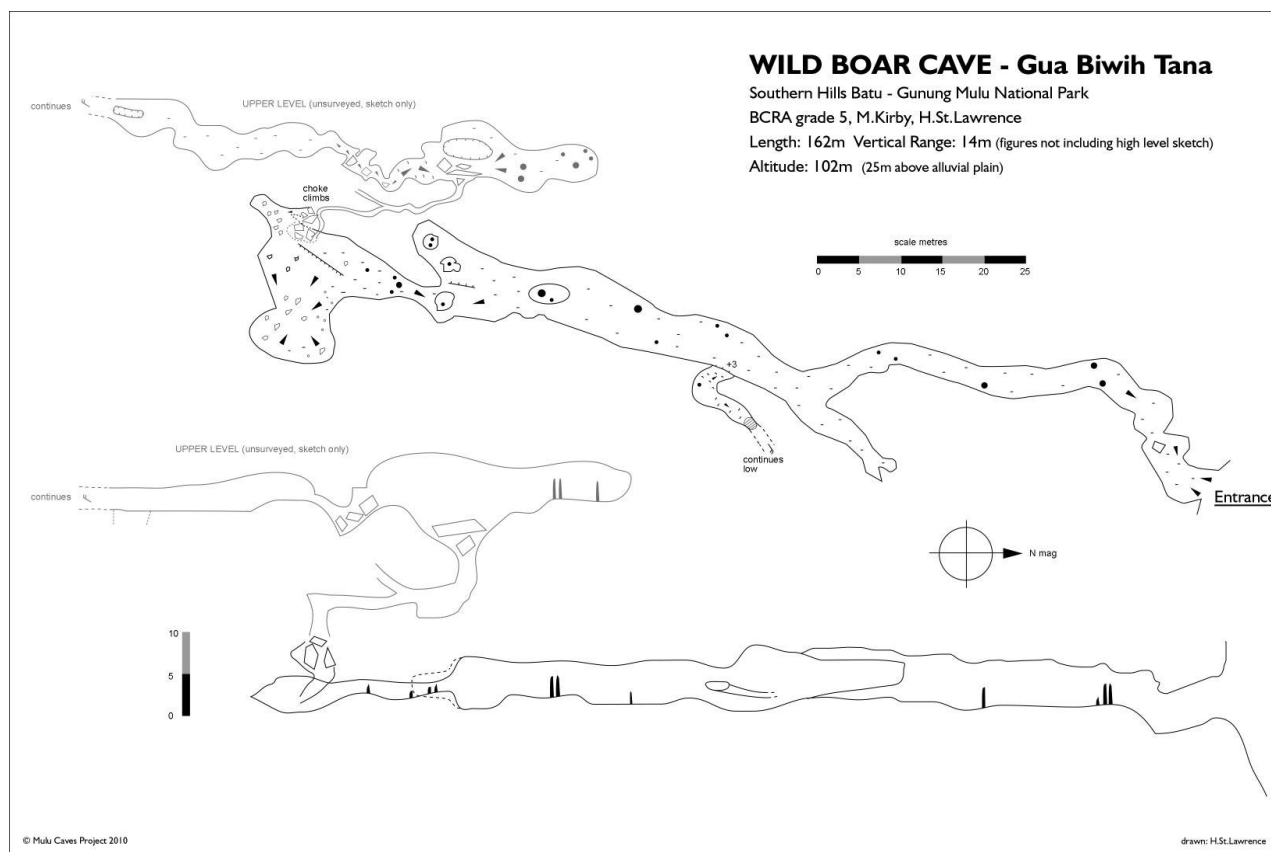


Wild Boar Cave – Explored 21st May '10; Length 168.20m

Explored by Matt Kirby & Hugh St.Lawrence

This cave is believed to be Peter's Cave as described in the Api 1994 expedition report.

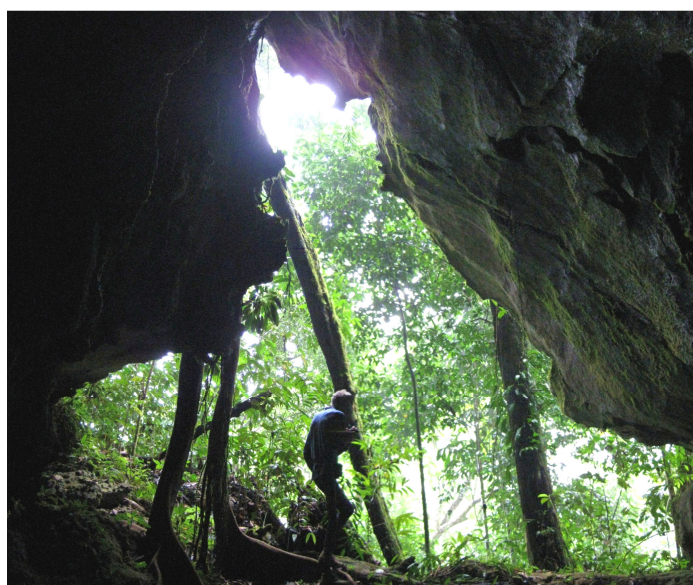
This cave is the easternmost of the trio of caves explored in the prominent batu west of the Park HQ to Deer Cave boardwalk. The well concealed entrance is about 30m above the plain and about ten minutes along the disused Deer Cave to Long Pala boardwalk west of the Deer Cave helipad. A sandy portal leads into easy passage 3x5m which soon arrives at a T junction. Left quickly chokes, but to the right the passage enlarges to a comfortable 5x8m between occasional flowstone and old stal. A climb on the left shortly after the T-junction leads to a pool and a small rising tube, not followed. The main passage continues easily until appearing to end in a choked area to the right, but a slot between columns on the left leads forward and down into a low wide chamber.



