

Journal of
British Speleological Association

CAVE SCIENCE

IMPERIAL COLLEGE EXPEDITION
TO THE
KARST OF PERU

CAVE SCIENCE

Imperial College Karst Research Expedition to the Peruvian Andes, 1972

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The Caves of the Palcamayo Area

R. J. Bowser and J. M. H. Coward

LA CUEVA DE HUAGAPO

La Cueva de Huagapo has been studied and explored by three expeditions during the last four years, each making fresh discoveries. The entrance is an obvious landmark in the Shaca valley west of Palcamayo and has been a tourist attraction for some years; the braver tourist venturing in for 100m or so, just out of daylight.

The first expedition to explore the cave was led by C. Morales Arnao. This was an entirely Peruvian venture; they explored the cave for some 600m, half of which was surveyed, and also studied the geology, hydrology and cave paintings near the entrance. The next expedition to visit Huagapo was a Polish one, from the Klub Wysokogórski in February 1972. They explored the cave to its sump — a total length of a kilometre. The water level is very high in February — usually 1.5 metres above normal — so it is perhaps understandable that their trip lasted some 22 hours with no survey being made; they did, however, take many photographs.

We arrived at Huagapo in mid-August, with the water at its lowest, and exploration proceeded rapidly. On the first trip in, the sump was reached in little over an hour, the deepest water encountered being only two metres. On the way out 400m of side passage — Wilderland — was explored, together with the canal under the dry bypass, and the streamway to the resurgence. On this occasion we were accompanied by Modesto, the cave guardian, who was pleased to be the first Peruvian to the sump.

On subsequent trips a further 100m of passage was discovered in Wilderland and Hero aven was climbed to a ledge ten metres up — the way on looking difficult. The sump was lowered 30cm by digging away the floor and it was free dived for five metres or so, but little rise in the roof could be found. A lot of time was spent in the roof looking for high level passages, but with little success. All that was found was 60m of passage above the present stream. The cave was surveyed to C.R.G. grade 5b in three trips, and three photographic trips were held. The entrance was triangulated on to our 1:25,000 map of the area, using a five second theodolite.

Description

The entrance is situated on the north side of the Shaca valley, 3,572m a.s.l., on a terrace 42m above the valley floor. It was dug out by the Peruvians as a tourist attraction, and is now an impressive arch, 30m high and 15m wide, phreatic in origin with large fossilised stalactites in the roof. There are also a few simple cave paintings on the left hand wall at the entrance. These were studied by the Peruvian expedition and are said to be about 10,000 years old.

Once inside, the passage drops five metres down a scree slope into the stream. On the right a low arch leads downstream through a descending phreatic passage, 1.5m high, with boulders and deep pools, to the wet entrance. The water resurges over a small waterfall and forms a tufa terrace running down to the Rio Shaca.

Back at the main entrance a two metre climb on to a ledge on the right is followed by 15 metres of phreatic passage to a blind chamber with no way on. A path over stepping stones leads upstream in a fine passage 30m high and 10m wide. A scramble

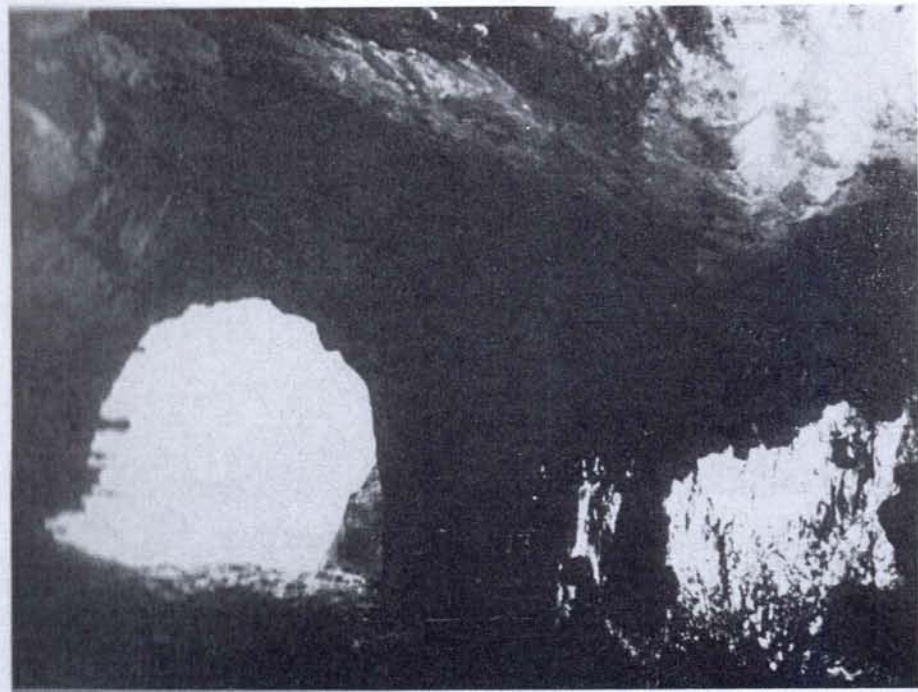


Plate 4.1. Looking out of the Huagapo entrance.

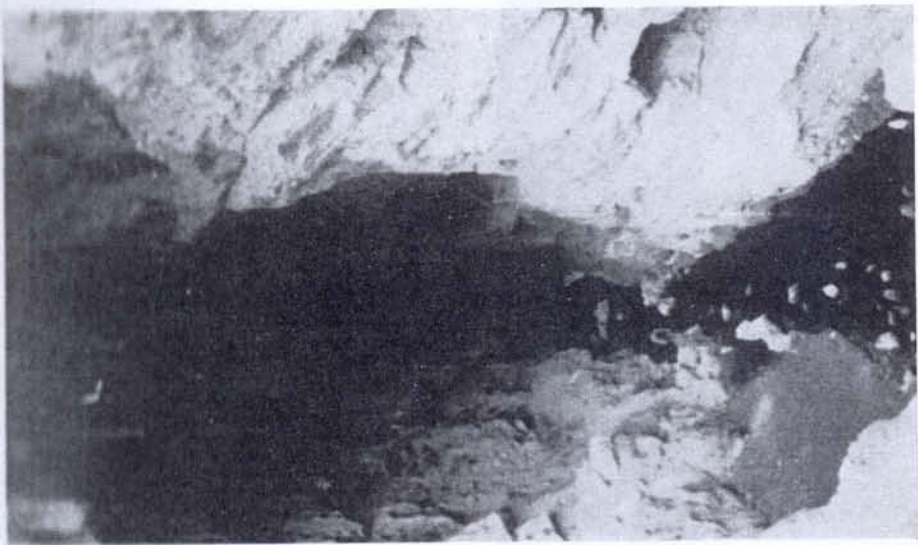


Plate 4.2. Looking into the Huagapo entrance passage.

