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EXPEDITION TO THE KAMENO-MORE REGION, MONTENEGRO, 2009: THE EXPLORATION OF CAVE PIŠTET 4

by

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ABSTRACT

A summary is presented of a multi-club expedition to the Kameno-More region, "Sea of Rock", of Montenegro specifically relating to the extension of the cave, Pištet 4, which is ongoing. It is now the 7th deepest cave in the country. A short, muddy pitch at the base of mud banks c.20 m high marks the current limit of exploration. A large chamber is visible ahead.

INTRODUCTION

On 6th August 1999, D. Mirović of the Belgrade Caving Club, Speleološki Odsek Beograda, discovered Pištet 4 (PT4) during reconnaissance as a part of the Kameno-More '99 Speleo-Camp. The first pitch and meander were explored the following day by U. Akšamović, S. Mesarević and D. Mirović. Further exploration in 2000 by U. Akšamović, N. Božović, A. Dodig, M. Marković, B. Šili and C. Bicalho and in 2004 by U. Akšamović, N. Božović, J. Duxbury and M. Tringham increased PT4 to a depth of -178 m, ultimately limited by a lack of time and equipment (Božovic, 2004).

In 2009 Duxbury *et al* returned to continue the exploration. From 21st June to 4th July, an eight strong team from the UK spent two weeks revisiting and exploring the cave after establishing camp in an adjacent valley with a good natural water supply. The team comprised C. Backhouse, C. Binding, A. Clark, J. Duxbury, G. Jones, G. Kiely, C. Smith and P. Taylor.

In total, nine days were spent underground, rigging, exploring and surveying; significant discoveries were made, doubling the depth and tripling the length of the known cave but time constraints forced an end to exploration, despite open, unexplored passage remaining in view.

Advanced plans are already underway for a return to PT4 during the summer of 2010 to push, survey and photograph more of the cave.

DISCUSSION

PT4 is located in the Presjeka region, in the vicinity of the village of Velji Pištet, approximately 800 m above sea level in the hills overlooking Boka Kotorska bay, in Risan county, Republic of Montenegro, Eastern Europe. The two coastal resurgences, Sopot and Spila, lie close to the town of Risan. During spring, the flood discharge rate from Spila regularly reaches 100 m^3/s (Milanovic, 2007) while the Sopot resurgence has recorded up to 350 m^3/s.

Speleologically, this region was completely unexplored before 1999. Near to Kameno-More is the village of Crkvice (940 m above sea level), which is the wettest place in Europe.

Figure 1. *Map of Southern Montenegro.*

The average annual precipitation for the period 1931-1960 was 4927 mm/m² and for 1961-1990 was 4631 mm/m². The highest amounts per year surpass 7000 mm/m² with an all time historic high of 8036 mm/m² in 1937 (http://en.wikipedia.org/wiki/Crkvice). There appears to be great scope for many further speleological discoveries.

PT4 begins as an impressive cascading pit leading to areas of major breakdown followed by a misfit streamway, with boulder chokes intermittently blocking its course, possibly a result of roof sections yielding to seismic events (Milanovic, 2001). This appears to be the most likely mechanism resulting in water backing up and depositing massive, and significant, mud layers on the upstream approaches.

Numerous aven inlets presumably augmented the streamway in the past during times of heavy weather, but this no longer appears to be the case; although the 2009 exploration coincided with exceptionally poor weather, the avens, and other inlets, did not become active. No evidence of recent flood debris was apparent anywhere in the known parts of the cave.

The explored cave has eleven distinct elements or changes of character:

The entrance chamber
Narrow meanders with an intermediate wide chamber
A large vertical shaft
Breakdown boulder choke with mud banks
A secondary active inlet and heavily sedimented vadose trench
A streamway, with occasional aven inlets
Boulder choke chamber

Further streamway, waterfalls and cascades
Boulder choke causing (presumed) ancient and massive sediment banks
Undescended mud trench/pitch and
Huge chamber visible beyond large mud banks

Figure 2. *Map of Kameno-More region.*

The entrance chamber appears to have been formed as a result of normal karst processes, combined with the ceiling collapsing, which may also have been the case with the other areas of major breakdown.