The only way out is an alcove to the right where a short ramp leads up into a choke of large boulders. Following one's nose up corkscrew climbs and tight slots lands in a drainpipe crawl for a few metres until another tube enters from above and the passage becomes a narrow .7m wide rift passage where thrutching and traversing for 15m reaches the bottom of a hole up into a sizeable well decorated chamber. To one side this chokes amongst large stal columns. To the left of entry a route up flowstone and then up and down bouldery holes following the draught eventually leads into a low, wide, flowstone floored passage with footmarks and arrows. This was followed as far as a prominent hole in the floor with the passage continuing beyond. At this point the solo explorer returned to rejoin his companion back at the choke climbs.

More passage than we traversed is described under the Peter's Cave description in the Api 1994 report. On the whole, our exploration, as far as we went, tallies with the 1994 description, although there are one or two anomalies.

Our experience of the upper series and access to it differs somewhat, so the various routes in the choke-climbs and all the upper passages should ideally be re-examined and re-surveyed in the future.



Wild Boar Cave entrance

Photo: Matt Kirby

Kenyalang Cave – Explored 21st May '10; Length 479.70m

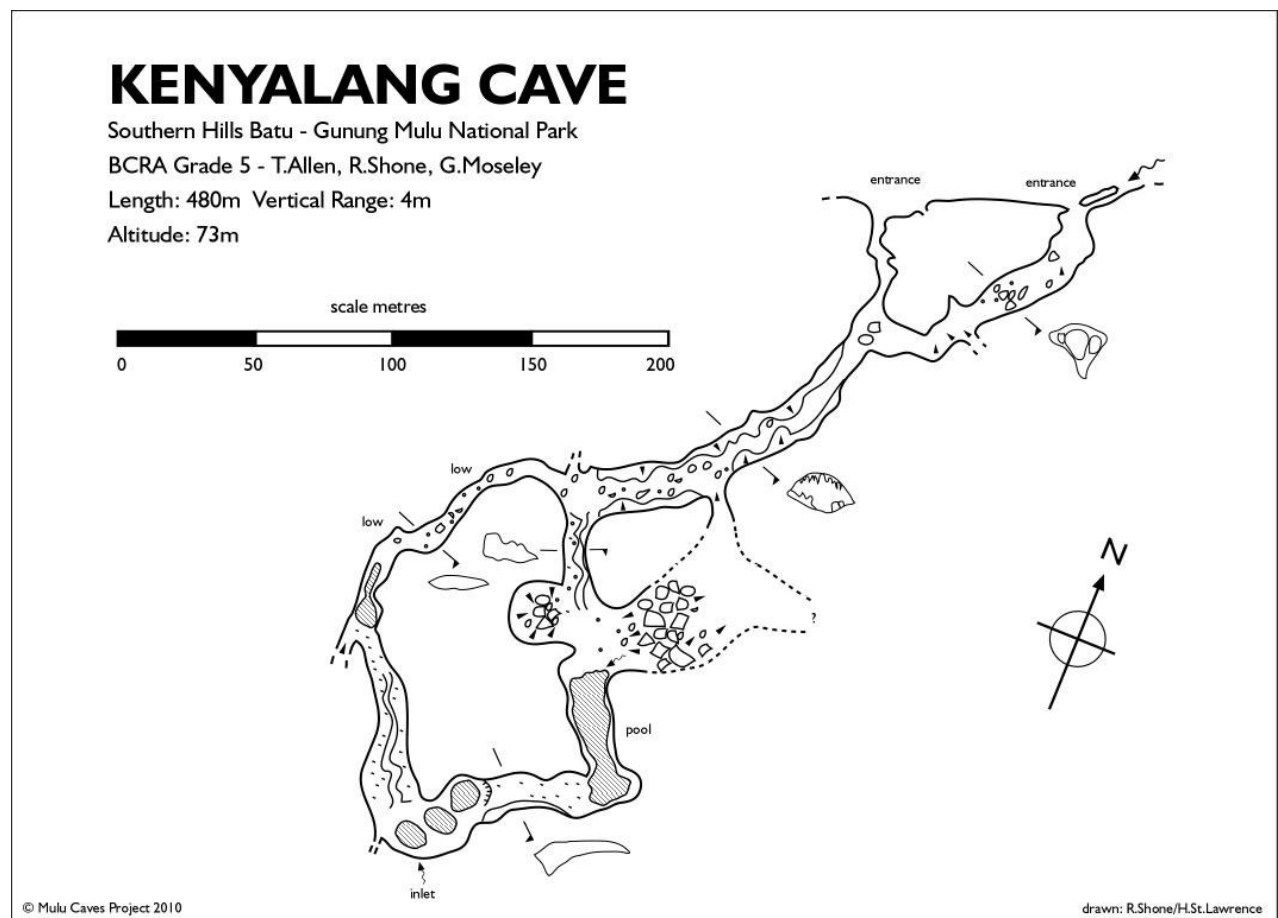
Explored by Tim Allen, Robbie Shone & Gina Moseley

The cave had reasonable proportions throughout and was heavily marked with guide wires and reflective markers. However, this led to some confusion as to the way on. A circular loop was located and a number of side passages were not explored. The survey was taken to another entrance. In all 470m were surveyed but the cave is obviously longer. In the future a full survey will need to be undertaken to measure its full extent.