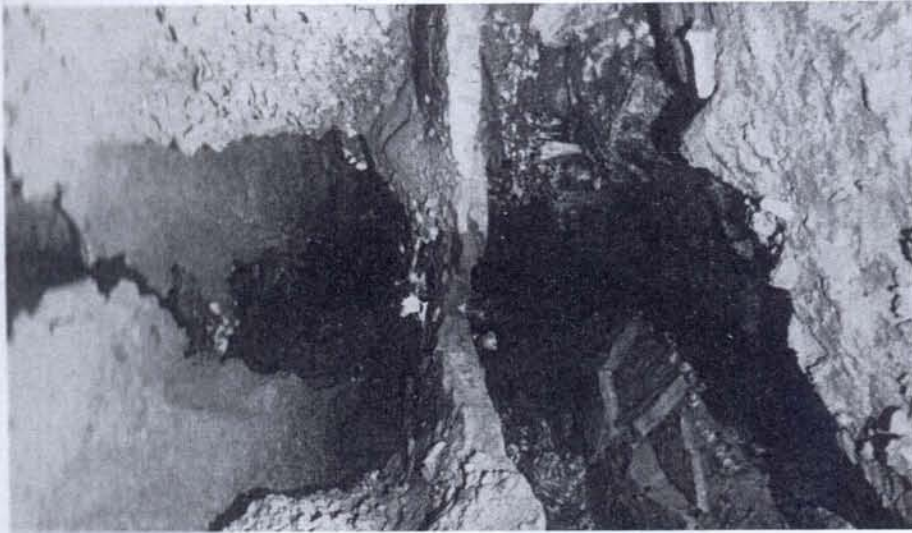


Plate 4.3. The false floors of Wilderland, in Huagapo.

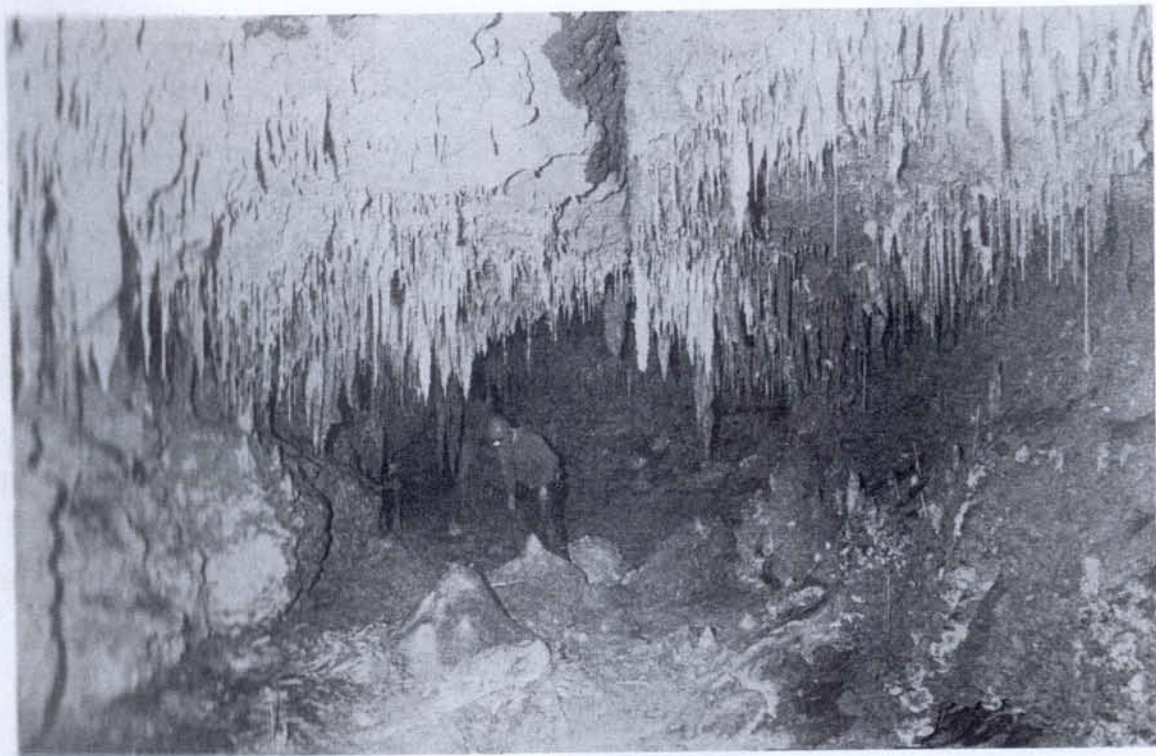


Plate 4.4. Wilderland, near the main streamway in Huagapo Cave.



Plate 4.5. The third canal in Huagapo Cave.

over boulders just past a rock bridge takes one out of daylight to an eight metre climb on the left needing a peg; a nail serves the purpose admirably. This is the dry bypass to the first canals. An ascending climb over a stalagmite floor with pools leads to a stalagmite choked climb in the roof. To the right the passage descends a few metres to a gently sloping ramp with several holes in the floor connecting back to the streamway. At the end of the ramp a traverse to the right ends with a seven metre overhanging pitch back into the streamway.

Returning to the bottom of the eight metre climb, 70m of two metre high phreatic passage, with waist deep canals made awkward by hidden blocks underwater, ends in a shallow streamway at the bottom of the 7 metre pitch. This passage contains many immature stalactites in the roof indicating that total flooding probably does not occur.

The cave once again resumes its magnificent proportions and after 50m of shallow stream passage the start of the next canal is reached. On the left here some 6 metres above the streamway stands the statue of Nefertiti — a magnificent six metre high stalagmite guarding the way on. The canal is fairly short, some 40m long, but with sections over two metres deep; an ice axe (spade) lost here proved difficult to retrieve. It is, however, possible but not worth the effort to traverse over the stream on ledges. This is followed by 150m of walking streamway with occasional deep pools, up to 1.5m deep, leading to the best decorated passage in the cave. This splendid 150m section of passage, Wonderland, contains glistening white stalactites, curtains and flowstone banks up to 20 metres long. Fortunately the passage is wide enough to avoid touching them.

