

Shan Plateau Expedition 2015-2016

Final Report

Compiled by the expedition members, January 2016

Summary

The Shan Plateau Expedition 2015-16 was a five-person, three-week caving expedition to the ridge of mountains to the west of Ywangan Township in Myanmar. The field area straddles the boundary between the Southern Shan State and Mandalay Division and was based initial at the base of the ridge (Mandalay side) and then subsequently on the Shan Plateau (Ywangan side). The expedition was the sixth in the (UK-China) Shan Plateau series and the fourth to focus on the area around Ywangan.

The expedition was initially based in the town of Kyaukse, from where the team commuted to the base of the ridge every day. The aim of this part of the expedition was to investigate possible resurgences along the base of the ridge which may represent water sourced higher up on the Shan Plateau. Two significant resurgences were located, one smaller outflow near Khin Lae village, and one larger outflow near Phoe Inn village. The Phoe Inn resurgence also had an associated cave located nearby from which the subterranean river and other dry fossil passages could be accessed. In total Phoe Inn Cave was explored to over 1.2km in length, including two entrances. The river sumped in both upstream and downstream directions.

During the second part of the trip the expedition was located in Ywangan. Day forays were made into the surrounding areas to search for caves. Initially a number of small caves and blind shafts were identified, including within areas that lie up to 1400m above the Phoe Inn resurgence.

Subsequently a major (two river) sink was found at ~780m above sea level on the newly improved road from Ywangan to Padalin Cave. Ju's Gu was is now the deepest mapped cave in Myanmar, extending to a depth of over 300m (of which 280m was descended by the team). This makes it almost twice as deep as the previous depth record for a mapped Myanmar cave (155-160m). There are three large (30-50m) pitches continuing from the exploration limit of Ju's Gu, one of which appears to lead into large horizontal development, but they have bad air that prevented further exploration. The termination of the explored cave is ~50m above the base of the escarpment, in an area where villagers report 9 cave entrances some of which are 'large enough to house an aeroplane'. Cat Hulse was hit by a falling cobble in the entrance shaft of Ju's Gu, resulting in a rescue and subsequent return to the UK for an operation on her broken wrist.

During the final day of the expedition the remaining team visit Htee Hlim village and the huge (100m wide and up to 80m high) Bat Hole entrance that is visible on satellite images. Bat Hole quickly ends in a chamber with numerous swifts, which are protected by a gated fence around the entrance. However, this trip confirmed good potential for further caves in this area of limestone karst.

In total, the 2015-16 expedition mapped 2.8km of cave at 11 sites and recorded a further 3 sites of speleological interest. They include Ju's Gü, which is the deepest cave (-300m) with deepest single shaft (-125m) yet mapped in Myanmar.

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With Thanks

This expedition would not have been possible without the ongoing help and assistance from Mr Phyo Wai Yar Zar, Managing Director of All Asia Exclusive and vice chair of the Myanmar Tourism Promotion Board. We are also indebted to our excellent guide and translator Sai Phone Myint Naing who worked tirelessly to help us achieve our objectives, and our dedicated and thoughtful driver Mr Myo Lwin.

We were also fortunate to receive financial support from the Ghar Parau Foundation. Visiting Myanmar is not a cheap activity and we are therefore extremely grateful for this contribution which makes a big difference in helping to make the expedition viable.

In this type of terrain we rely heavily on the goodwill and advice of local people for discovering cave entrances. We are extremely grateful for their help. Our experience is that Myanmar is probably the most friendly country we have visited worldwide, and it is a real pleasure to sit and drink tea or eat oranges with our local acquaintances.

Introduction

Background & Rationale

After a year away in 2014-15, this was the sixth (British) Myanmar Shan Plateau Expedition. It followed on from the successful 2011-12, 2012-13 and 2013-14 trips to the Ywangan area that explored Kyauk Khaung (Stone Cave), Yae Htwet Kyote Kone Gu (Spring Stone Cave) and Dragon Cave, which include several of the longest (up to 4.8 km) and deepest (up to 158 m) caves yet mapped in Myanmar. These expeditions in turn built on the early trips organised by Joerg Dreybrodt and Imogen Furlong to a number of different locations within the Shan States before settling on this location.

The 2015-16 expedition was based in two areas that focussed on the more rugged plateau area to the west of Ywangan, as previous trips had been almost exclusively been to the east of Ywangan. This western plateau and its final ridge are a particularly attractive target for cave exploration they have the potential for caves that are up to 1400m deep, within thick sequences of limestone. We know of few, if any, other areas in Myanmar with potential for such deep cave systems. Home based reconnaissance using satellite imagery had identified several potential resurgence locations at the base of the ridge as well as a particularly large hole and a number of extensive depressions on the top of the plateau itself. These were to form key targets for the expedition.

Permissions

Permissions for the 2015-16 expedition were obtained at the national level via Mr Phyo Wai Yar Zar, Managing Director of All Asia Exclusive and vice chair of the Myanmar Tourism Promotion Board. Without such special permissions it is clearly impossible to carry out expeditions in these rural areas and we are grateful to the authorities for facilitating this.

Locally, the Immigration Departments in Kyaukse and Ywangan were also required to grant permissions for the destinations we wished to visit. In Kyaukse, we also needed permission from the Archaeology Department due to the remains in Padalin Cave. In all cases, we needed to be back at our base by nightfall. We found all these parties to be very welcoming and extremely hospitable. Our guide and interpreter Sai Phone Myint Naing worked tirelessly to get these local permissions for which we are also very grateful.



a)



b)

Figure 1 Location of the Shan States; a) Location of the states in Myanmar; b) Area of the Shan States



Figure 2 Location of Expedition

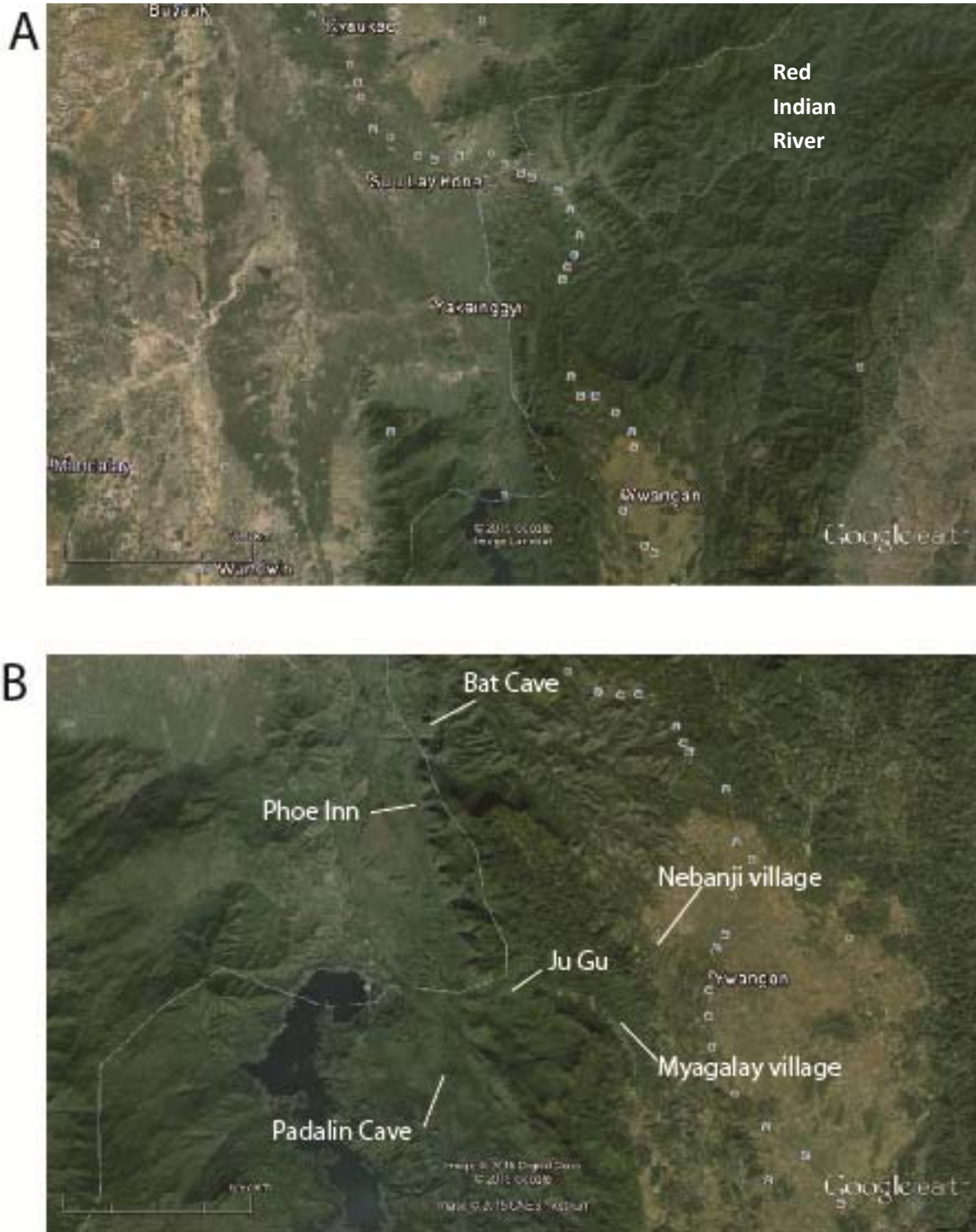


Figure 3. Satellite images of area. (A) Map showing the location of two bases where we stayed at Kyaukse and Ywangan Towns. (B) More detailed map of area explored showing position on main caves (Ju's Gü; Phoe Inn Cave, Padalin Cave and Bat Hole) and villages (Myagalay and Nebanji).