Kenyalang Cave entrance

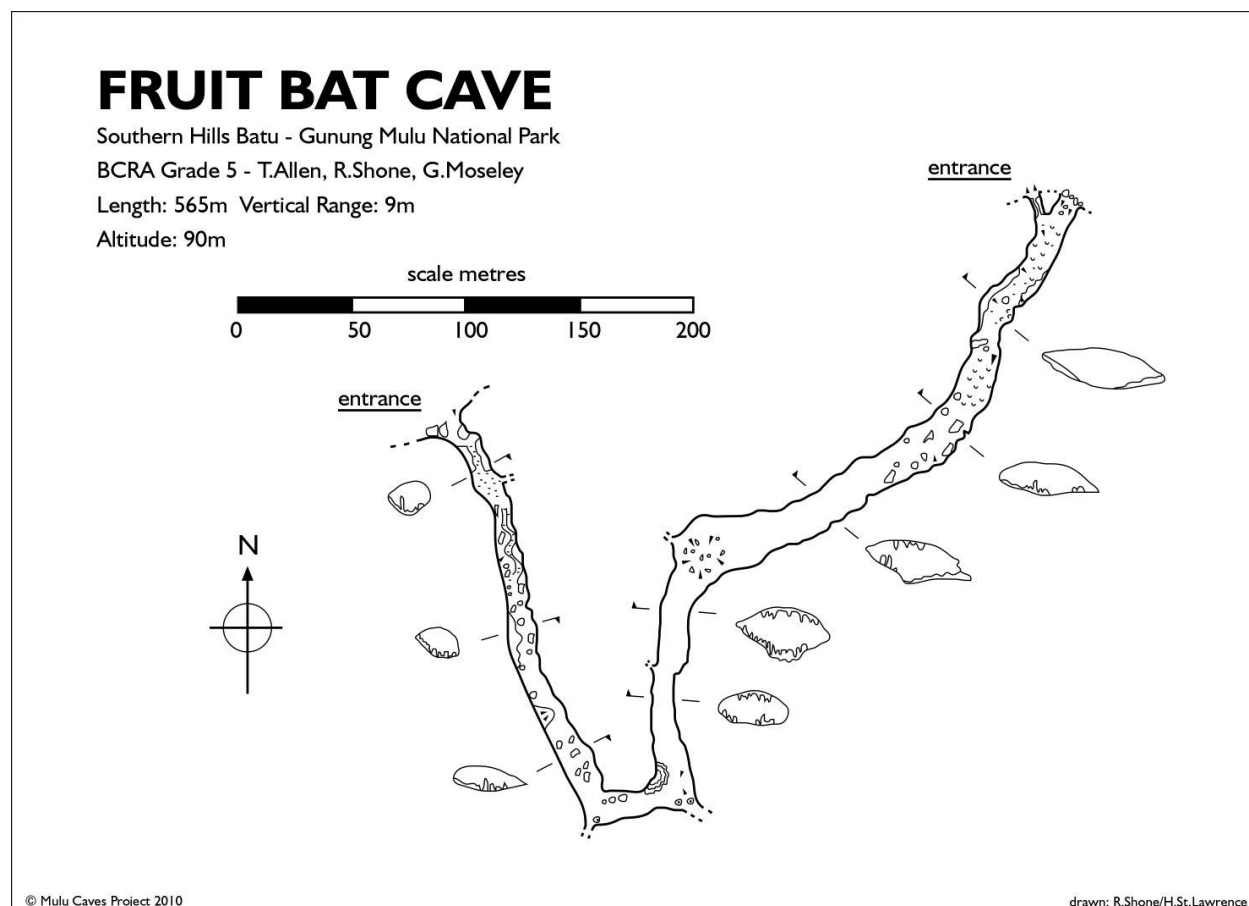
Photo: Matt Kirby



Fruit Bat Cave – Explored 21st May '10; Length 575.20m

Explored by Tim Allen, Robbie Shone & Gina Moseley

At a higher level, some 15m above Kenyalang Cave, is located Fruit Bat Cave. This is a larger passage which passes through the hill and exits at an overhang above Kenyalang. Again this cave is well marked for adventure groups. No side passages were explored and the through passage was surveyed at 500m in length.



OTHER INVESTIGATIONS

Fern Rock Cave (resurvey) – 11th May '10

Explored by Andy Eavis, Matt Kirby & Hugh St.Lawrence

Several visits were made to Fern Rock. The first, on 11th May, was with the purpose of resurveying a section of the cave so that it could be compared with the existing fake data – an anomaly existed somewhere in the Southern Hills dataset which caused the Fern Rock (and Daniels Cave) entrances sticking out of the hillside on the Survex wireframe survey.

In the absence of any surface survey data to interconnect the caves in the Southern Hills the positions of all the entrances had been based on the 1984 area plan and fake data fixed points. Deer Cave was the only cave which had a fixed point near its entrance and an interconnecting surface traverse, however, it had still been guesswork fixing the cave's fake data to this. The error had first manifested itself when Fern Rock entrances appeared to stick out of the terrain overlay. It was at first thought that this was due to a scaling error when the Fern Rock fake data was

constructed. There was some doubt about the accuracy of the scale bar on the plan and it was thought that this had caused the cave to appear larger than it was. The only way to prove, or disprove, this was to re-survey a section of cave between two known points.