A third canal passage is entered next. The roof drops to two metres but after 30m of canal it rises again and a side passage is met on the right. It is blocked by flowstone and becomes too tight after ten metres. The roof drops suddenly again and the canal continues for another 120m. This is the lowest section of the main streamway, six metres wide with 60cm of air space above the same depth of water. It is phreatic in origin and now contains a profusion of straws and small stalactites; unfortunately some have been destroyed by the exploring parties. Beyond the canal 200m of large stream passage, containing a large number of huge boulders, leads to the sump. A small aven is passed 25m before the sump on the left, but it is too tight. The sump is fairly shallow, less than a metre deep; the underwater passage is two metres wide and one metre high, and has been dived for five metres. It appears to be held back by large banks of well consolidated shingle and clay; it was lowered by about 30cm and could be lowered more though at the expense of considerable effort.

150m downstream from the sump a three metre climb on the left over boulders leads to Wilderland. This dry passage 3m wide and 7m high follows round in a loop for 250m, and ends near the choked passage off the third canal. The first 50m contains fine roof formations, and after 60m an inlet passage is met. 30m further on, at a collapse area with many fallen blocks, two inlet passages are met. The last 160m, Split Personality Passage, has fine false floors and mud formations, and ends in a delightful grotto eight metres above the floor with fresh calcite crystals growing on older formations in a crystal pool. A crawl under the grotto becomes too tight after a few metres but is presumed to connect with the main streamway.

The two side passages on the left at 90m, one reached by a short climb and traverse, lead up-dip and unite; they contain fine mud formations. A third passage leads off from a small chamber, to descend over blocks and flowstone banks into

a small vadose canyon. The passage continues in the roof on the left but soon blocks with flowstone. Following the vadose canyon upstream it contains several false floors and formations. A metre high climb through a hole in a false floor, and then a three metre climb leads to a 20m aven, Hero aven. A difficult climb ends on a flowstone ledge six metres up, further progress requiring artificial aid. Followed downstream the canyon leads to a tight crawl after 10m with a voice connection to the inlet passage 60m from the main stream, a similar tight crawl.

Speleogenesis

Huagapo is formed in massive Triassic limestone dipping at 25° to the south west. The main streamway is structurally controlled in a direction parallel to the axis of the syncline running north west through the Shaca valley, which is also parallel to the monocline-fault to the north east (see fig. 3.2). It is virtually impossible to say which aspect of this system controlled the cave. Some of the entrance series appears to be on a hading joint; a lack of extensive faulting is suggested by the considerable undisturbed bedding plane development near Wilderland. Other parts of the entrance series appear to have developed along a fault-monocline structure — large collapse areas lend weight to this theory, though no direct evidence of faulting was seen. The line of the main streamway has been locally modified by minor joint control, and Wilderland is controlled almost entirely by minor joints with the exception of the two down dip passages (see survey).

During the assessment of the actual history of the cave formation the following observations were taken into account.

1. The phreatic nature of the large roof of the cave entrance.
2. The roof height discontinuity at the end of the long canal.
3. Split Personality Passage is a phreatic tube with a deep vadose trench and also several false floors — evidence of ponding and probable fill.
4. The rise in roof level at the end of Split Personality Passage — an ascending phreatic tube to join the main streamway.
5. The choked high level passage in Wilderland is phreatic.
6. The long canal, Wonderland, the canal under the dry bypass, and the present resurgence are phreatic, and recent compared to the rest of the cave.
7. Hero aven series is vadose, false floors again give evidence of ponding and fill.
8. Most parts of the main streamway show evidence of collapse, particularly at the entrance and near the sump.

The cave has gone through six stages of development; there is no reason to suppose that these were clear cut, and considerable overlap of the phases almost certainly occurred (see fig. 4.1).

1. The cave began as a phreatic trunk route running parallel to the syncline; the maximum diameter reached was of the order of 10m. There is no evidence to suggest whether the cave resurged in the then shallower valley or continued along the syncline.
2. The second stage was probably the emergence of water from beyond the present sump. This cut the present route from the sump and the main passage in Wilderland joining the main stream at the now choked exit to Wilderland. At the same time the high level passage in Wilderland was formed (this is also choked). These passages were formed under phreatic conditions, Split Personality Passage attaining a size of about 8m by 5m.