Travel & Accommodation Logistics

All five expedition members entered Myanmar at Yangon airport having travelled from Britain. Cat Hulse travelled out a few days earlier. An internal flight was then taken to Mandalay where the expedition team was met by Sai and Mr Myo, and the expedition vehicle. This vehicle was closed and more comfortable than some previous vehicles, but it was not a 4-wheel drive and has some issues on very rough terrain or river fords

We then travelled by road to reach Kyaukse Town and subsequently onto Ywangan. The return internal flight was from Heho that is closer to Ywangan.

Table 1 Expedition Time Line

| Date From | Date To | Comments |
|---------------------------|---------------------------|--|
| 20 th Dec 2015 | | Main party arrive in Yangon, and all arrive in Mandalay. Drive to Kyaukse |
| 21 st Dec 2015 | 26 th Dec 2015 | Explore caves at foot of mountains near Phoe Inn and Khin Lea |
| 27 th Dec 2015 | | Move base to Ywangan |
| 28 st Dec 2015 | 8 th Jan 2016 | Explore caves to west from Ywangan |
| 2 nd Jan 2016 | | Enter Ju's Gu master system. Cat Hulse breaks wrist and goes to Ywangan and Taunggyi hospitals; she flies back to UK on 4 th Jan. |
| 9 th Jan 2016 | | Main team travel to Heho and fly to Yangon. |
| 10 th Jan 2016 | | Fly back to UK from Yangon |

Kyaukse Town

This is a large town on the plains about 90minutes drive from the caving area around Phoe Inn at the base of the plateau. It is the nearest place we were allowed to stay by immigration as it has hotels licensed for foreigners. We stayed in a hotel with hot showers for 30,000 kyak/night for double room, or 12,000 kyak/night without hot water. Apart from the drive, it is a nice town to stay in with a wide range of restaurants and colourful pagodas on a nearby hill. A colourful procession of floats (with elephant) was seen on one local festival day (28 Buddha's festival).

Ywangan Town

Ywangan Township had been the main base for the previous three expeditions, and is a lovely place to stay. It is significantly smaller than Kyaukse. The guest house is essentially a truck stop and offered good facilities for washing equipment at the end of the trip.

Equipment

Over six Shan Plateau expeditions we have now built up a supply of rope and rigging gear in Myanmar to allow exploration. This included a new drill to place bolts for vertical caving. We now have ~300m of rope in Myanmar. A range of tapes and slings are stored in two trunks, shared with Joerg Dreyboldt's trips each year.

Surveying

All caves were surveyed to BCRA Grade 5 and the entrances logged using GPS. Surveying was mainly by use of a “DistoX2”, which allows laser measurement of distances, bearing and inclination. Traditional instruments were carried for wet river passages.



Figure 4 Sunset over the edge of the plateau with the reservoir in the Pin Laung valley below

Key Findings

The first week of the expedition targeted potential resurgence caves at the base of the plateau where the ridge intersected the plain, using the town of Kyaukse as a base. This involved a 90 minute drive to the villages of Phoe Inn and Khin Lea at the base of the escarpment. We initially took a touristic boat trip across a major reservoir to see the Padalin Caves. These comprised a 358m long, dry, phreatic cave and an associated smaller cave which is an important Neolithic archaeological site in Myanmar. However, a major (1.2km long) cave was then explored that is linked to the Phoe Inn resurgence. Even in the dry season, there is a significant flow (~3 cumecs) in the lower level of Phoe Inn Cave. This river was found to sump in an upstream direction, and was followed to a second entrance near the resurgence itself. A large upper phreatic level was also explored, with wide ongoing leads heading east left due to bad air. A second resurgence to the north, near Khin Lea village, was visited but could not be entered. Local villagers were also aware of a very large entrance in the hills, which we had identified based on satellite imagery, and we know learnt was called Bat Hole. However, this was not accessible as it involved a 6 hour approach, and we had to be back in Kyaukse by nightfall. Overall, this work showed that there may be significant cave development in the lower levels of the plateau, and that major resurgences drain significant areas.

The team then moved to the base of previous expeditions in Ywangan, located on the top of the plateau. Here the team initially only found small shafts or caves; first near a waterfall north of Ywangan, and then a spider-populated cave south of Ywangan and the adjacent village of Myagalay.

However, exploration along the newly improved road from Ywangan towards Padalin Caves proved very exciting. A major sink at the confluence of two dry river beds entered a very large shaft series (Ju's Gu) that is strongly drafting and ongoing into the mountain. This appeared to be the discovery of a major 'master' cave system, with 400m of depth potential, located 8.5 km horizontally from the Phoe Inn resurgence. The scale of monsoon water flow in Ju's Gu is even larger than that in Phoe Inn Cave, so there may also be other monsoon resurgence at the base of the mountains. Unfortunately, a single large loose rock fell from its entrance shaft and broke Cat Hulse's arm, necessitating rescue and her eventual return to the UK. Ju's Gu was eventually explored to a surveyed depth of -300m, of which -280m was descended. It was left at three large ongoing pitches, one of may link to large horizontal development. However, bad air stopped exploration at this point, which is 50-100m above the base of the escarpment. Villagers report 9 more caves in this area, one of which is large enough to contain 'an aeroplane'. It may benefit from further trips.

The remaining team spent the final day mapping the huge (100m wide and 800m high) Bat Hole, although this quickly terminated. The area they traversed around Htee Hlim village looked promising.

Caves Explored

Caves explored or logged during the 2015-16 expedition were reached either from the base of the plateau (Phoe Inn, Khin Lea or Padalin) or from Ywangan at the top of the plateau. Their locations are included in Appendix A. Descriptions for the major surveyed caves are given in the following sections.

Padalin Caves

They comprise two adjacent caves, one of which is more of an alcove. They are a well-known local destination that can be reached via a boat trip across a reservoir, as we did, or via a newly improved road from Ywangan. The road from Ywangan terminates at these caves.

The first and larger cave is a well decorated phreatic system of large phreatic passages that is 358 m long, with numerous sky lights and Buddhas. It seems to a fragment of large phreatic development within the now eroded terraces below the plateau's break in slope. Its chambers are well decorated and photogenic. One high passage was not entered but there is little if any scope for further exploration.

A short distance away is a small cave (really an alcove) that hosts a wide range of Neolithic cave paintings that include wild boars, the sun and hands. They are quite rightly protected by a small wall.



Figure 5 Padalin Cave

? aven in roof
(no draught)

Padalin Cave Ywangan Township Southern Shan State, Myanmar

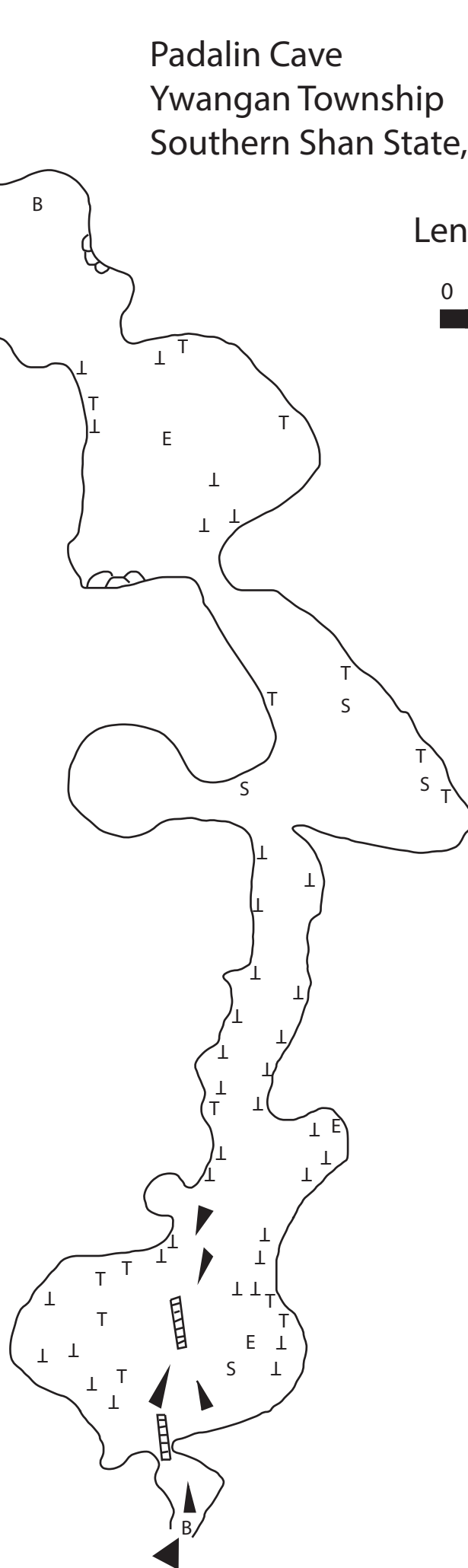
Length: 358m

0 25m

North



- T stalagmite
- ⊥ stalagmite
- S stupa
- B buddha
- ☪ lying buddha
- E entrance (skylight)