Matt, Hugh and Andy travelled via Stone Horse and Paris caves and dropped the 25m pitch into the end of Fern Rock. As it was also important to locate the entrances, so that they could be tied in to the surface traverse, quite a bit of the cave was visited. Canopy Exit was located. This entrance opens onto a long ledge which stands high above the forest canopy and provides excellent views across the lower Paku valley. The Main entrance was also located and markers were left in both entrances so that they could be sighted from the waterfalls track. This was later successfully accomplished.

A resurvey of some of the main passages was then undertaken from the junction of Canopy Way with Roberts Highway back to the bottom of the pitch from Paris Cave. Later computation showed the fake data to closely match the re-survey, so the error was not in the Fern Rock data itself.



View from the Fern Rock Canopy exit ledge

Photo: Matt Kirby

Antler Passage; Deer Cave – 13th May '10

Investigated by Hugh St. Lawrence & Pete Smart

Dick Willis has always maintained that there must be a way on in Antler Passage, the high level which climbs up to the south half way through Deer Cave; and as he's an old friend I thought I better get one over on him by finding the passage he missed! So with photo trips beckoning, Hugh and I set off up the long climb, initially slippery over steep rock (with an equally slippery rope in place: care on the way down!), and then a plod up steep cascading dry guano, aided by cables put in to help the crew maintaining the cave lights. The view down into the cave from the top is stupendous, with towering formations on the brink of a vast drop down into the day lit main cave with tiny figures scurrying ant-like along the tourist trail. To the right at the top of the cables (past the 'Pheasant Rock' as named by Hugh), there are ways down through boulders, but no obvious way on or draft.

Climbing up and to the north, the towering columns can be surmounted to an area under the north wall. Here fragments of residual quartz gravel are found in drip pockets (sampled for cosmogenic

isotopes), attesting to a once more extensive clastic fill which has rotted and been removed by the drips waters over time. Searching along the rear (eastern wall), revealed a hole into a further small room rifting to the south. Without a rope it was not safe to descend, but there was no evidence for a strong draft (this is marked on the very detailed American survey of the cave, but they didn't enter the chamber). At the lowest point in the southern corner of the main passage, two possible leads were noted, one an overhanging climb into a horizontal opening and the other a small phreatic tube, which could be a diversion maze over the choke (neither of these is on the American survey). There was some sense of air movement but not a clear strong draft.

There is no doubt that Antler Passage is an early precursor to the lower level main Deer Cave passage from the Garden of Eden. It is very large, has a phreatic roof and contains the resistant quartz remaining from a once more extensive clastic gravel fill. The end of the passage is in fact a breakdown dome over a very substantial phreatic boulder choke with a vertical range of many tens of meters. There are spectacular and classic Mulu passage wall unloading rifts down the southern side of the choke, and the whole thing has been stabilised and infilled over an extended time by accumulation of the spectacular stalagmite columns. From Green Cave we were able to see the south eastern wall of the Garden of Eden, and there is a prominent high level break in the cliffs which may be the fossil sink for this stupendous passage. Whilst making the connection to this would be very satisfying, the additional cave would be quite short, and it is quite possible that there may be a substantial accumulation of gravels behind the Antler Passage choke which might greatly restrict its true substantial vertical extent.



Looking up the Antler Passage slope

Photo: Matt Kirby

Mayday Cave – 14th May '10

Investigated by Tim Allen & Hugh St.Lawrence

Mayday Cave was explored in 1978 and has probably not had many visits since that time. It is 900m long and appears on the same survey as Deer Cave which dwarfs it. However, it has a significant section of passage nearly 40m wide so was thought to be worthy of re-investigation. The entrance was located and tied into the surface survey and Tim and Hugh spent an afternoon re-exploring. All the passage on the survey was found to be accurate with very few possibilities for extension. There was one high level passage in the roof where the lower passage ascended up into the higher passage. This would need bolt climbing equipment and was not attempted.

Racer Cave Sump – 16th May '10

Investigated by Tim Allen & Hugh St.Lawrence

Racer Cave sits between Cave of the Winds and Lagans Cave and even passes over the top of the latter. The most likely connections looked like they would come from the higher levels but these seem to have been truncated by surface erosion. Despite a number of searches during past expeditions no connection could be found to either cave. A careful study of the survey revealed a short section of streamway below a pitch at the far end of the lower series. The stream was shown to sump both up and down stream and caused speculation that this could be a diving prospect for future trips. Connecting the three caves together would add nearly 10km to the Clearwater System total; a tantalising prospect.



Racer Cave entrance

Photo: Robbie Shone

During a photography and sample collecting trip Tim and Hugh located the pitch down at the end of the main level. The pitch was marked as 23m deep but a 38m rope was only just long enough for the first sloping section and the muddy 2m vertical drop which followed. Just beyond was a window onto a further 10m ramp which had to be free climbed down to the stream. The volume of water was considerable but the passage was immature. Upstream got too small but had a possible climb up a ramp which might by-pass the blockage. Downstream the roof dipped to a small duck and probable sump beyond. Neither route looked possible for diving so the chances of a connection look even more remote.