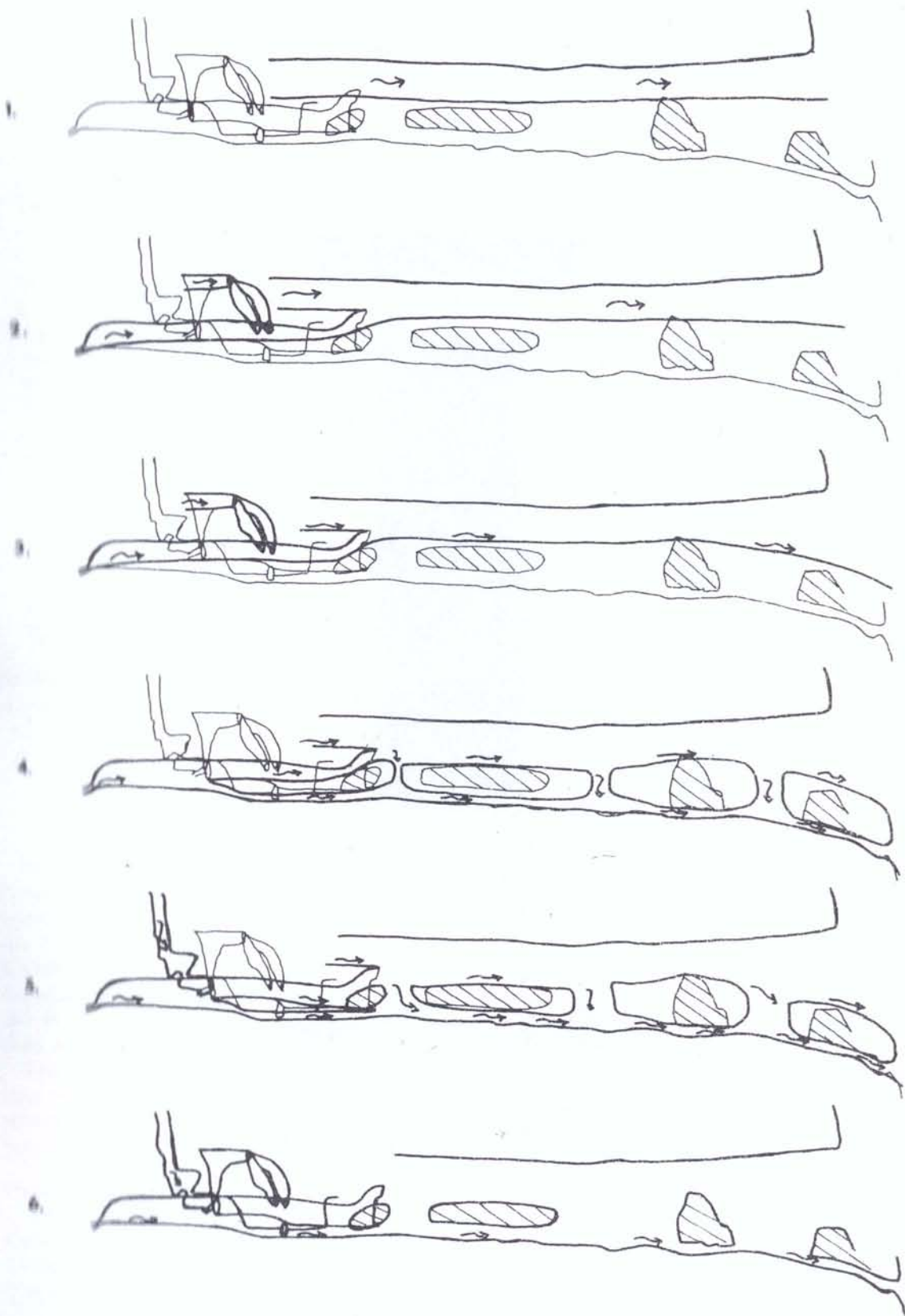


Fig. 4.1 Speleogenesis of Huagapo

3. The surface valley was deepened and the cave became a vadose resurgence. Wilderland and the passage near the sump were still enlarging under phreatic conditions. As the valley was gradually deepened so the vadose stream flowing over the dry bypass gradually lowered the entrance passage.
4. The stream from the sump began to cut the canal passages and the present resurgence under phreatic conditions, forming a second resurgence in the valley. The main vadose stream started to sink along its length creating connections between the streamways.
5. Continued downcutting of the valley rejuvenated the stream further, Wilderland became vadose, and the now vadose high level inlet in Wilderland assisted in cutting the deep trench in Split Personality Passage. Meanwhile the Hero aven series was developing, discharging its stream into Wilderland.
6. The new resurgence and canal passages captured the entire main stream and it assumed its present course. The remaining streams were soon captured upstream of the sump and calcite began to block their abandoned sections. These calcite barriers blocked the exit from Wilderland and the exit from the Hero aven series into Wilderland. Ponding probably with subsequent fill then occurred in these series, permitting the false floors to develop. Eventually small passages were formed releasing the water into the main streamway. Collapse occurred at the entrance to the cave, above the second canal, near to the sump, and in Wilderland between the high level inlet passage and the Hero aven series. The cave assumed its present form. (R.J.B.)

Reference

Morales Arnao et al, 1966-68. Primera Expedicion Cientifica de Espeleologia Caverna de Huagapo, Tarma, Revista Peruana de Andinismo y Glaciologia, Club Andinista Cordillera Blanca — Huaraz, Lima, Peru, 8: 173-91.

LA SIMA DE MILPO

Behind Huagapo cave is a deep gorge, Quebrada de Ushto, which cuts through the Pucará limestones to the north of Huagapo. The lower part of the gorge is very impressive, up to 300m deep and only 10m wide at the bottom; one kilometre from the Rio Shaca the gorge opens up to a deep V-shaped valley. A small stream flows from the hills above the upper part of the valley, past the village of Cauquiran, and sinks during moderate flow in a cliff face on the western side of the valley. The stream sink is a pair of tight joints, which were not entered, but 50m lower down the valley there is another joint, which is the entrance to the Sima de Milpo.

The lower part of the gorge is usually dry, but occasional floods (return period of at least ten years) flow down the gorge, to the Rio Shaca, and can cause considerable scouring in its floor. Under low flow conditions, throughout most of July to September, the stream sinks in the streambed near Cauquiran and does not enter the cave.

Description of the Cave

The entrance is a 50cm wide rift two metres deep, running back into the cliff face. Immediately inside is a small crawlway, 50cm by 50cm, for a few metres which fortunately soon opens out to a balcony overlooking a three metre deep, circular pot. The pot is blind but a traverse to the left leads into a rift and to a climb followed by

a nine metre pitch. At the foot of the pitch a small crawl leads off to a phreatic network, containing a few climbs, which gradually opens up to walking height due to vadose trenching. The second, or Polish, pitch leads down to a small chamber and a traverse on the right leads into the Polish streamway. This streamway can be followed up for 150m, until the stream appears from a narrow rift, which according to the survey is only 13m from the surface stream sink.

Below the Polish pitch the stream sinks in gravel and cobbles, probably to reappear in the wet bypass series (see survey). After a few more climbs and two pitches a large passage enters on the left hand side. This is the start of the Wet Bypass series and the passage can be followed up to a stream chamber where a stream enters and then down a wet narrow and sporting rift to Four-Way Chamber. This small chamber can also be reached via a series of climbs down the main passage. The entrance stream flows down through Four-Way Chamber and along a short passage to the high level sump. A small inlet passage enters above the sump pool but it was not explored.

The main passage leads off from Four-Way Chamber along a sandy and muddy floored passage to a series of climbs to Modesto's Pitch. The cave continues as a very sporting vadose streamway down a large number of climbs, pools and pitches to the final pitch. This eleven metre shaft drops into Rimstone Chamber.

At the northerly end of the chamber are a series of gour pools, and beyond are two short pitches leading to a mud blockage. Soil and leaves were seen here although this point is 500m below the surface.

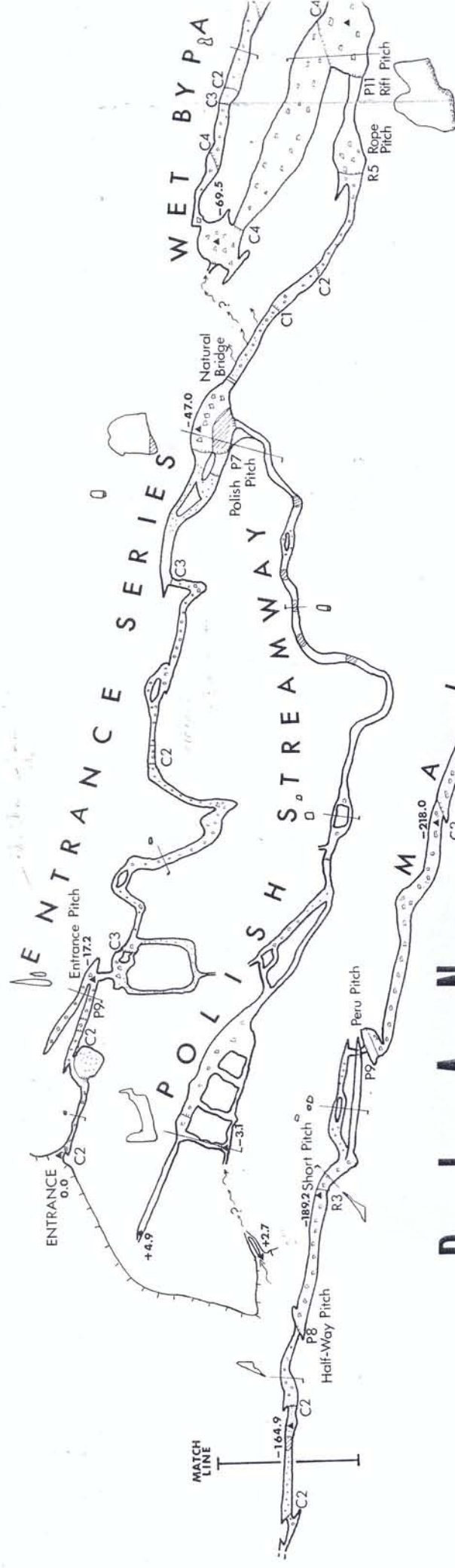
At the southerly end of the chamber, underneath the pitch, is a large pile of boulders and it is possible to climb down through these to a passage leading to the final sump. The sump pool is 10m long, 2m wide, and at least a metre deep. The sump was found to be the deepest point in the cave at 402.3m (1,320ft.) below the entrance giving the cave a total depth of 407.2m (1,336ft.). The sump is only just (6.9 metres) above the final sump in Huagapo cave.