Surveyed by F Loveridge, B Wright, P Talling
21st December 2015
Drawn F Loveridge 31st December 2015

Phoe Inn Resurgence

A large resurgence which is not enterable. However, the associated Phoe Inn Gu can be accessed via the main entrance a short walk away or via a small entrance in the cliffs above and to the left of the resurgence waters.

Phoe Inn Gu

1210m long; 55 m depth

This cave is located about a 20 minute walk from Phoe Inn village, and has two entrances. Phoe Inn village is reached by a rough track, which involves fording two streams. Our vehicle cracked its head gasket in one such fording, so care is required to recheck water levels and banana leaf dams.

The cave first entrance is into an upper level of large phreatic passages, which are located above a lower level that contains an active river (~ 3 cumecs) even in the dry season. This river resurges a short distance away, with a second entrance located above that resurgence, ~60 m up and to the east of that resurgence. This is the start of the river in Phoe Inn village.

Entrance Series: The air is very hot at the start of the entrance series that comprises a set of gently descending passages, and some loops. A strong draft is encountered as one drops into a much larger phreatic passage that trends north-south (the North South Divide). There are several minor leads in the entrance series that did not contain a draft and are not yet pushed to a final conclusion. The locals retrieve guano from parts of these passages.

Great North-South Divide: This major horizontal phreatic development is often 20m wide, and has cooler air than the entrance series. Both ends are marked by ~30m pitches down to the river.



Figure 6 Pete Talling in the Northern Area of Phoe Inn Gu

Northern area to resurgence exit: The pitch down to the north ends at the river, which is followed downstream to a muddy sump pool in what may be bad air. This sump must be a short distance from where the river resurges. Upstream also sumps immediately. However, at the base of the pitch a large ascending ramp can be climbed (handline useful near top) to regain the high level phreatic passage. This passage can then be followed north past formations, holes down to the water, and small climbs (tapes useful) to an exit above the resurgence. There is a very strong cold draft in this high level.

Southern area: The pitch at the southern end of the north-south passage lands in a big chamber with the river. An ascending slope reaches a high level, whilst the river is at the lower level.

The Serpentine River can be followed for ~150 m, after an initial wade in the big chamber. However, the flow is fast at times and an initial canyon is best bypassed. The river is regained by short climb up and down on the east side of the chamber. This is followed by a roped traverse above the river to an oxbow with in-situ snake, reached by a short 5m swing pitch across a gap, or by a tricky swim up rapids to same place. The sump pool is around the corner after a short 3m pitch down from the oxbow.

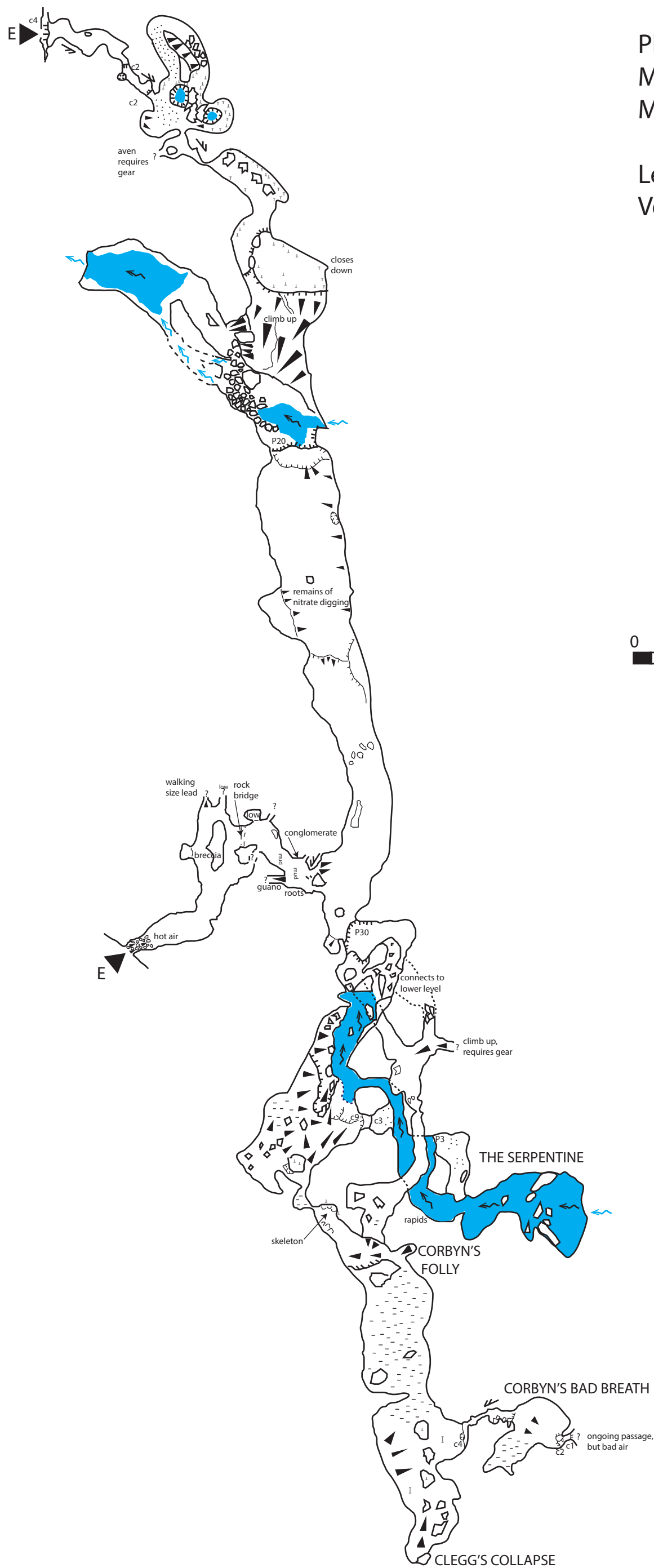
The upper levels have much hotter air, and bad air may need caution.

Clegg's Collapse: First ascend to the top of the big chamber, and then crawl through a low arch. This soon emerges in larger (20m wide) phreatic passage. Immediately left and back on oneself (returning north) makes vocal connection with the stream in the vicinity of the 30m pitch down. . There is a sketchy climb up (east) in this vicinity that will need a short rope for further progress. Back in the main phreatic passage Corbyn's Folly leads off from the left hand wall but is blind. The main passage continues south and finishes at a choke (Clegg's collapse) close to the surface with roots.

Corbyn's Bad Breath: Further back along the main passage on the left hand (east) wall there is a short climb down which leads to a drafting small tube which was dug out to enter a chamber. From here a climb up reaches a large passage heading east into the mountain. However, the air here is bad, with heaving chests even when people are standing. This otherwise excellent lead was thus not pushed any further.

Length: 1210m
Vertical Range 55m

Vertical Range 55m



Surveyed by F Loveridge, B Wright, P Talling, C Densham, C Hulse
22nd to 26th December 2015
Drawn F Loveridge, P Talling January 2016

Khin Lae Resurgence

This is a second major resurgence at the base of the plateau that is active even in the dry season. It is located near Khin Lae village, to the north of Phoe Inn village. There is a small local spirit shrine by the resurgence, which is ~20 mins walk from the village. Interestingly, this resurgence is at the foot of the hill that contains the large Bat Cave entrance. It has a flow of ~0.8 cumecs, which is ~30% of the flow seen in the Phoe Inn resurgence. No cave is enterable at the Khin Lae resurgence.

Phyu Thwin Cave

This is a small alcove used by the locals in the travertine terraces to the west of Khin Lae village, on the edge of that terrace. It is ~20 mins walk from Khin Lae village.