Surface Searching from Camp 1 – 19th - 21st May '10

Investigated by Andy Eavis, Pete Smart, Rambli Ahmad, Chris & Lucy Victor and Manny

Having tired of the plod back to Park HQ each night, Andy and Pete opted to work from Camp 1. A small five person team headed out for a two night camp and made best use of the manpower.

Day 1:

On arrival Andy, Rambli and Manny crossed the river and went directly to the limestone outcrop. They then followed the cliff line steeply upwards where very soon the contact between the underlying shale and the limestone was reached. The contact, in appearance, is exactly the same as that behind Mount Api and Mount Benarat. It is remarkably devoid of cave features and was followed for about half a kilometer steeply climbing to an altimeter reading of 369 metres, well above Camp 1. The terrain was quite rugged but the vegetation was easy, however, rain and impending darkness stopped progress. It would definitely be worth continuing along here at some time in the future. The torrential rain did produce high river levels so crossing back to Camp 1 proved to be an interesting exercise. This river responds rapidly to heavy rain.

Meanwhile Pete, Chris and Lucy returned to a point where the Camp 1 track was nearest to Batu Nigel (the tower at the north eastern end of the Deer Cave Massif). They then cut a track towards the limestone, and were surprised to encounter a steep boulder bedded stream running westwards parallel to the river at Camp 1. Andy also encountered this stream when traversing across to the limestone. Subsequently Tim reported that when returning from the northern entrance of Green Cave to Park Headquarters, they had also encountered this stream bed which, apart from long pools, had been dry at the time. Its course led to the Camp 1 track. This is perhaps similar to the stream sinks in the lower course of the Melinau Paku below the first crossing, where water also sinks, presumably into the limestone. It is unlikely that entrance to any caves will be possible because of the copious boulders derived from the sandstones of Mulu Formation which mask the underlying limestone, and form high terraces.

Day 2:

Returning the next day, the edge of the massif was reached directly below Batu Nigel. At this point a small but very steep marginal stream channel derived from the sandstone uplands is present. This sinks in the limestone cliff after a short distance, but the overflow course can be followed along the limestone /terrace margin, with four tributaries flowing south off the terraces, to a choked stream sink with no underground access. The overflow channel again continues along the flank of the hill. Three cave entrances are visible above the channel, the first entrance is obvious and some 8-10 m up a cliff face just before the second marginal sink. Unlike the others it is not a simple phreatic opening, but appears to have some vertical vadose development. The cliff face is covered in a slimy grey green tufa, and all hand-holds slope down dip towards the valley, not a pleasant prospect for climbing. The second is found just after the second sink, and can be entered after a 7 m climb (see Small Cave description in Exploration section above).

The face of the Deer Cave massif in this area is broken by a series of major north-east- south west joint or fault guided faces. On some aerial photographs these appear to form sinks, but searching demonstrates that the main joint face is fronted by scree and steep rock ramps which fall to the valley floor, and lack obvious cave entrances. However, it is somewhere in this vicinity that the Melinau Paku entrance to Green Cave is located. Unfortunately no markers to its position were left by the party which had previously traversed this route earlier in the expedition, although some marks on the track they used were encountered along the marginal drainage system.

The lack of a significant marginal cave system in this area is probably due to the relatively steep slope of the terrace's surface in this proximal part of the fan system. In contrast, the Clearwater marginal drainage (Blackrock, Imperial, Metric, Goldwater caves etc.) is in the more distal part of the fan, gradients are lower and there is a greater head advantage in the underground compared to surface flow route.

Whilst Pete was moving south and west along the margin of the Deer Cave massif, Andy, Rambli and Manny went down the summit track to the river crossing and then to the start of the path up to Big Cave. They then cut a track along the bottom of the cliff. After 300 to 400 metres they found an old track and followed it up the cliff line. Eventually they went steeply up the cliff and traversed back to the west at an altitude of about 80 metres. After 150 metres an entrance was found. This had a big draft and snake tracks, and eventually Rambli and Andy realised it was the entrance to Daniel's Cave. After a reconnaissance in for a couple of hundred metres it was decided to leave further exploration and the surface survey until the following day. They then met Pete pretty much at the corner where the margin of the massif turns to the northeast.

Day 3:

Next day, the surface survey was progressed from the Big Cave big tree to the east along the margin of the massif. Some 400 m from the Melinau Paku junction and cliffed corner, a resurgence was encountered which appeared at first to be from slope derived debris. Following the discontinuous overflow channel upstream, several windows into the subterranean flow system were encountered as pools incised into the terrace gravels. But after a short distance the near dry course of the marginal drainage system was present. Crossing this towards the hillside onto a lozenge shaped terrace remnant, a large cave entrance high above the river was seen; this was Daniel's Cave. The entrance was reached via a scramble up steep rock and blocks to a short but steep wall immediately below the cave entrance, care needed on descent. From the main entrance, a traverse to the right (facing the cliff) apparently leads to a second tight entrance be spoiled by the detritus of nesters.

Daniel's Cave – 21st May '10

Investigated by Pete Smart, Andy Eavis, Rambli Ahmad, Chris & Lucy Victor

Daniel's Cave was discovered during the Sarawak '84 expedition its main entrance lying approximately half a kilometre west of Green Cave's northern entrance. The cave runs east-west to a second entrance which stands high above the river crossing on the Camp 1 trail. Although the second entrance is closer to Park headquarters its small size would make it a near impossible task to find from outside. Andy Eavis was the only team member who had visited the cave but that was 26 years previously in 1984. It was known that re-locating the main entrance would not be easy.