Tackle

The cave is extremely sporting, containing a large number of climbs, rope pitches and ladder pitches. The exact number of ladders and ropes needed to descend the cave depends on the climbing ability of the party. The equipment marked on the survey seems adequate for a caving party of average climbing ability. We used eight eight-metre-ladders (plus two to descend from Rimstone Chamber) and four ropes. The belays on Rift and Waiting Pitches should be 20m long, on the Entrance and Peru Pitches one metre long, and on the other pitches they vary from two to ten metres. Eight metre long ladders are satisfactory on every pitch, although slightly longer ladders would be better on Rift and Final Pitches. Due to its isolation care should be taken to prevent injuries in the cave. Double ropes or singles with a self lifeling arrangement are best left on the Entrance, Modesto's, Half-way, Peru and Final Pitches. At least a single lifeline should be carried of course by each party descending the cave.

Development of the Cave

The cave is developed almost exactly down the dip, largely by vadose erosion. Just below the Entrance Pitch and for a short distance beyond Four-Way Chamber the passage is mostly phreatic; occasional phreatic half-tubes are seen in the roof



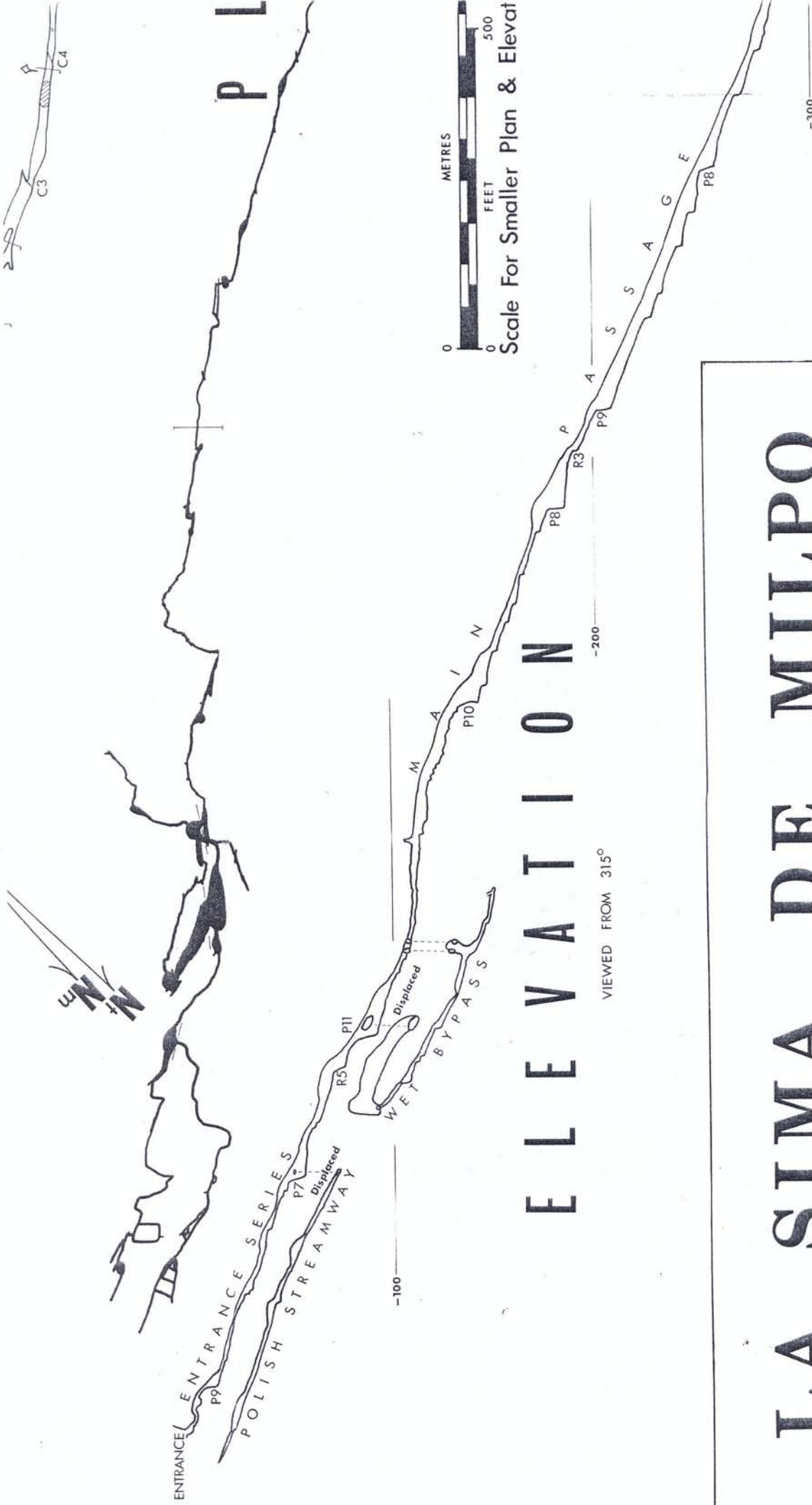
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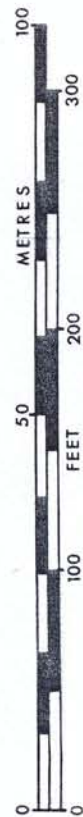
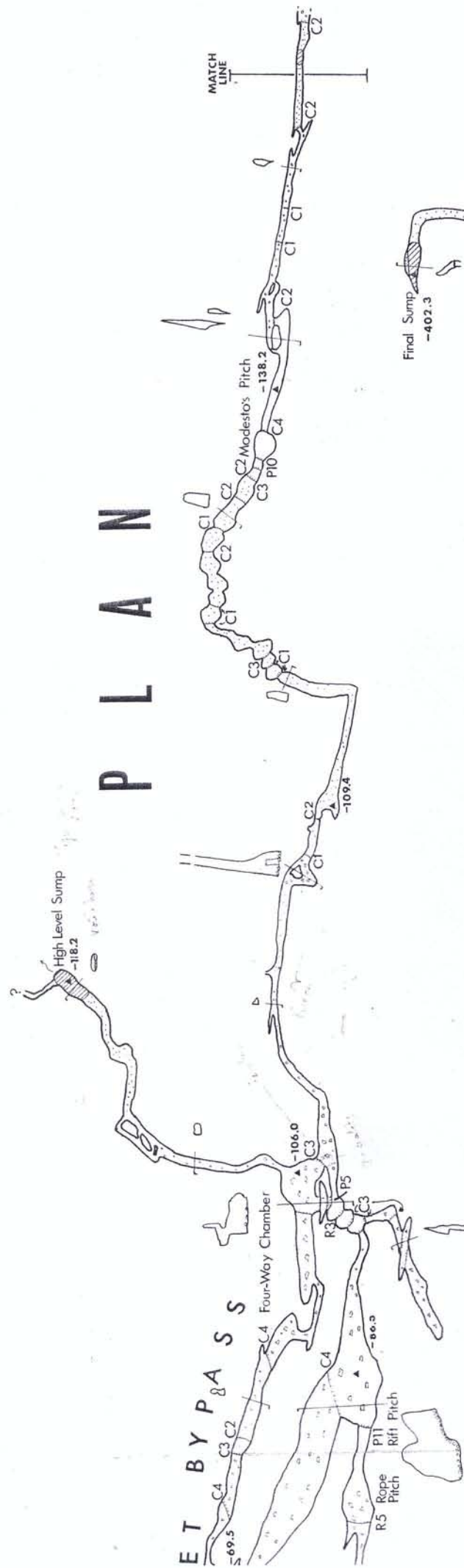
LA SIMA DE MILPO