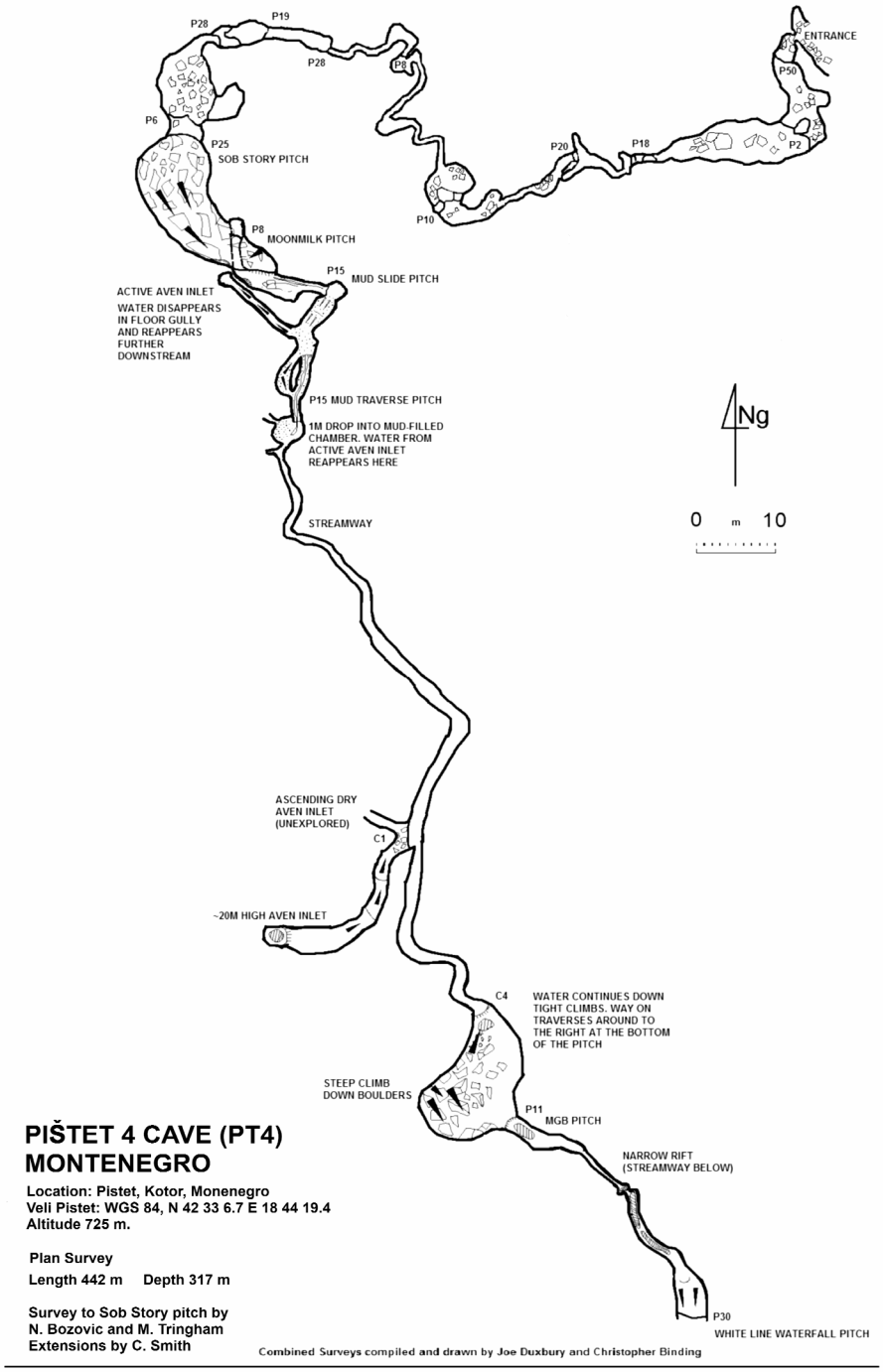

Figure 3. *Plan survey of Pištet 4.*

The first part of the cave has distinct, deep, narrow passages with numerous small pitches. In the section with an intermediate chamber, at a depth of about 90 m, there appears to have been a collapse of the ceiling, or possibly even a complete upper gallery. It is possible that this resulted in a convergence of two channels: a vertical shaft and a horizontal gallery, and that there was a collapse of the already eroded walls at the point of the intersection of the passages. This has led to today's configuration of the channels: a high chimney and a chamber at its foot at the wider point in an otherwise deep, narrow, winding passage. Also, the pit in this chamber was not previously explored but it was subsequently proven by investigations during the expedition that it descends below the presumed floor of this level, which would support the theory of there having been two different passages, perhaps even two completely separate pits, merging together. The fact that the deep vertical cut has almost the same characteristics, before and after this chamber, seems to corroborate this.

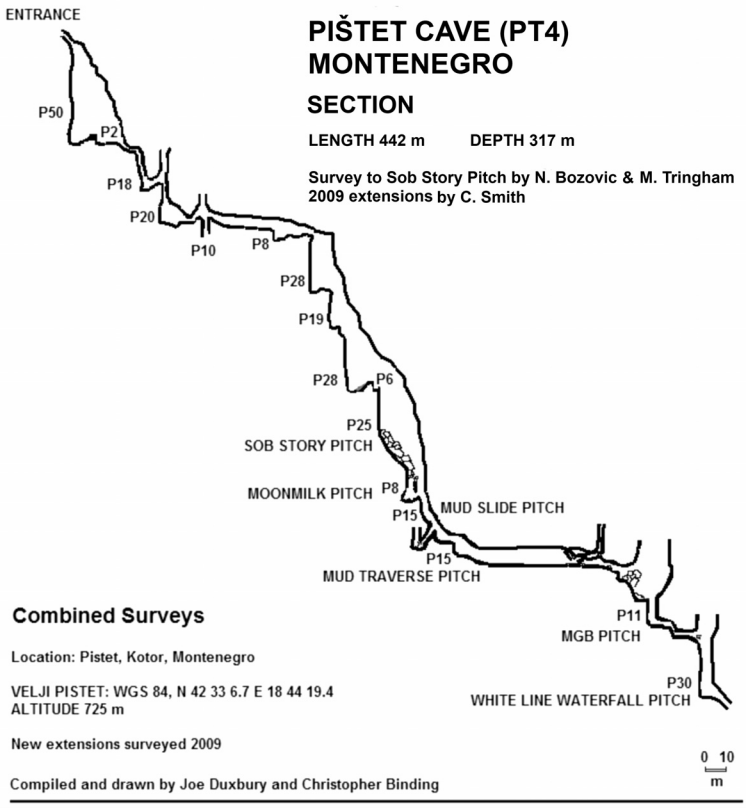

Figure 4. *Projected section of Pištet 4.*

Apart from a small pond and a slight water flow emerging from it, a result of dripping water, not a concentrated flow from above, this section of the cave is completely dry.

Further down, the character of the passages changes dramatically, being mostly vertical and of impressive dimensions. The dominant massive shaft appears to have once been the collector for several strong flows of water coming from the surface but observations

provided no evidence that this remains the case. There was no significant flow entering this part of the cave despite frequent instances of torrential rainfall during the expedition. This fact, combined with the configuration of the surrounding terrain, suggests that the pit itself is a part, maybe even a central part, of a larger, deep cave system with multiple associated surface inlets.

During the course of the 2009 expedition, the weather was extremely poor (Smith, 2009) with thunderstorms almost daily and torrential downpours the norm rather than the exception. Local inhabitants claimed the region was experiencing 'the worst (summer) weather in fifty years'. PT4 contains features which are indicative of active passage such as fluted, clean-washed waterfall pitches, heavily scalloped streamway and massive fluvial sediment banks adjacent to boulder chokes; however, despite the appalling surface conditions, these characteristic parts of the cave exhibited no signs of reaction to the rainfall, begging the question 'Where is all the water/rain going?'. It seems likely, therefore, that PT4's 'active' passages are now mostly fossil, the present day watercourses having since bypassed them, funnelling surface water via other, unseen routes. It is true that there was *some* water in the streamway but it was not exhibiting signs of high flow rates, insofar as flood debris was not visible anywhere along its banks and the running water was clear and lipped over gours and bedrock rather than churning over them.