Kayauk Gu Teat (and nearby waterfall)

This is a short trough trip cave located north east of Ywangan at the village of the same name. It has a small stream and extends for ~100m. It was not surveyed due to time constraints.

We were initially taken to this village to see a spectacular waterfall that drains the northern lip of the plateau in this vicinity. There was also a very short cave nearby. The waterfall round trip involved a rather fine climb of tree roots back up the cliff down which the water flows, very much reminiscent of an alpine via ferrata. The locals had installed a steel cable next to the root climb, with a view to future tourism. But that cable seemed to not be well attached in places.

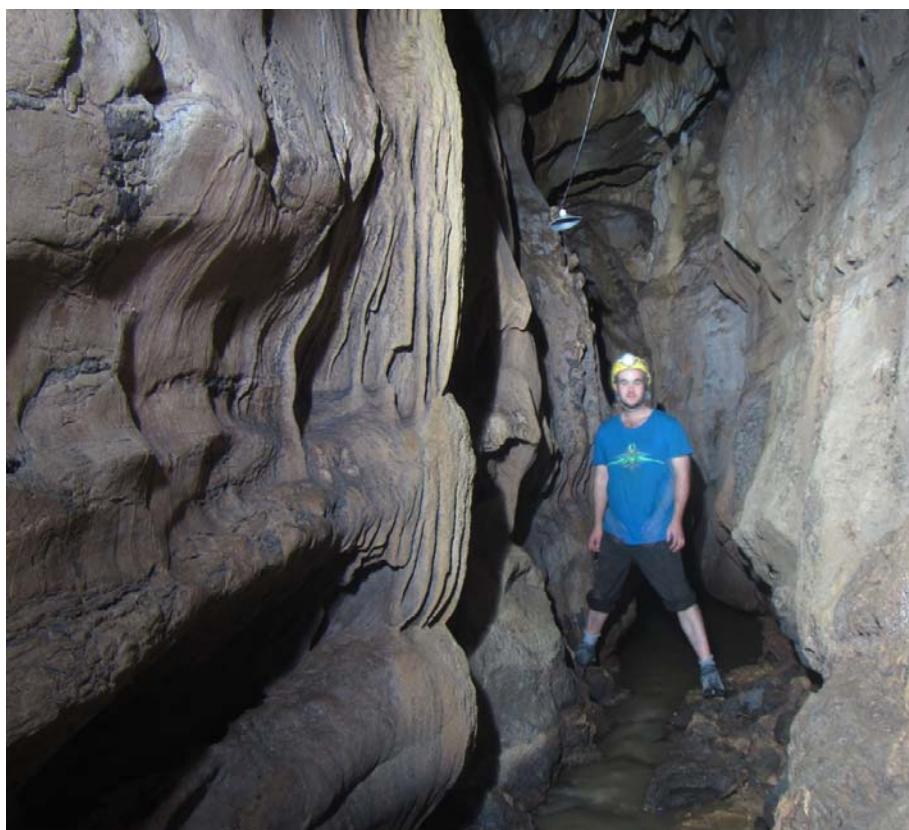
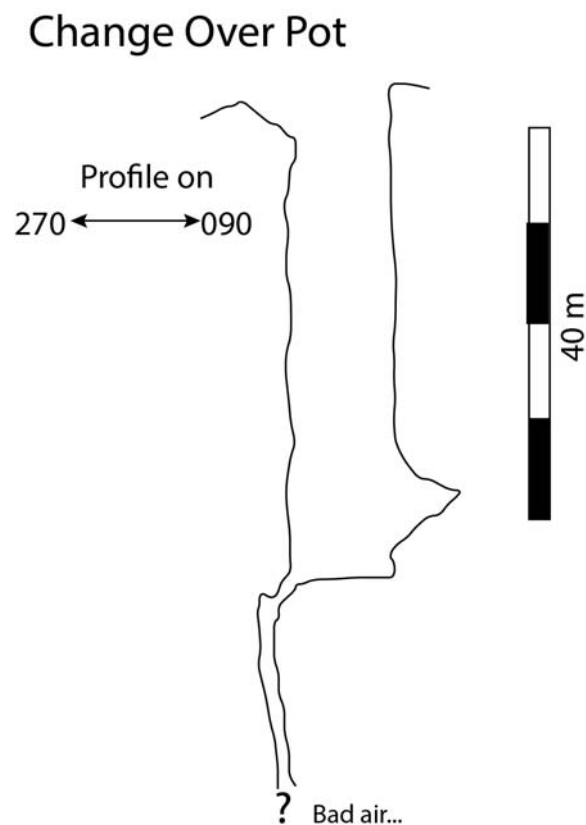


Figure 7 Ben Wright in Kayauk Gu Teat

Changeover Pot

This 70m deep pothole is located at the lower part of the ridge, west of Ywangan near Nebanji village.

This is shaft that is located about 20minutes walk from the village. It is a vertical pitch of ~45m that lands above a small hole leading to a descending rift. The rift was partially descended by abandoned due to bad air. There is no draught.

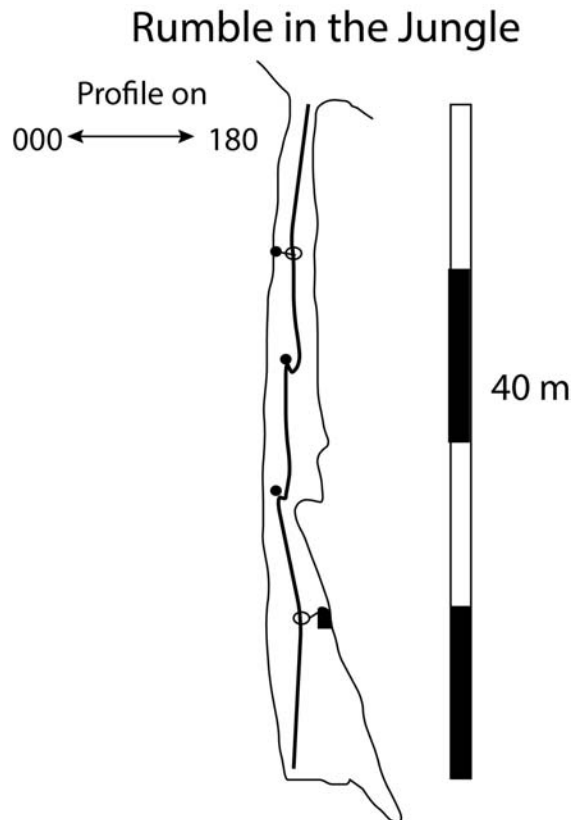


Covered Pots

These two small potholes are located on the high plateau above Nebanji village some two hours walk away. They are located near a distinctive pond of water, and were covered to prevent cattle falling into them. The interest in this area is that it is ~1200-1400m higher than the Phoe Inn resurgence cave, and 4-5km in horizontal distance. However both of these covered pots were only 3-5 m deep, and close down.

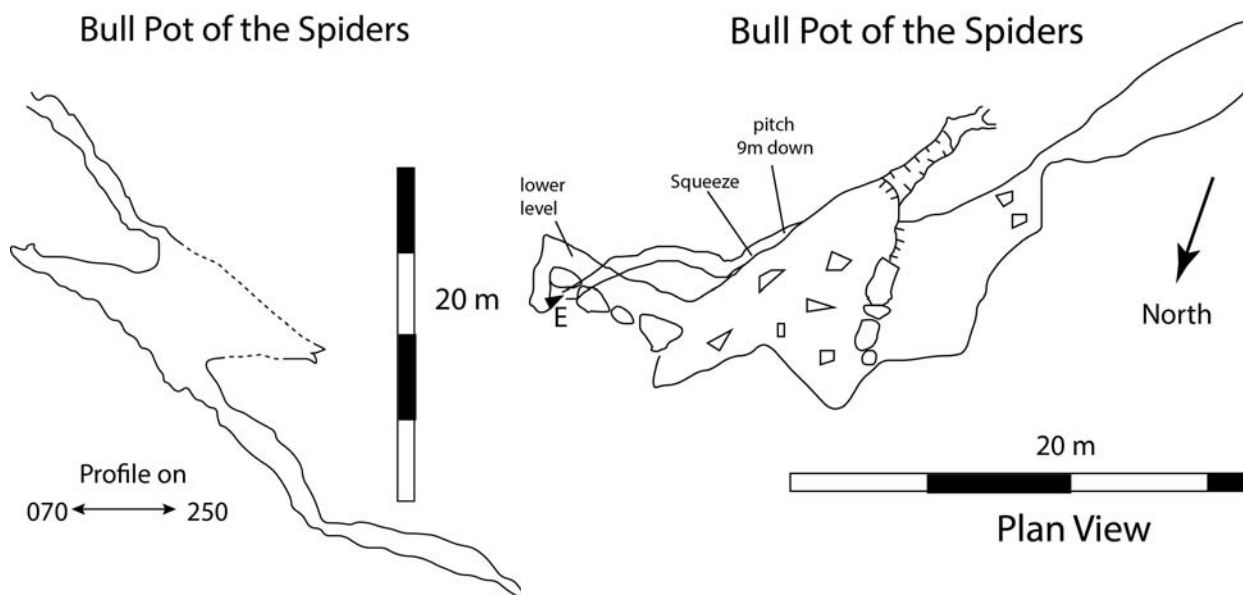
Rumble in Jungle

Also on the high plateau above Nebanji village, this is a deeper (44m) shaft that is located near covered pots, but somewhat further north near a hut. This was explored to a conclusion but does not go.