Department of Tarma, Peru

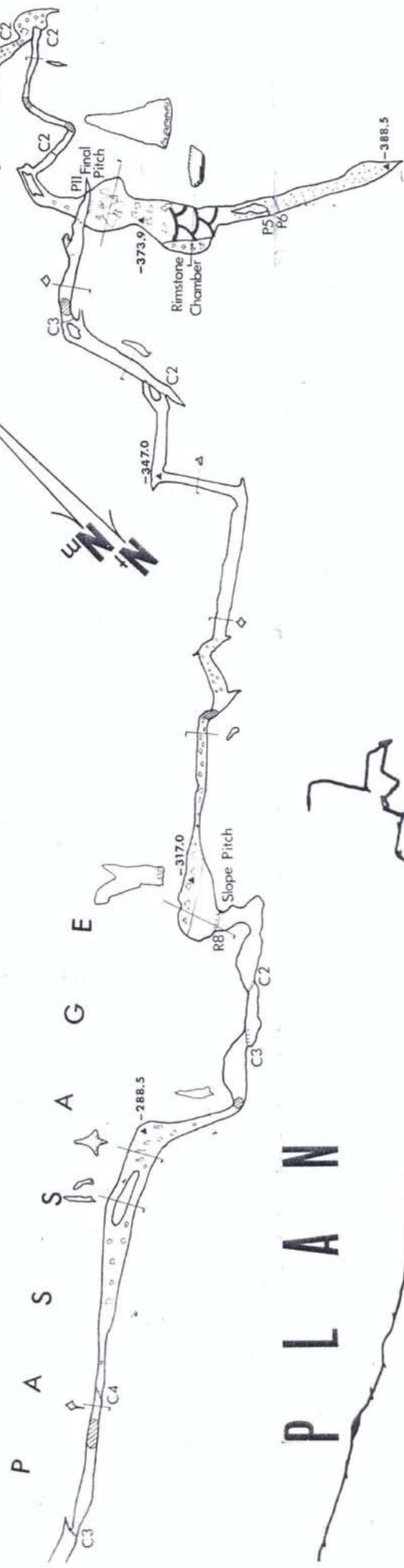
11° 14' 36.2"S 75° 47' 30.5" W

I. C. K. R. E. P. A.

SEPTEMBER 1972



Scale For Detailed Plans



P L A N



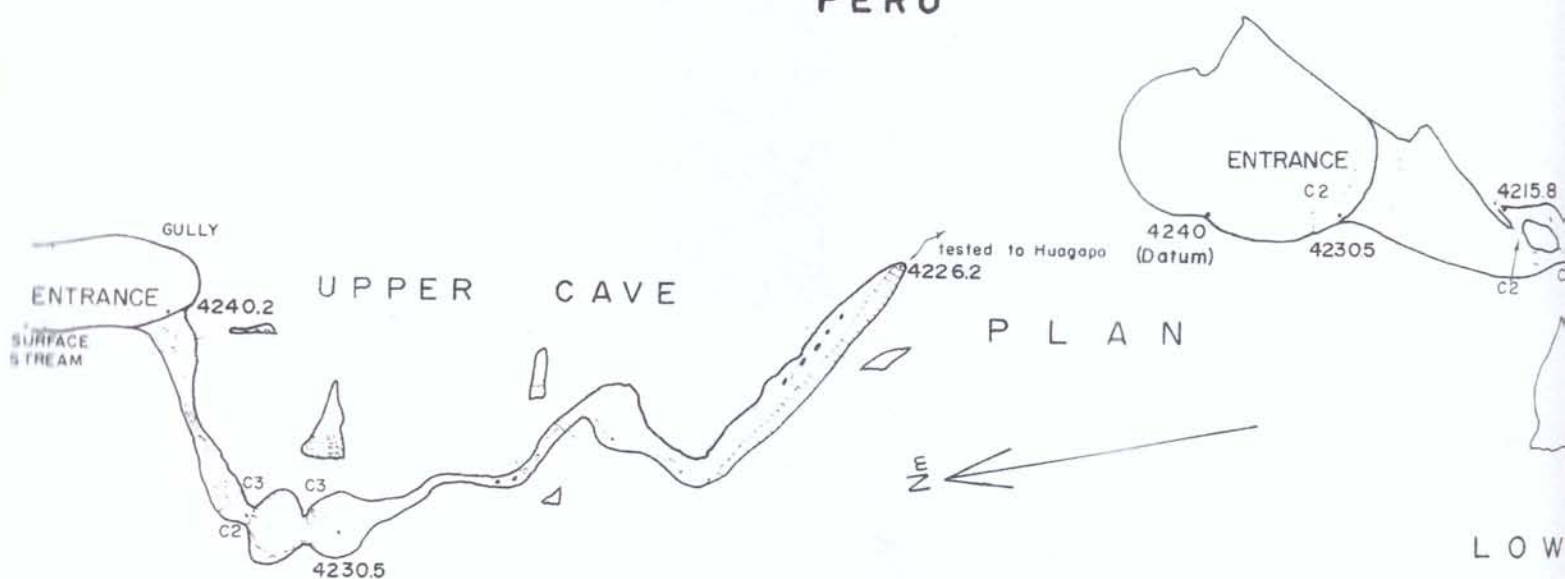
Plate 4.6. Rift Pitch in La Sima de Milpo.