It is reasonably envisaged that the PT4 streamway augments a master system or main subterranean river/sump, which subsequently resurges at the Sopot and Spila Springs in Risan Bay, approximately 3 km away, and 300 m lower, than the present 'end' of the cave. The secondary spring in the bay is sufficiently powerful that it creates significant visible turbulence, despite being 50 m below the surface (Milanovic, 2007).

TOP TEN DEEPEST CAVES IN MONTENEGRO

Ranking	Name	Depth	Location
1st	Jama n Vjetrenim brdima	-775 m	Durmitor, Žabljack
2nd	Kozí Díra	-662 m	Krivošije, Orjen
3rd	Jama u Malom Lomnom dolu	-605 m	Durmitor, Žabljack
4th	Duboki do	-506 m	Njeguši, Lovćen
5th	Jamski sistem u Obrucinama	-464 m	Durmitor, Žabljack
6th	Jama u Crkvenom dolu	-463 m	Moračka kappa, Nikšić
7th	Jama u Priabatovom dolu	-395 m	Maganik, Nikšić
8th	Jama u Majstorima	-388 m	selo Majstori, Lovćen
9th	Njegoš pećina	-340 m	Njeguši, Lovćen
10th	Samo Lepo	-321 m	Surutka, Durmitor, Žabljack

Table 1. *Deep caves in Montenegro*
After: Akademski speleološko-alpinisticki klub, Belgrade.

The 2009 surveyed depth, to the base of pitch 14, is -317 m; however, add to this the guestimated additional depth of the ongoing passage team members followed beyond it, at a conservative 80 m, and this results in an overall projected depth of -397 m, provisionally ranking PT4 as the 7th deepest known cave in Montenegro.

It is worth remarking that PT4 would only need to achieve an additional depth of 110 m to take it into the top 4 deepest caves in Montenegro and, considering the local geology, this does not seem unreasonable.

During the expedition PT4's entrance was observed to exhale air at an apparently near-constant rate. Not once during the expedition did the breeze cease or change direction. The movement of air continued to be felt all the way down to the present limit of exploration. Mike "Fish" Jeanmaire (*pers. comm*. August 2009) explained that caves of fixed volume have a temperature 'switch point', usually at a similar time of year whereupon the direction of the breeze alters from inhalation to exhalation, to reflect the seasonally changing surface temperature. It would therefore be interesting to note the wind direction at PT4 during the Winter and Summer months to find out whether it alters. At the aperture above pitch two where the air current is very strong, it would also be easy to get a good wind speed reading and area cross-section and determine the flow, allowing calculations to be made which might help deduce the volume of lower parts of the cave.

Figure 5. *Pištet 4 Entrance pitch.*
Photo. C. Backhouse.

CONCLUSION & FUTURE WORK

The cave has yet to yield all its secrets and there remain multiple unexplored areas – pits and inlets abound, high avens will probably thwart all but the most determined, and well

equipped, expeditions. PT4 presently has an approximate maximum depth of -400 m and the 2009 expedition surveyed down to -317 m. The total length of the explored passages is approximately 800 m, of which 642 m have been surveyed.

The cold conditions inside the cave played havoc with the various cameras in use, even including those which were left in overnight to adjust to the lower temperature and increased humidity. However, the portable video camera and recorder did get good footage of some of the earlier parts of the cave. Sadly, there is no photographic record of the new discoveries, and this clearly needs to be addressed as a matter of priority by the next visiting team.

Further surveying will also be necessary, since there are probably easily several hundred metres of unsurveyed passage if the present downstream section is included, along with the unchecked inlets and various pits en route. Most importantly, there is the undescended mud trench and the intriguing, and exciting, blackness discernible beyond the immense mud banks. Therefore these goals should be the key workload for a future expedition.