Bull Pot of the Spiders

This pot is located at the foot of a rock cliff, to the west of the road that goes south from Myagalay. From the road a higher alcove is seen. Monsoon water sinks at the base of a vegetated cliff, into a rift. This rift leads to a 5m constricted climb down to a horizontal squeeze to the top of a 10m pitch down. This enters somewhat larger rift passage inclined down to a sump, or up into a surface choke. It is a collector's piece that allows different types of spiders, and the 'mother ship' swarms that they form, to be inspected at close quarters.



Baby Arrow Shaft

This was the first shaft that we were shown along the road from Myagalay to Padalin and is after a 20 minute walk from a road bend. It is well placed but only goes down about 10m to a chamber that is mud choked.

Ju's Gu

This is a major discovery located in a broad (> 1km wide) enclosed depression that is on the road to Padalin Caves, just before the start of the final steep descent to the terraces that host the caves. The depression is a major feature with at least two large dry river beds that are active in the monsoon season. Unusually, the entrance shaft is at the exact confluence of these two large dry river beds, which are a 5 minute walk from the road. Note that there is a strong draft throughout this cave, even in passages that are 20 m wide, which makes this cave significantly cooler than the other caves we explored.

Feline Grace (Entrance Pitch): The entrance shaft is very water worn, and must be the site of exceptionally powerful waterfalls in the wet season. It is a circular feature that is ~10-15m wide. Two threads at the (SW) river lip, are followed by a third thread a few feet down, and then by a two-bolt y-hang to the left (facing in) on a smooth rock wall. This provides a 30-35m free hand to the floor of a chamber. Although the y-hang is away from any loose rock, a large cobble somehow fell down this pitch to break Cat's arm as she got on the rope at the bottom.

Ginger Apocalypse: The second pitch follows immediately from a y-hang above a wedged boulder. It is a single 30-35m free hang down a circular shaft in beautiful photogenic waterworn rock. It lands in a 5m wide chamber. An upward trending passage from this chamber soon terminated in a muddy choke, and a narrow rift at the back of the chamber also terminates after a few metres.

Great Expectations: But.... a gravel floored low arch provides access into the rest of the cave. This arch is followed by a 20m crawl and stoop to a window that looks out across a (very) large rift into the mountain. The rift is initially descended via 15m long third pitch down a flowstone boss.

The Library: Great expectations lands in a large chamber called the Library (the flowstone has flakes like book pages), reaching 20m wide yet still strongly drafting. This chamber is the lip of a very large and surprisingly draughty shaft.

The Dark is Rising: The large shaft is around 120m deep and is descended in three parts. A short pitch (P10) lands on a large muddy ledge. From here a P20 is descended to a smaller ledge with a convenient bucket seat overlooking the main shaft. Two P10 pitches arrive at a lip where the wall moves away with a more airy P30 and P40 reaching the floor of the shaft.

The shaft lands in a large rift. Almost immediately on the right there is a small water worn drop (P12) leading to another pitch down (2 second drop plus 1 second rattle). At the far end of the rift there is another pitch down (P50). Traversing over this on the left hand side reaches a further drop down (P30). The P30 and the P12 both lead to bad air. The P50 was not descended. It is theorised that the strong draught felt in the main shaft must return up another aven, possibly at the far end of the main rift where the roof level does rise.



Figure 8 Fleur Loveridge and Chris Densham derigging Ju's Gu



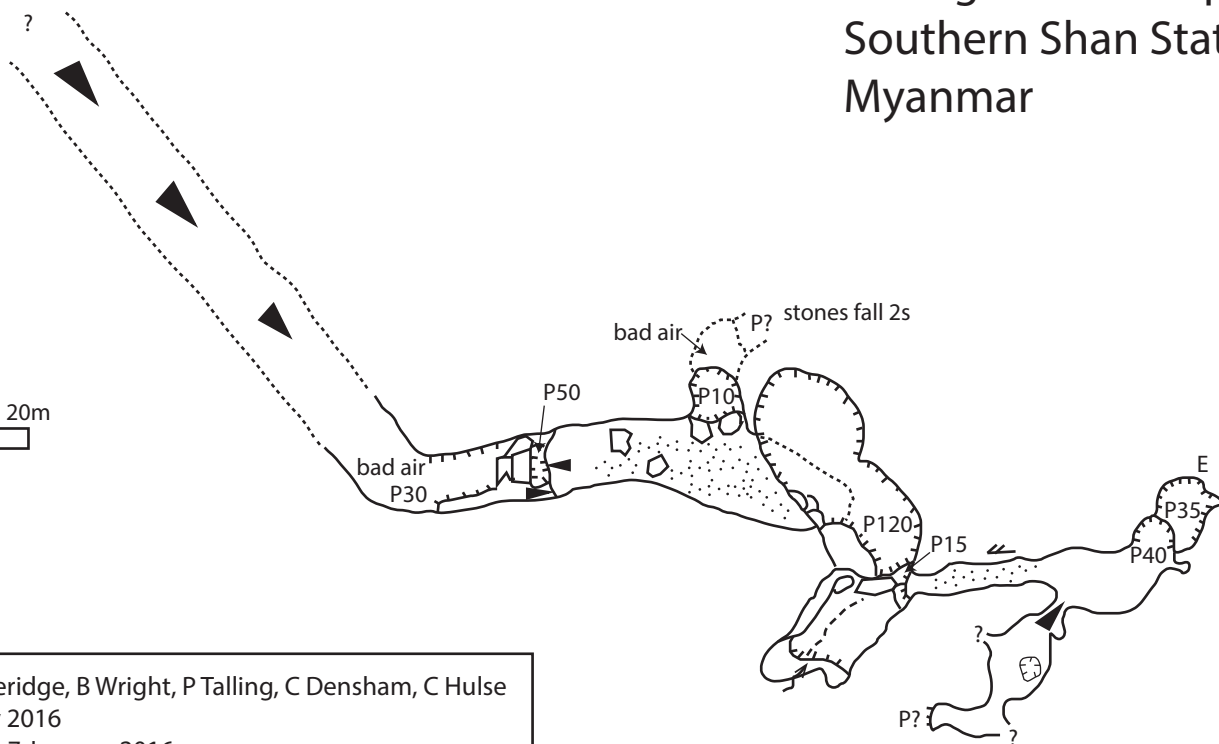
Figure 9 Chris Densham rigging to the approach to the P30 beneath the Dark is Rising in Ju's Gu