Plate 4.7. The streamway in Upper Antacocha Cave.



- 41977 Elevation in meters a.m.s.l.
 702 Climb with height in meters
 Sand or mud
 Gravel
 Boulders
 Formations
 Stream

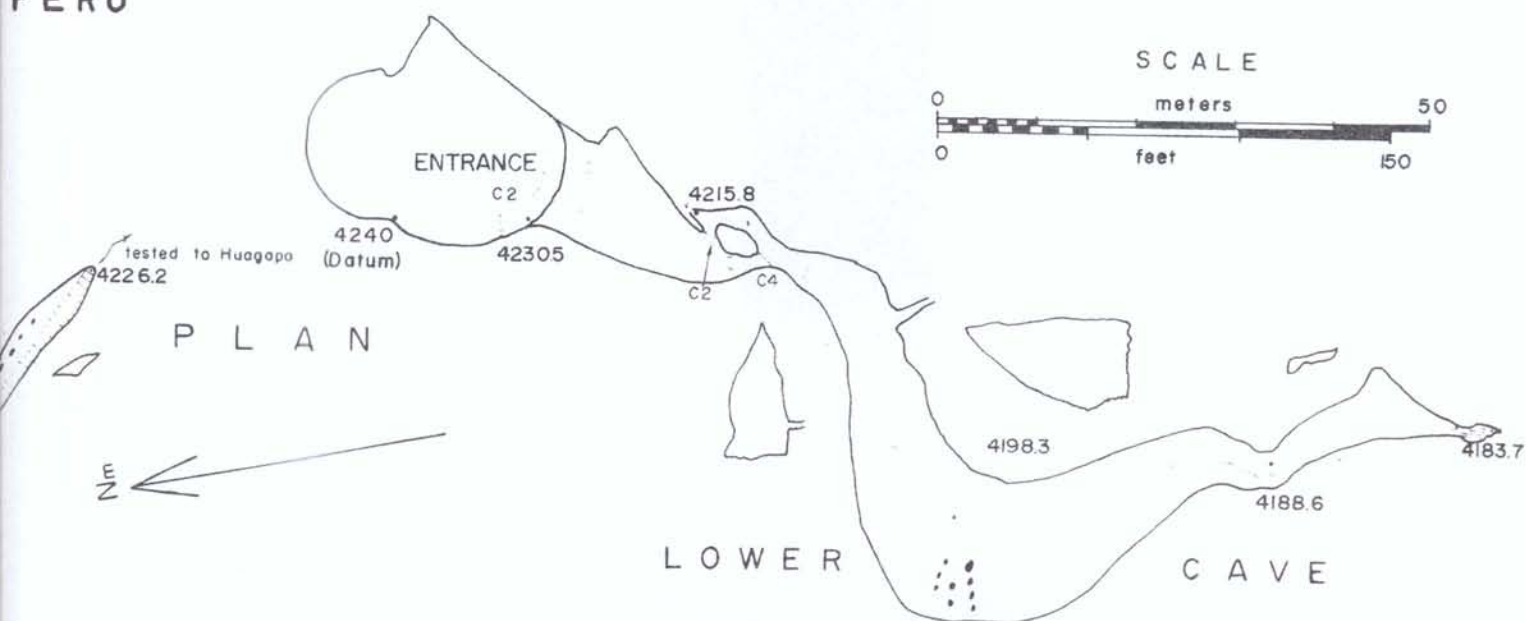
ANTA-COCHA CAVE DEPARTMENT OF TARMA PERU



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PERU

Notes

- 1) Datum elevation 4240 \pm 20 meters a.m.s.l (by altimeter)
- 2) Total horizontal length, Upper Cave 107.7 m.
Lower Cave 126.6 m.
- 3) Depth, Lower Cave 46.8 m.
- 4) Water in Upper Cave traced to Huagapo Cave (elevation 3570m)
- 5) Surveyed with Suunto's to C.R.G. grade 4d
- 6) Sections drawn to scale looking out of cave



in other places. The rest of the main passage is a classic vadose streamway with joint control particularly prominent in the lower part of the cave.

Rimstone Chamber is much older than the main passage. It was formed by collapse into a lower passage, which was probably developed by the strike oriented trunk drainage to Huagapo cave. The rest of the cave was developed when the surface stream sank at or near the present entrance and flowed down the main passage to Rimstone Chamber and into the final sump. The stream was then diverted at Four-Way Chamber to the high level sump, and later diverted to flow through the Wet Bypass. The surface stream also sank further upstream to flow along the Polish Streamway. The origin of the large boulder strewn passage between the foot of Rift Pitch and the Wet Bypass is unknown.

At present any normal stream sinking near the entrance flows down the Polish Streamway, sinks in the floor near the natural bridge, and then flows along the Wet Bypass and through the Four-Way Chamber to the high level sump. During high flow, water would flow down Rift pitch to Four-Way Chamber and on to the high level sump. During floods, water sinks at the entrance, and would probably also back up at the high level sump to flow along the main passage down to Rimstone Chamber and the final sump. During low flow conditions no water sinks near the cave and the cave is relatively dry; only a few inlets come into the main passage and a small stream collects and flows down to the final sump.

The water in the sumps in Sima de Milpo has not been tested to Huagapo. It is very probable that the water does flow to Huagapo however, as this is the only large resurgence nearby; Milpo's final sump is only 6.9 metres above the Huagapo sump, and Antacocha Cave has been tested to Huagapo, proving that this resurgence drains the area to the north.

There is no prospect of extending the depth of the Sima de Milpo, unless an upper entrance can be found, as the end is near base level. Other than the passage above the high level sump there is little prospect of further extension to the cave. However the cave is a classic streamway, is extremely sporting to explore and is well worth a visit.

(J.M.H.C.)