It is reasonable to speculate that there remains a, as yet undiscovered, master river/collector lower in the cave, especially in light of the observation that the twin resurgences of Sopot and Spila in Risan Bay have a gargantuan combined flood flow rate approaching 500 cumecs. The entire karst valley in which PT4 resides could therefore be a single huge, sieve-like catchment comprising literally hundreds of active avens feeding a very large system beneath. The author believes that what has been seen so far could, metaphorically, be just the tip of an iceberg.

APPENDIX 1
CAVE DESCRIPTION

ENTRANCE CHAMBER

The entrance itself is unassuming, being just 0.6 m wide by 0.8 m high, inclined at approximately 50˚, at the base of an undercut cliff face, approximately 6 m high. Above and to the right of the entrance is an identifying name ‘SOB PT4’ in red spray-paint. To the left, immediately above the entrance, are two anchor placements - a spit M8 and a bolt M8, within 20 cm of each other. These are the principle anchoring points for the first pitch and lead down a slope comprised of a variety of rock sizes, some of which are loose, and cautious progress is advisable. The next anchor is on the right, at a good standing platform/alcove, and is a bolt M8 (although the drill hole is shallow and so the bolt itself protrudes somewhat). The next anchor is ahead, in the opposite wall/ceiling (spit M8) followed by another on the lip down slope (spit M8) about 6 m below. A short rebelay follows to an excellent natural spike, and the impressive and airy main free-hang begins, with a further rebelay some 25 m below. Generally, due to the quantity of loose rocks at the top of the pitch, it is sensible to rig as far to the right as possible, in order to avoid the rocks falling straight on to people or rigging. Even so, as the chamber is bell shaped, immediately upon arriving at the bottom cavers should vacate the drop zone.

The passage continues on the left with an awkward 2 m climb, and a right turn across the rock-floored chamber. The walls are of a honey-coloured limestone, smooth and dry, and with good moonmilk deposits. Passing over and beyond large boulders stacked at the far end of the chamber leads to a simple slope down and a narrow passage ending at a small vertical shaft, where a very strong wind blows – suggesting a significant void lies beyond. Two anchors facilitate rigging, but a rub point between them exists which is easily solved with a chain of maillons. The pitch leads via a steep slope, and a rebelay at a lip, to a final short abseil. These two pitches, and the chamber they descend, are on a much smaller scale than the principle entry pitch and the going also becomes tighter. At the bottom of the pitch is a choice of squeezes (the first, lower, one is 0.4 m wide and 0.5 m high and the upper one is 0.5 m wide but taller). Larger cavers removed their SRT gear for this obstacle. Beyond is a small, tall, rift chamber with a narrow slot in the floor descending via two rebelays to a clean washed inlet with a visually pleasing aven and a traverse/meander leading off.

THE FIRST MEANDER

Inlet water running away from the shallow plunge pool has subsequently carved a narrow, but deep, trench downstream which is far too constricted to descend. This can be traversed and opens into another, bigger, largely clean-washed inlet aven chamber. Immediately ahead, on the left, is a bold step over a pit approximately 10 m deep. This is believed to be the continuation of the earlier water-worn trench. Before the bold step, also on the left, is an unexplored inlet approximately 2 m up the side of the wall. This should be explored on a future occasion.

There are two impressive inlet avens, neither of which were seen to be active despite heavy weather. These presumably lead to surface depressions. The top of the avens appear to be in the region of 25 m high.

Figure 6. *Pištet 4, 3rd pitch*.
Photo. G. Kiely.

THE SECOND MEANDER

A strongly draughting side tunnel indicates the way on, again in the form of a meandering traverse, beginning at low level with thick moonmilk deposits on the walls. Easy hands and knees progress on ceiling height ledges lead around a couple of corners to the 8 m fourth pitch. Although beginning narrow and awkward, it bells out to a second ledge which can be bypassed via an easy wet cascade into a small pool. Mud covered ledges on either side of the passage lead to the next series of meandering traverses, and the head of the fifth pitch where a major change of character in the cave morphology occurs.