The cave is initially an easy walk on sediment fill, but further into the cave care is needed as there are holes in the sediment floor which require care in traversing. The western termination of the cave is a complex stalagmited choke, with a single entrance high in the wall of the final chamber. The climb to this is problematic, being on a grey slick calcite, so an overview to locate the position of this entrance was not gained. A rope and protection would be needed in any future visit. There was no evidence of any other exit, although only a cursory inspection was made.

The 1984 survey marks two points in the cave where higher level passage was thought to have been encountered. The second of these is simply a high phreatic rift, and there is little evidence for a laterally continuous high level at this point. The alcove to the left should, however, be checked by a roped climb using suitable protection (stalagmite slope to lip). The first high level definitely offers more promise. The passage climbs from the ceiling of the main passage with a

phreatic roof, the floor climbing steeply up over breakdown. What is marked on the survey as a possible passage to the left appears, with the aid of a high powered Scurion light, to be a blind alcove with solid walls. There also appears to be no high level outlet above the connecting passage to the main cave. However, following round parallel to the main passage a steep wall is encountered, some parts of which are bedrock and some an eroded sediment filled boulder choke. Some 15 m above there is an echoing void. There is a possible route to gain some height by free climbing on stalagmites on the left hand wall, but thereafter aid will be needed to traverse right into the high level opening. Alternatively a full frontal attack up the initially overhanging face on the right may be more efficient for someone skilled in bolting.



Roof pendants in Daniel's Cave main passage

Photo: Andy Eavis

The main passage in Daniel's Cave represents a typical Mulu aggradational notch. However, this appears to be superimposed onto a high amplitude deep phreatic system developed along a series of joint or fault guided rifts. Above the main level, gravels are not ubiquitous, but at and below this level there has been extensive fill of the original phreatic voids. This includes a series of spectacular narrow joint rifts below the notch floor in the main passage, which have been revealed by subsequent excavation of the gravels into the lower levels (not visited but accessed by nesters from the signs). Large scallops in the wall indicate that flow came from this high level to the lower part of the cave. This is opposite to the direction of gravel imbrication in the main passage, which is towards the southern (inaccessible) entrance. Nesters do not appear to have made the climb into the first high level. There is a possibility that the chamber at the top of the first high level is a closed dome, but given the size and the presence of gravels in the boulder choke, there seems to be good potential for further cave exploration at this level.



Crossing the flooded Paku River on the return from Daniel's Cave

Photo: Andy Eavis

Clearwater; Southern High Levels – 24th May '10

Investigated by Pete Smart, Gina Moseley & Andy Eavis

The discovery of Whiterock Cave has revealed a complex multilayered development with its highest passages being on the 230m horizon. Repeated attempts to find horizontal development above this level have proven to be unsuccessful although ramps do extend beyond this height and up to 350m. In southern Clearwater horizontal passages exist on the 290m horizon, these are in the Heavens Gate area. In order to establish whether this development is unique to the southern parts of the system, or whether there is chance of the same developmental horizon extending northwards into Whiterock, a small team visited the area. The opportunity was taken to carry out sampling in this rarely visited, high level area.

Some words required from PLS?

Sarawak Chamber 3D Laser Survey

Although it had been an aim of the expedition to carry out a three dimensional survey of Sarawak Chamber this was abandoned before the team left the UK owing to the non-availability of the necessary laser scanning equipment. This task has been postponed until the 20011 expedition.

Sarawak Chamber Photography

The last photograph of Sarawak Chamber was Jerry Wooldridge's stunning image taken during the 1984 expedition. Since then the Project had not revisited the chamber with this aim. It had

been planned to take advantage of the 3D survey trip into Sarawak Chamber and to make best use of the manpower by attempting to photograph it using modern digital equipment. Unfortunately with the abandonment of the laser scanning it was seen as a considerable drain on the available manpower and limited time in the field to attempt this as a sole objective. In addition, weather conditions had not been favourable and local advice suggested that the high water levels which were being experienced had the potential to make the Nasib Bagus streamway impassable. Instead, it was thought a better use of the limited time to concentrate on the other objectives and postpone this project until the 2011 expedition.

OTHER FINDS

Archaeological feature

During the course of the expedition a cave entrance was found which contained features which may be of archaeological interest. This was reported to Park Management and no further action was taken.

CONCLUSIONS

Although small in scale the achievements of this expedition provided a vast amount of data, photographic records and furthered the understanding of the area.

Volunteers?

EXPEDITION MEMBERS



The 2011 Team

Photo: Robbie Shone

Andy Eavis, Rambli Ahmad, Dr. Pete Smart, Matt Kirby, Hugh St Lawrence, Veno Enar, Gina Moseley, Tim Allen (Leader), Robbie Shone

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APPENDICES



Stalagmite curtains in Racer Cave

Photo: Robbie Shone

The expedition took place between 3rd May and 25th May 2010 and should have involved eight members for the duration. Unfortunately, a number of different circumstances conspired to delay the arrival of three members and prevented one joining the expedition at all.

Expedition members flew out from the UK on Emirates Airline which offers 30kg baggage allowance as standard which was necessary for our equipment. Arriving in Kuala Lumpur the team transferred to the low cost terminal to catch an Airasia flight to Miri. The advance team bought supplies in Miri with the help of our local support crew and air freighted the goods up to Mulu before following on the commercial flight.