North

PLAN

Juliet Pot (Ju's Gu) Ywangan Township Southern Shan State Myanmar

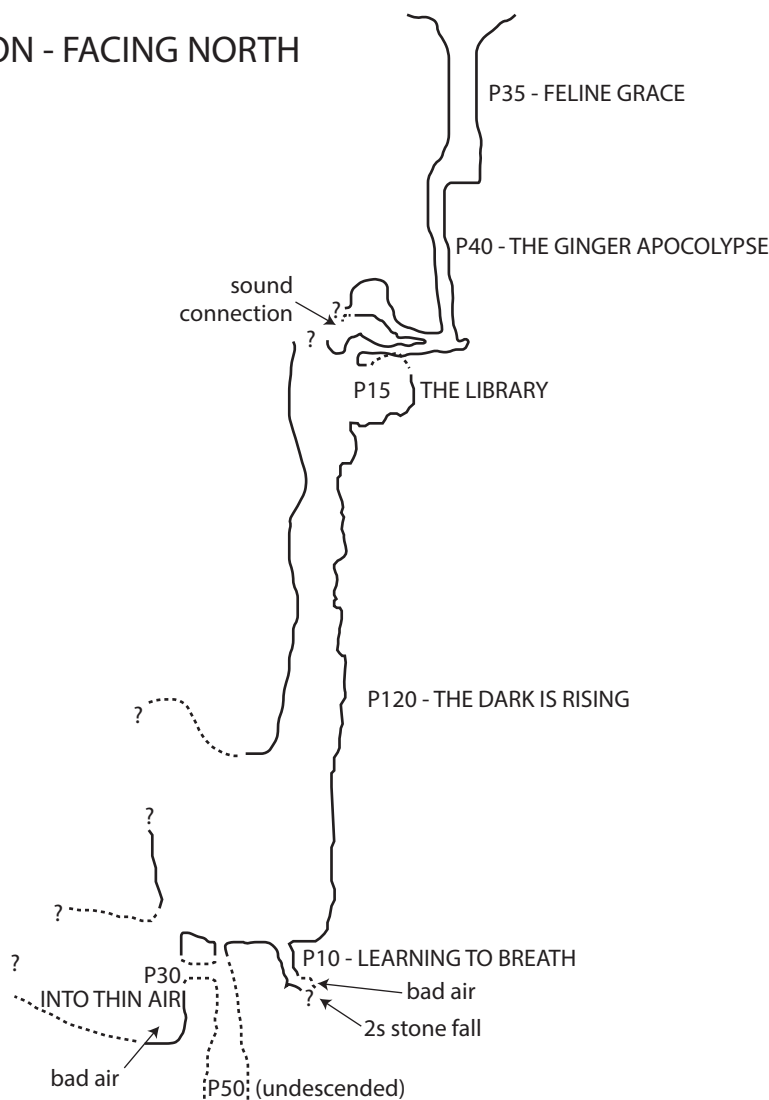
0 20m



Surveyed by F Loveridge, B Wright, P Talling, C Densham, C Hulse
2nd to 6th January 2016
Drawn F Loveridge 7 January 2016

0 40m

ELEVATION - FACING NORTH



Surveyed depth: 279m
Total depth: >300m

Bat Hole

This extremely impressive feature is visible on google earth, and it is located on the frontal ridge. It is best approached via the village of Htee Hling, which is itself reached by a (all terrain) truck journey from the main Ywangan-Kyaukse road. It takes ~2 hours by truck to the cave, followed by a 30-40 minute walk on a good path. Note that there is a locked gate and fence around the cave entrance, and the key was obtained via contact at Htee Hling village.

The gate and path leads quickly to a massive entrance that is ~80m high, and over 80-90m wide. The limestone cliff above the entrance forms another 70-100m of amphitheatre. The entrance slopes down to an even bigger (100 m high) flat floored chamber that unfortunately has no way on. There are numerous swifts (and possibly subsidiary bats?) nesting in the roof, which also has a second smaller skylight. The swifts make a lot of noise, and produce copious guano on the floor. This guano is being extracted for fertiliser.

The limestone in the vicinity of Bat Cave and Htee Hling village looks very karstic, and further efforts to find cave in this general area are likely to be rewarded. However, it may become necessary to stay in the village (which has a monastery) for longer caving or prospecting trips.

Future Prospects

The 2014-2015 expedition showed the potential for large and deep cave systems to the west of Ywangan, with both a significant resurgence cave and a vertical shaft series. Both the upper level of Phyoe Inn Gu and the ends of Ju's Gu were left ongoing in large open passage. However, the problem was bad air in both cases. It may be prudent to carry an oxygen/CO₂ meter during future exploration.

The very strong draft in the upper parts of Ju's Gu is intriguing, and further efforts could be made to search for its continuation. This could be linked to the reported 9 caves, one of which can fit an aeroplane, near the Mango House below Ju's Gu. Some of these entrances are reported to draft.

The valley that hosts the road from Myagalay to Padalin has large enclosed depressions, some of which also drain the high plateau to the north. Further exploration may prove rewarding here. We also hardly scratched the surface of the high plateau that has 1200m+ depth potential during a single day. This high area looked very karstic, and it would just need the right local person to contact.

There are two as yet unvisited resurgences at the foot of the escarpment. One is north of Khin Lea, and the other is in the far south. The northern resurgence may be reached via Kyaukse, but the southern perched valley resurgence is more difficult to access.

The area around Htem Hlee looked very karstic on the way to Bat Hole, and is thus promising for caves. The villagers report caves in the area, and a resurgence may be located < 2 km to the south of the village. This area around Htem Hlee is worth further efforts, but a substantial cave would need a base in the village, perhaps at the monastery.

Environment

Geology and Geomorphology

In the following description all geological terms are taken from the memoir of Garson et al (1976) due to the detailed map available, rather than the more recent reclassification of some limestone units by Oo et al (2002).

The distinctive ridge which forms the escarpment to the west of Ywangan drops for up to 1400 m down to the Pan Laung River and Reservoir. The villages of Phoe Inn and Khin Lea are located on uplifted terraces at the foot of the main escarpment. The escarpment itself has been assigned to the Mwalbo Fault Complex on the geological map of Garson et al (1976), and our experience is that this complex is actually mainly good quality limestone. This Mwalbo complex forms north-south striking strata that form the north-south trending hills along the foot of the escarpment. Behind these Mwalbo Complex frontal ridges the escarpment can be subdivided into three parts.

(i) To the north of Phoe Inn and Khin Lea the escarpment has a large valley behind the frontal Mwalbo Complex Hills, which contains the Htee Hling village that is hard to reach from below. The frontal ridge contains the huge Bat Hole seen on satellite images. Jurassic ramp upwards to reach the hanging valley south of Tettaung at elevations of 1300m above the range front. Note that the low hills south of Tettaung that lack karstic weathering are dolomitised limestone that has a prismatic cubic weathering.

(ii) The highest plateau area lies just south of the Phoe Inn and Khin Lea villages, and their resurgences. Here the plateau has relief of up to 1400m. The high plateau comprises three units; the deeply karstic Jurassic Pinnacle Limestone that forms rugged jungle, the Triassic Netteik Limestone that tends to form cultivated but still karstic terrain (with our Rumble in Jungle and Covered Pots). These two limestones are separated by a thin sliver of mudstone, such as seen at the pond near Covered Pots.

(iii) The major valley from Myagalay to Padalin Cave then splits the escarpment, and Ju's Gu is at the end of this valley. The bowl with Ju's Gu shows some dolomitisation but the cave itself is in pure dark grey limestone, probably the younger Dahatpin Limestone (Cretaceous/Tertiary) or the fault complex itself. The area is at the contact with the limestone conglomerate of the Kalaw Red Beds Formation, but in general, there is less limestone conglomerate than shown on the geological map in this bowl. South of this valley it comprises other karstic Jurassic limestone units.

The terraces that are located at the foot of the escarpment have a travertine cover above what seems to limestone bedrock. Padalin cave lies on such terraces, as do the villages of Phoe Inn and Khin Lea.

Hydrogeology

The expedition made progress in mapping at least some of the main resurgences at the foot of the escarpment.

Phoe Inn resurgence: A major (3 cumecs) river that is active in the dry season exits through Phoe Inn cave, and must drain large parts of the high plateau (ii in above list). The geological map shows a second adjacent resurgence to Phoe Inn but we believe this second Phoe Inn resurgence may be in error as the villagers were unaware of it, despite the general high quality of the map.

Khin Lea Resurgence: A second significant resurgence occurs ~4 kilometers further north near Khin Lea village. It has a dry season flow of ~0.8 cumecs or about 30% of the flow of Phoe Inn resurgence. This Khin Lea resurgence comes out of the frontal hill that contains the big Bat Cave, and it may hint at large cave systems in that area.

Dry valley between Khin Lea and Phoe Inn: The team also walked up a well developed dry valley that originates from the mountain front, which ends at an internal 60m high cliff line. This feature has a dry river bed that may carry monsoon water.

Ju's Gu and its monsoon water: The water-worn nature of this cave suggests that it is a major sink of monsoon water. The scale of water flow in Ju's Gu during the wet season appears to be significantly larger than that seen in Phoe Inn Gu (even during the wet season). We thus hypothesise that the monsoon water from Ju's Gu resurges at an as yet unknown location. However, it is possible that it links with Phoe Inn Gu in some way, as the north south strike of the Nwalbo Fault Complex favours such north-south connections.

Dry stream beds near Padalin Cave: We saw no evidence for other resurgences in the vicinity of Padalin Cave, or from satellite images of the mountain front for a considerable distance south from Phoe Inn resurgence. But there may be some dry stream beds entering the reservoir further south. Looking for this potential monsoon overflow from Ju's Gu may need further work.

Htee Hling village and resurgence below village: We were told of a resurgence near Htee Hling village, which may be linked to small dry stream bed ~600m east of village. There is another resurgence on google at the foot of the mountains that is even further north than Khin Lea resurgence, at the foot of the escarpment near where the path heads up to Htee Hling village. This northerly resurgence may bear further reconnaissance and was not visited on this trip..

Southerly resurgences: There is also a resurgence near a village that is ~13km south of Ju's Gu, which may be worth visiting. It does not seem easy to get to this far southerly village.