A LARGE VERTICAL SHAFT

The meandering trench approaching the fifth pitch soon becomes a 'bottomless' traverse. The belays are high, near the roof. The descent is easy at first but the walls quickly form a troublesome pinch point beyond which they widen significantly to reveal a magnificent shaft dropping away to one side – the audible echoes from the top of Pitch 5 are in excess of 8 seconds.

Pitch 5 is approximately 30 m and leads to another mud-coated ledge traverse to an 18 m pitch with a clean-washed ledge pool, a 4 m overhang and a further 28 m pitch to a floor of large (and some huge) wedged boulders.

A scramble up a boulder pile gains a high stance with two routes on – undescended (deep) pitches on the left or a short (6 m) overhanging pitch on the right hand side leading to yet another large pitch (the ninth pitch). The lip of the ninth pitch appears to be mid way down an awesome shaft of unknown dimensions with a great deal of loose rock. A 25 m pitch leads to another floor comprising yet more impressively large clean-washed boulders.

In July 2004 surveying ceased at the head of the ninth pitch (at point 52 which is the site of an M10 anchor sleeve). The 2009 expedition began surveying from this point.

THE BOULDER SLOPE AND MUD BANKS

At the base of the ninth pitch a loose gravelly slope on the right offers a bypass descent to the far wall, dipping at around 50˚ following the strike, still descending wedged boulders. An undercut climb opens in a small cubby hole with all surfaces coated in thick moonmilk deposits. Natural belays allow an easy rigged descent to a boulder floor.

Up-slope comprises a choke of yet more clean-washed boulders. A route on the right hand side allows a free climbable descent of an impressive vertical, wet, fluted pot. It is presumed that this area is the continuation of the main wet pitches higher up, which has suffered a collapse/choke at some point but which remains hydrologically active.

Down slope from the base of the 8 m Moonmilk Pitch, an abrupt change of character occurs with breccia fill and dry mud banks running the width of the sloping chamber. The mud banks are on a large scale, sloping away for tens of metres, with funnel-like pots aligned with the strike here and there. A slide down beyond one of these banks leads to an easy traverse, again on mud ledges, which opens to a pitch, easily rigged off natural belays, although with an awkward launch and return. The pitch is initially vertical then, after 4-5 m, a steep mud slope of about 60˚ with a couple of large vertical steps, descends for around 15 m to a col, one side of which continues its steep descent to a clean-washed cascade aven inlet. On the other side a passage leads to the head of a muddy, meandering vadose canyon approximately 20 m deep and approximately 2 m wide. The water feeding the canyon enters at the clean-washed aven and immediately disappears into a narrow slot. A descent of the muddy vadose canyon is rigged from naturals to give a good central hang to a ledge about two thirds of the way down along which relatively easy progress and an awkward slot (while remaining on rope) opens to a three-way stream junction and a standing chamber with mud banks for a floor; an easy descent to the streamway is ahead. The walls are coated with many evaporitic vermiculations.

STREAMWAY

The streamway is approximately 1 m wide and well scalloped, with light coloured limestone and sculpted protrusions adding to the visual appeal. The vadose canyon is approximately 6 m deep, not overly sinuous and with a gentle gradient at first. About 70 m downstream it opens to an inlet chamber where two watery passages on the right add to the flow. The water level experienced during the expedition was only around ankle depth. Ahead, a 4 m free-climbable pitch is soon encountered.

BOULDER CHOKE

Immediately downstream from the climb the water disappears into a boulder choke but a straightforward ascent on the right leads to a more precipitous exposed ledge and a climb down into a significant boulder choke chamber. Large boulders allow a circuitous route to be taken, regaining the streamway at another short free-climbable pitch. The way on is via an easy traverse and a steep rock slope which drops into a small plunge pool.