Field logistics for the 2010 expedition were simple due to our base location at National Park Headquarters. For the duration of the trip we shared the impressive Research Centre as our base. This has a large air-conditioned working area together with 4 x four person bedrooms, two bathrooms, a kitchen and plenty of outside drying areas.

The vast majority of the field work was undertaken in day trips from HQ. Three members of the team spent two nights at Camp 1 where they were supported by our local crew and three others overnighted in Clearwater to gain access for work in the high levels.

As has always been the case in Mulu, the team worked positively with the National Park staff and the local community. Due to our long experience in Mulu we were able to have a minimal impact on National Park resources.



The Waterfalls on the Paku River just below Surfrace Cave resurgence

Photo: Hugh St Lawrence

Appendix 2; **The Largest Cave on Earth – Tim Allen**

Deer Cave – the largest single cave passage in the world?

Introduction

For many years it has been accepted by speleologists that Deer Cave is one of, if not the largest single cave passage in the world. In 2009 an expedition to Vietnam claimed to have discovered an even larger cave passage, Hang Son Dong. This was widely reported in the press and the discoverers returned to the cave in 2010 with professional photographers and film makers to make a feature article and documentary for National Geographic Magazine and television. Anecdotal evidence from several members of the Vietnam expedition team suggested that the dimensions of the cave had been exaggerated. In order to assist the National Park authorities with the promotion of Mulu the Mulu Caves Project has tried to make sense of these claims and report the known facts.



Looking into Deer Cave's vast northern entrance

Photo: Robbie Shone

Background.

During the 1978 Royal Geographical Society Expedition, the first cavers to explore Deer Cave stated, "This is undoubtedly one of the world's speleological wonders, for our survey showed that the monstrous passage was 174m wide and 122m high in one section. It is nowhere less than 90m wide and high and it passes right through the mountain for a distance of one kilometre."

The 1978 expedition report came to the following conclusion; "...it is a strong contender for the title of the largest cave passage in the world."

As time went on it became clear that Deer Cave did indeed contain the largest genuine cave passage in the world. A further survey in 2009, undertaken by the Hoffman Institute of Western Kentucky University, confirmed the dimensions.

The 2009 survey effort reported an increased overall passage length of 4.1 kilometres and a connection to Langs Cave, another show cave within the park. The maximum cross sectional area was in the large southern passage. This was documented at 169m wide with a ceiling height of 125m and is consistent with the RGS survey. The northern passage registered the greatest ceiling height at 148m with a cross sectional width of 140m. The main entrance of Deer Cave was measured at 146m and the Garden of Eden Entrance was measured to be 140m in width. The survey revealed the existence of an un-ascended 305 meter high aven in the roof of the upstream passage. The highest elevation roof passage was measured at 226m above the main cave trail.

Best of all, this speleological wonder can be seen by all visitors to Gunung Mulu National Park. It is only a short walk from the accommodation at Park Headquarters along a raised plank walk to the great cave entrance. Every evening a spectacular natural event takes place here, when millions of bats leave their roosts and exit the cave in great snaking streams across the sky, on their way to distant feeding grounds.

The Vietnam Discovery

In early 2009, a team caving in Vietnam claimed to have discovered an even greater cave passage, Hang Son Dong. This was excitedly published in newspapers and National Geographic film and magazine became interested. For a while the Vietnam discovery became an accepted truth as the 'world's largest cave', and a documentary film and major article for National Geographic were made in 2010. Rumours started amongst international cavers that the size of Hang Son Dong had been exaggerated. It was noted that the expedition never managed to produce any factual evidence to demonstrate that Hang Son Dong was as large as Deer Cave.

The expedition did publish a BCRA Grade 5C survey in 2009 but scaling from this survey does not show any passage larger than Deer Cave. In fact the largest part of the cave is a collapsed doline and could not be considered part of a single cave passage. It has also been claimed that Hang Son Dong is larger because it is longer. This is mixing two different types of measurement and does not take into account the very many longer caves in the world such as the Clearwater System (176km) or the Mammoth Cave System (627km). The survey shows that Hang Son Dong is not a single passage for its entire length, but is split into three by two large collapse dolines as emphasized on the comparison sketch (fig ??).

In correspondence the Vietnam expedition has described two sections of passage as the largest in the cave. 'Passendael' at 150x150m for 1.2km, and 'The Hand of Dog' at 150m high and 120m wide for 800m. Neither of these claims are substantiated by fact, either from the survey or further correspondence with the expedition surveyor. He has stated that in Passendael, for example, they only managed to take one height measurement. This was taken at a prominent pitch and measured 149m. This 'pitch' location has been shown in

photographs where it is clear that the width at the same location is less than 50m. Further down the passage the survey shows it to be much wider, but here both the survey, and evidence from members of the team, suggest it is much lower in the order of 80-100m. Similarly, in the passage around the 'Hand of Dog' the stated individual measurements are less than the overall claim.

The evidence suggests that the facts behind the claims of Hang Son Dong reveal a large cave but not of the scale of the large sections of Deer Cave. Perhaps the best judgment comes from two explorers who traveled directly between the two caves in 2009 and 2010. In their separate opinions there is no part of Hang Son Dong that is bigger than the main passage of Deer Cave. Undoubtedly both are magnificent caves; Hang Son Dong with its amazing formations, skylights and underground forests, Deer Cave, more featureless but with its incredible daily bat flights. No judgment is being made on magnificence, beauty or brilliance we have limited our review to known facts on the size of a single cave passage.