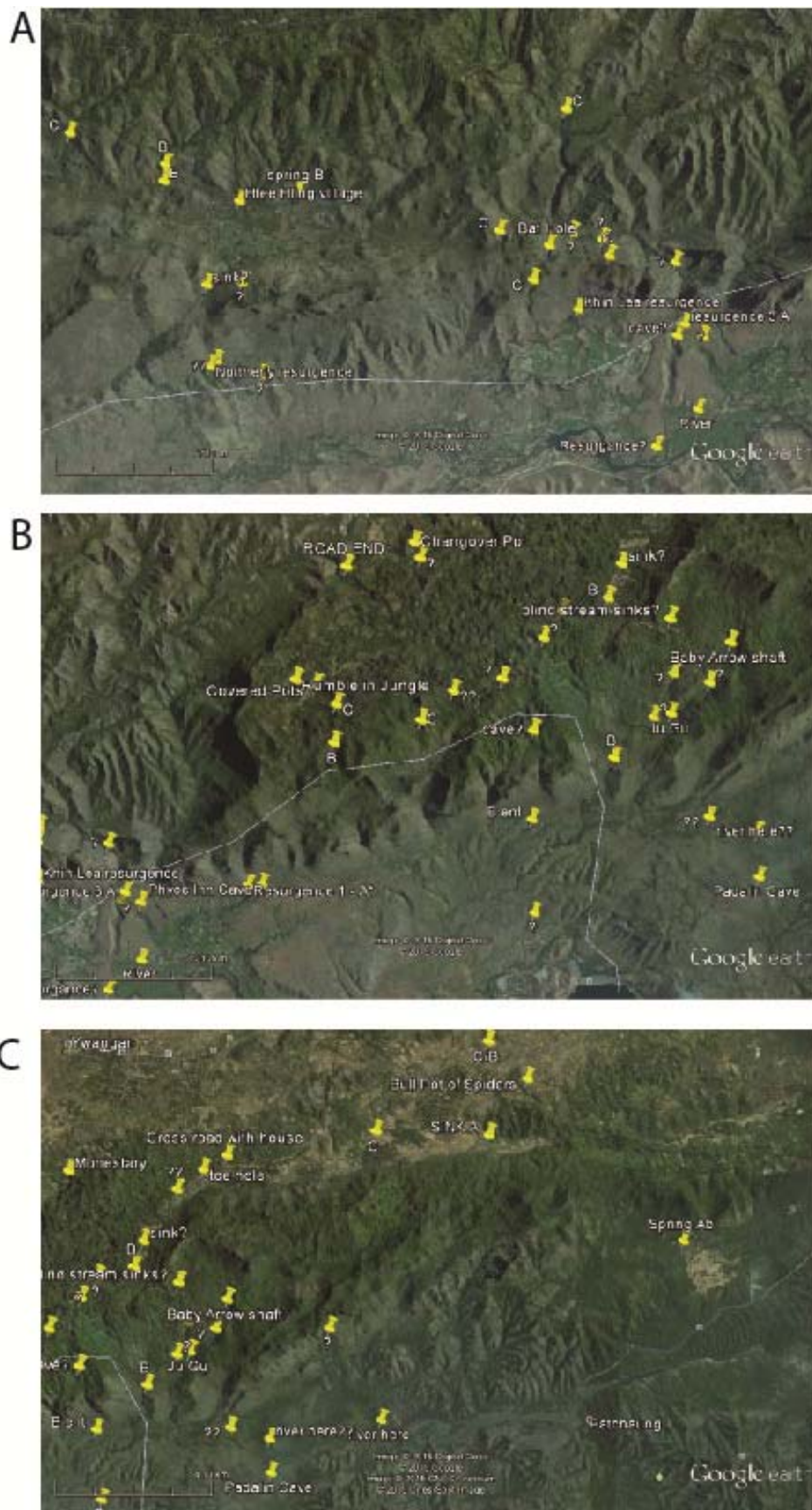


Figure 10 Satellite images of the caving area roughly corresponding to the north, central and southern parts of the escarpment.

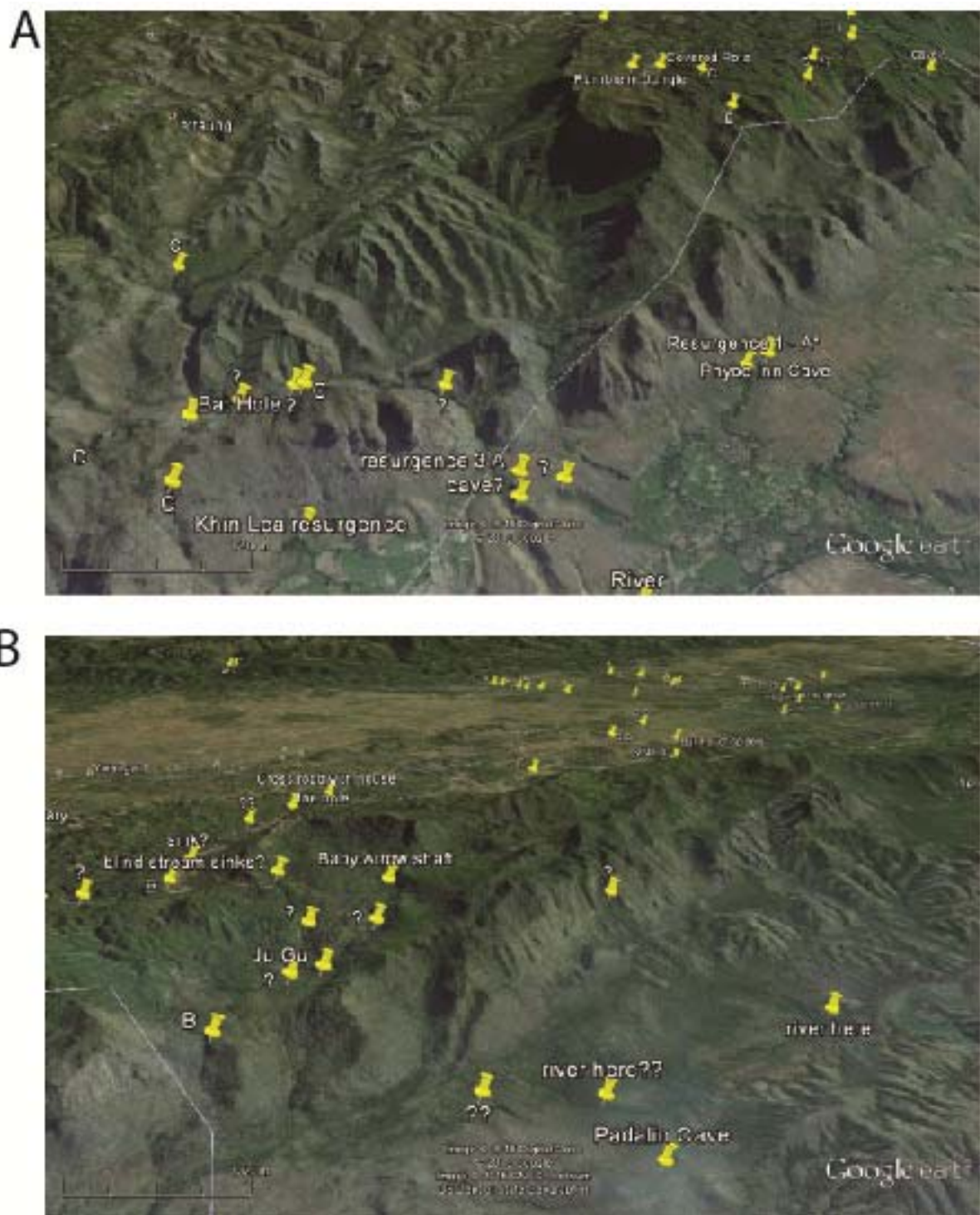


Figure 11 Perspective views of google earth satellite images. (A) Phoe Inn resurgence below the highest plateau with 1400m relief (with Rumble in Jungle and Covered Pot). (B) Mountain front further south including Ju's Gu and Padalin Cave.