WATERFALLS AND ENLARGED WATERCOURSE

Beyond, a stoop opens to wider streamway passage and a short phreatic-style tunnel where a gour pool lips over into a change of character and a significant enlargement of the dimensions of the passage. The roof arches out of sight, while the walls widen either side of a noisy 11 m waterfall pitch. Well sculpted rock is the main visual appeal. The streamway continues to another pitch, reached after about 30 m. This is a two-part descent, both wet, the first being approximately 6 m and the second, 14 m. The second pitch has a steeply dipping exposed vein of white calcite visible. The conditions at the spray-lashed base of the second part of the pitch are the most hostile yet encountered in the cave. Communication between the top and bottom is impossible. The dip of the calcite vein is contiguous with a steeply descending tempestuous water ramp (approximately 30 m). Personnel logistics meant the 2009 surveying had to cease at the base of the waterfall. However, a description follows of the ongoing passage.

DIPPING CHAMBER, BOULDER CHOKES AND MUD BANKS

The base of the ramp ends in a narrow rift where cramped progress opens to more streamway and another similar rift. The passage continues as a cascading descent and another ramp leads to a ledge onto mud-coated boulders where the stream disappears once more. Progress over the boulders is slippery and a route back underneath and through a ruckle regains the watercourse beyond the choke. A short traverse and then another short drop lead to a split passage where dry progress through a walking sized passage on the left once again rejoins the streamway. This drops further to yet another area of boulders and once more the water disappears from sight.

Another dry route to the left leads to a vantage point where the present exploration ended in an area of mud-coated boulders with huge mud banks on either side of the passage (circa 20 m high). There is another trench on the right which also forms the way ahead where the stream can be easily heard but the approach to the edge is treacherously slippery and returning without climbing aids would prove exceptionally difficult, if not impossible.

Tantalisingly, viewed beyond and between the mud banks ahead is a large black chamber of unknown dimensions. Exploration ceased at this point due to time constraints.

APPENDIX 2
CAVE SURVEY

The plan and profile include drawings from the survey of July 2004 (Božovic and Tringham, 2004) and the newly surveyed discoveries. The 2004 surveying was carried out with a combined compass/clinometer, with a precision of 1° and a 20 m fibreglass measuring tape whereas the 2009 surveying was done using an SAP and Leica Disto.

The surveyed part of the pit has been divided into 15 arbitrary levels reflecting a reasonable perception that the horizontal (or near horizontal) parts of the cave such as passages, traverses and/or ledges that are vertically more than 5 m apart can be regarded as different horizons.

The plan was drawn using 'Paint' software.

RIGGING INFORMATION, OBSERVATIONS, TOPOS

The rigging is largely done along standard European SRT lines (Single Rope Technique) for progression with Stop/Bobbin-type descenders, as opposed to racks. Rigging used three types of anchors: spit M8, bolt M8 and bolt M10. During the 2004 expedition, SOB placed four bolt M10 anchors for experimental purposes to test durability on pitches 4, 6, 7 and 9. All remained usable in 2009. However, some of the spit M8s were rusty and will probably be defunct within another 2-3 years; therefore anyone entering this cave after 2011 should be prepared to install replacements, as required.

Appropriate bolts were left in the spit M10s but riggers need to be equipped with several anchor plates drilled with 10 mm holes if they are to be utilised. At least one drilled out hanger should be a ring hanger (specifically relevant for the P4 ceiling placement).

The rigging plans show locations and characteristics of all the anchors that were placed and include a table of used anchors and ropes and topographical sketch drawings. These may be viewed at http://www.ubss.org.uk/resources/pt4_rigging_topos.pdf.

ACKNOWLEDGEMENTS

I am grateful for the valued feedback supplied by the anonymous referees. On behalf of my fellow team members I should like to take this opportunity to thank the following organisations for financial assistance or the loan of equipment towards the expedition: the University of Bristol Spelaeological Society, the BCRA Ghar Parau Fund, the Cerberus Speleological Society, the Chelsea Speleological Society, the Gloucester Speleological Society, the Royal Forest of Dean Caving Club, the Wessex Cave Club and the Gloucestershire Cave Rescue Group.

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Last, and certainly by no means least, my hearty thanks go to the expedition leader, Joe Duxbury, for his months of organisational effort and for providing me with the opportunity to engage in pioneering exploration in this impressive cave.

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Maps of Montenegro:
http://www.montenegromap.net/mapofmontenegro.html

Soviet Military Map Archive:
http://www.topomaps.eu/europe/Montenegro/

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