Conclusion

It seems certain that the size of Hang Son Dong has been exaggerated in the media. Claims of the largest cave passage and largest cave in the world have more recently been downgraded to 'greatest cave' on the lecture circuit. Perhaps this is an admission by the team that the initial hype cannot be substantiated in fact.

The truth of the matter is that there is no accepted measure for the largest cave passage, all is subjective opinion. At the best there is a single cross sectional measurement at the widest/highest part. To be definitive a set of criteria would need to be established by which large passages could be compared. This would have to include setting a length over which the passage was measured and then defining average dimensions or a volume, perhaps by laser scanning techniques. Most importantly, it would be necessary to agree a set of rules as to what constitutes a 'passage' in the first place, otherwise Nasib Bagus (Sarawak Chamber) would surely be the largest passage in the world at 700m long, 400m wide and 100m high. Along with Api Chamber, at 300m long, 200m wide and 120m high, these great chambers are just large sections of a collapsed passage, or junction of passages. So, if we exclude these types of chambers then we should be careful what passage elements we do include such as junctions, skylights, avens, alcoves and cross rifts which all distort the true dimensions of a borehole-like passage.

Unlike the longest cave in the world, where one cave stands out way above the rest, the largest known passages of Deer Cave, Gebihe System, Hang Song Dong, Gruta do Janelao etc. are more difficult to compare. As it was in 1978 it is the same today; Deer Cave is still a strong contender for the title of the largest cave passage in the world.

Southern Hills Caves														
English Name	Malay Name	Area	RGS '78	Mulu '80	S'wak '84	Api '91	Mulu '91	DWG '92	DWG '93	Api '94	DWG '94	DWG '95	Mulu '10	Total Lengths
Bat Cave			0.00											0.00
Daniel's Cave	<i>Gua Daniel</i>				900.00									900.00
Deer Cave	<i>Gua Payau</i>		1760.00	400.00										2160.00
Deer Water Cave	<i>Lubang Sungai Payau</i>		885.00											885.00
Fat Frog Cave	<i>Gua Katak</i>								1136.00					1136.00
Peter's Cave	<i>Gua Peter</i>													300.00
Fern Rock Cave	<i>Gua Batu Paku</i>					845.00				815.00		310.00	225.14	2195.14
Green Cave	<i>Gua Hijau</i>		2895.00	550.00										3445.00
Langs Cave	<i>Gua Lang</i>		0.00											0.00
Mayday Cave	<i>Lubang Darurat</i>		900.00											900.00
Panis Cave	<i>Gua Paris</i>							658.00					568.30	1226.30
Porcupine Cave														295.13
Snake Cave	<i>Lubang Ular</i>			295.13										780.00
Stone Horse Cave	<i>Gua Batu Kuda</i>			780.00			2664.00	428.00						3092.00
Surface Cave	<i>Gua Permukaan</i>				1500.00									1500.00
Pendant Cave														
Big Cave													183.59	183.59
Wild Boar Cave													227.45	227.45
Fruit Bat Cave	<i>Gua Babi Hutan</i>												168.20	168.20
Kenyalang Cave													479.70	479.70
													565.20	565.20
Southern Hills Total														20,438.71

Appendix 4;**2010 Discoveries Log – Matt Kirby**

	Survey Date	Length	Team
Surface surveys			
Stone Horse to Paku Bridge	08-May	946.21	HSL MJK
Deer to Stone Horse	08-May	778.11	GM AJE
Waterfall to Fern Rock	08-May	627.43	GM AJE
Fern Rock to Plankwalk	09-May	1026.03	GM AJE
Fern Rock Area	09-May	429.16	HSL MJK
Paku Bridge to Park Heli Pad	09-May	1461.39	HSL MJK
Fern Rock to Pendant Cave	10-May	277.52	HSL MJK
Paris's Cave to Stone Horse	10-May	176.60	PLS AJE
Pendant Cave surface	10-May	53.56	HSL MJK
Pendant Cave to cliff entrance	12-May	124.78	HSL MJK
Big Cave to Paku Crossing	17-May	790.47	AJE PLS
Waterfall to Paku Crossing	18-May	1633.53	HSL TRA
Green Cave to Garden of Eden	19-May	827.20	TRA RCS GEM
Garden of Eden to Deer Cave Gate	19-May	2106.31	HSL MJK
Snake Cave to Deer Cave	19-May	681.70	TRA RCS GEM
Wild Boar to Deer Gate	21-May	1450.61	HSL MJK
Kenyalang to Fruit Bat	21-May	516.40	GEM RCS TRA
Daniels Cave surface	21-May	738.71	AJE PLS
Paku Path to Hoover entrance	22-May	100.59	HSL RA
Total		14746.31	
Underground surveys			
Pendant Cave	10-May	183.59	HSL MJK
Paris Cave Black Hands	11-May	568.30	GM RCS
Big Cave	17-May	227.45	AJE PLS
Fern Rock Hoover entrance	18-May	64.17	HSL RA
Wild Boar Cave	21-May	168.20	HSL MJK
Kenyalang Cave	21-May	479.70	GEM RCS TRA
Fruit Bat Cave	21-May	565.20	GEM RCS TRA
Fern Rock Near East Passages	22-May	160.97	RA HSL
Total		2417.58	
Total survey		17163.89	

Appendix 5; The Mulu Caves Website – Hugh St. Lawrence

mulucaves.org