Incident Report

The incident occurred on January 2nd on the first full day of exploration in Ju's Gu, which is located 5 minutes from the road to Padalin. It occurred when a large cobble that fell 30m from the top of the entrance pitch hit Cat Hulse. She had just got on the rope at the bottom of the pitch, on her way out to get another long rope for exploration at the pushing front. The rounded cobble had dimensions of 30 cm x 15 cm x 15 cm; and had considerable force given the length of fall. Cat had little chance to avoid the cobble as she was attached to the rope a few feet off the floor. The cobble badly broke her left arm, and badly bruised her left leg. Most likely, she fended off the cobble with her arm before it then impacted her leg. Given her condition, she did very well to get off the rope (by down prussicking, to avoid cutting the rope) and regain the floor of the chamber. The incident occurred at ~12.30pm, and this probably took her 15-30 minutes. She is a qualified doctor, and once on the floor she was able to administer herself painkillers (50 mg cocodamol plus diclofenic) that then allowed her to splint the wrist using a twig and her first aid kit. CD, BW and PT were at the pushing front lower down the cave, and BW only headed back out two hours later to reach Cat at ~3pm. She had put on her oversuit, balaclava and warmer clothes, and sat on a welly; but was still chilled but in good spirits. BW then arranged for CD to bring up all remaining rigging gear to haul Cat out of the entrance pitch. This pitch is mainly a 30 m free hang with a further 5m of further pitch to the lip. BW and CD then exited the cave to set up a hauling system that used an additional long rope in the van and new bolts. It comprised a standard "Z rig" with 3 to 1 advantage. BW, Sai and Mr Myo hauled, while CD was placed on the y-hang at the lip where he provided a lifeline for Cat. PT prussicked up the original pitch rope level with Cat, and assisted her to get on the lifeline and haul rope. She was hauled out to the lip by ~5.30pm, and was able to use one leg to help fend off the rock on the last few feet above the y-hang. The hauling party did a very good job of producing a smooth lift.

The origin of the cobble is odd, given that the original y-hang comprises two bolts on a smooth wall of good rock. It seems most likely that the cobble was dislodged by rope weighted further along the belay chain, such as in the loop of rope that went from the y-hang to an upper thread. Elsewhere in the cave, powerful flow of water has produced solidly-wedged rocks and smooth rock walls.

Cat was assisted to the van and taken to Ywangan hospital, who referred her to Taunggyi private hospital after an initial examination and new plaster cast. She was driven to Taunggyi where the decision was taken on the 3rd to fly her home for an operation in the UK. She stayed overnight in Taunggyi assisted by BW, Si and Mr Myo; and flew to Heho and then back to the UK on the 4th January.

References

Oo, T., Hlaing, T. & Htay, N. (2002) The Permian of Myanmar, *Journal of Asian Earth Sciences*, 20, 683-689.

Garson, M. S., Amos, B. J. & Mitchell, A. H. G. (1976) The geology of the area around Nyaungga and Ye-ngan, Southern Shan States, Burma, Institute of Geological Sciences, Natural Environmental Research Council, HMSO, London.

Appendix A: Caves Identified & Surveys

Table 2: GPS coordinates for cave entrances (degrees and decimal mins – except in yellow that are degree, minutes and seconds) and other key features

| Feature | Altitude | Latitude | Longitude |
|---|----------|----------------|----------------|
| Padalin Cave | 275 m | 21° 07.938' N | 96° 20.424' E |
| Phoe Inn Gu | 316 m | 21° 13' 15'' N | 96° 20' 13'' E |
| Phoe Inn Resurgence | 285 m | 21° 13' 23'' N | 96° 20' 11' E |
| Khin Lae resurgence (no way in) | 312 m | 21° 15.648' N | 96° 20.199' E |
| Phyu Thwin Cave (alcove in cliff near Khin Lae village) | 197 m | 21° 15.700' N | 96° 19.600' E |
| Kayaluk Gu Teat (Cave) | 1311 m | 21° 15.145' N | 96° 29.555' E |
| Waterfall and cave | 1200 m | 21° 16.092' N | 96° 29.894' E |
| Changover Pot (near Nebanji) | 1396 m | 21° 11.685' N | 96° 23.971' E |
| Covered Pot (above Nebanji) | 1534 m | 21° 12.6144' N | 96° 22.4343' E |
| Rumble in Jungle (above Nebanji) | 1555 m | 21° 12.8039' N | 96° 22.4823' E |
| Bull Pot of the Spiders | 1013 m | 21° 04.5262' N | 96° 26.2827' E |
| Baby Arrow Shaft (on road to Padalin) | 1027 m | 21° 08.4795' N | 96° 23.0227' E |
| Ju's Gu (Confluence Pot) (on road to Padalin) | 775 m | 21° 09.0150' N | 96° 22.2520' E |
| Bat Hole (approach via Hlee Hting village) | 818m | 21° 15.943' N | 96° 20.817' E |

Appendix B: Expedition Log

| Day | Events |
|--------------------------------|--|
| December 19 th 2015 | Main team leave the UK; CH already in Yangon. |
| December 20 th 2015 | Main team meet CH in Yangon at 0630am; then all fly to Mandalay and drive to Kyaukse with Si and Mr Myo – and get permissions |
| December 21 st 2015 | Obtain permission from immigration & archeology depts.; drive to main dam and meet police outpost. Take boat and walk to Padalin Cave |
| December 22 nd 2015 | Visit Phoe Inn Village; see Phoe Inn resurgence and start exploring Phoe Inn cave – drop northern pitch towards end of day. |
| December 23 rd 2015 | Head gasket of van blows crossing river. Explore Phoe Inn cave to second entrance near resurgence (FL-CH-FL) and drop northern pitch (CD and BW) |
| December 24 th 2015 | Day off drawing surveys as van is fixed in garage at Kyaukse. |
| December 25 th 2015 | Explore Phoe Inn cave – Ben swim's upstream to meet snake with PT and CH. FL and CD go into higher level to south and east. |
| December 26 th 2015 | PT and FL explore for resurgences, including that at Khin Lae. CH, CD and BW push Phoe Inn river passage to conclusion and derig cave. |
| December 27 th 2015 | Drive and move base to Ywangan. Si gets phone number for truck to get to big Bat Cave. |
| December 28 th 2015 | Visit waterfall, root-ferrata and small through cave to north-east of Ywangan; near Kyauk Gu Neat village. |
| December 29 th 2015 | Near Nebangi village and area immediately west of Ywangan; descend Changeover Pot. |
| December 30 th 2015 | Walked up to high plateau to NW of Nebangi Village. Looked at Covered Pots and Rumble in Jungle Pot. FL has explosive stomach and does well to get off hill. |
| December 31 st 2015 | Visit Myagalay village to west of Ywangan; Pete meets family and doctor that helped with toe. Drove south whilst awaiting permissions and CH and Cd drop Bull Pot of Spiders. |
| January 1 st 2016 | Drive the road from Myagalay towards Padalin with guide. Rainy so uncertain of getting back on track. First drop Little Arrow Cave. Then shown much bigger Ju's Gu that CD descends first pitch. |
| January 2 nd 2016 | CH, CD, BW and PT explore pitches 1,2,3 and top of 4 in Ju's Gu. Seemingly entering the drafting Master System. Cat is hit by large falling rock at start of entrance pitch at 1pm, whilst retrieving longer rope. She has badly broken wrist and bruised leg, but gets off rope and makes own splint. Thers get back to het at 3pm. Hauled up entrance pitch by BW, CD, Si and Mr Myo; PT on parallel rope. She visits Ywangan hospital and then driven to Taunggyi with BW, Mr Myo and Si. |
| January 3 rd 2016 | Taunggyi hospital refer Cat back to UK, and she books flights home. BW assists with Si. Others in Ywangan. |
| January 4 th 2016 | CH flies back to Yangon from Heho, and then back to UK for operation on broken wrist. Very stoic. |
| January 5 th 2016 | FL, CD descend large shaft in Ju's Gu |
| January 6 th 2016 | FL, CD complete exploration and survey of Ju's Gu. PT visits Mango House at the bottom of the hill where he learns of more caves, before returning to help derig Ju's Gu. |
| January 7 th 2016 | Rope cleaning and gear sorting day |
| January 8 th 2016 | Visit to Bat Cave by 2 hour truck journey via Htee Hling village. Also visited |

| | |
|-------------------------------|---|
| | their monastery. |
| January 9 th 2016 | In afternoon, FL, BW, CD and PT fly back from Heho and stay in Yangon. |
| January 10 th 2016 | FL, BW, CD and PT fly back from Yangon, and arrive back at 20.25 in UK. BW drives back for work the next day in Manchester. |

Appendix C: Equipment in Myanmar

23 thu'-bolts

10 thru' bolts on hangers and maillons

25 hangers and maillons without bolts

11 bolts

20 maillons and 23 hangers (for use with spits)

47 cones

45 spits

Slings: 2x6m; 2x5m; 1x4m; 3x3m; 8x2m; 6x1m; 4x<1m

Ropes: 100m, 3x40m, 24m, 20m, 2x16m, 1x15m

1 surveying tape (50m, 6cm short); 6 nail polish, 11 pencils

1 spanner with lanyard

8 snaplinks

9 screwgates

1 bolting hammer

1 bolting driver

1 grappling hook

1 chisel

2 tyre inner tubes

Biology kit, including 2 fishing nets

1 figure of eight descender