ANTACOCHA CAVE

On the contact between the limestones and volcanic rocks above Shaca Marca are a series of lakes. The most easterly lake, called Antacocha, drains along 500 metres of stream course to the Upper Antacocha Cave. The valley from the lakes continues past the caves to Shaca Marca; it is dry all the way down and the few shepherds that live in the valley obtain all their water from Shaca Marca, from Antacocha Lake or from the small spring at Yanapuquio on the eastern side of the valley.

Along the valley side there is a disused aquaduct, presumably constructed by the Incas, which was used to carry irrigation water from Antacocha Lake down the valley. In several places however, the aquaduct has drained underground through small caves and joints in the limestone, and in use it must have required extensive maintenance to prevent water loss.

Upper Antacocha Cave

The upper cave leads off from the end of the stream draining Antacocha Lake. The stream on 8th September 1972 was carrying about five litres per second. The

entrance is five metres wide but less than a metre high, with the water running over cobbles, broken glass, cans and other garbage. Within a few metres the cave increases to walking height and a few formations and some flowstone occur. Beyond this are two short damp climbs down to a pool, which is easily traversed to a small boulder floored chamber. The passage continues out of this, past a natural bridge to a muddy chamber. Ten metres further on, the roof comes down to within 50cm of the muddy floor, and the cave continues low for 30m before becoming too low for further progress. The stream runs along the right hand wall and sinks at the end in a constricted sump. There are a few stalactites on the roof of the end passage but these are muddy and not now active.

Lower Antacocha Cave

The lower cave is 120m down the valley from the upper cave. The entrance is in a large twin shakehole and is 15m wide and 3m high. The passage slopes down over boulders to a window overlooking the end of the main chamber. Climbing down here would require a rope, but a few metres back a climb through boulders easily leads down to the streamway. The stream can be followed down, past a waterfall entering from the wall, to a large chamber 20m wide, 15m high and 100m long. At the end of the chamber a crawlway one metre high leads off to another small chamber, which is blocked at the far end by boulders. The stream runs into a small crawl at the foot of the boulder pile, and by crawling around in the boulders five more metres of passage were explored. No possibility of extensions was seen.

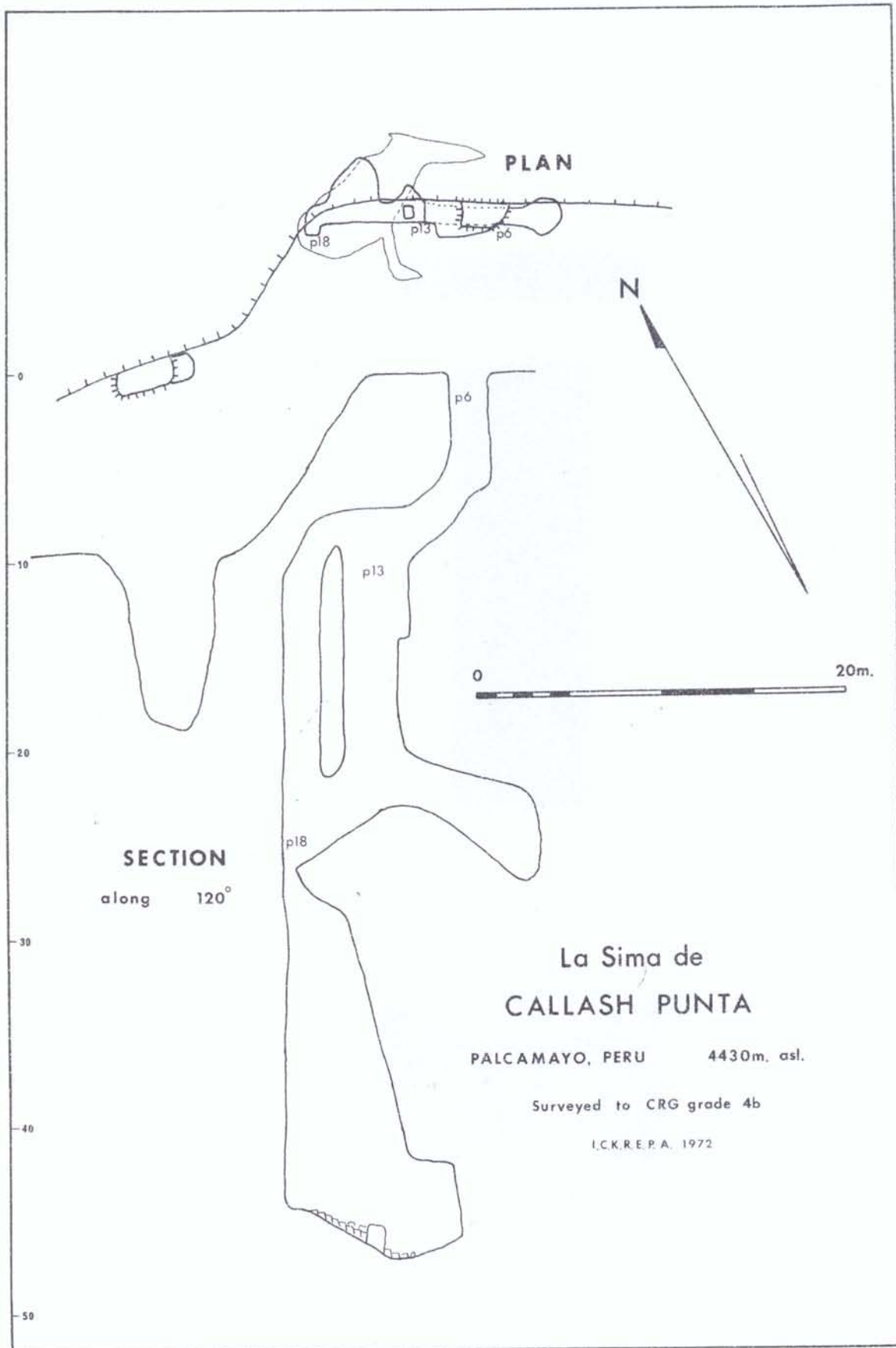
Before surveying the lower cave, four kilogrammes of Rhodamine 6G dye was put into the entrance stream of the upper cave. Two hours later the dye was not seen in the lower cave, either at the waterfall or in the stream appearing out of the boulder choke. Either the water takes at least two hours to go between the caves or the water in the lower cave does not come from the upper cave. The water in the upper cave was tested to Huagapo cave.

Although neither of the Antacocha caves seem to have much prospect of extensions the surrounding area is quite hopeful. The potential depth from the Antacocha caves down to Huagapo is 650m, and a few other entrances were seen in the area. The local people did say that these other entrances did not go very far, but it would be worth having a further look at this area, particularly along the limestone — volcanic contact. (J.M.H.C.)

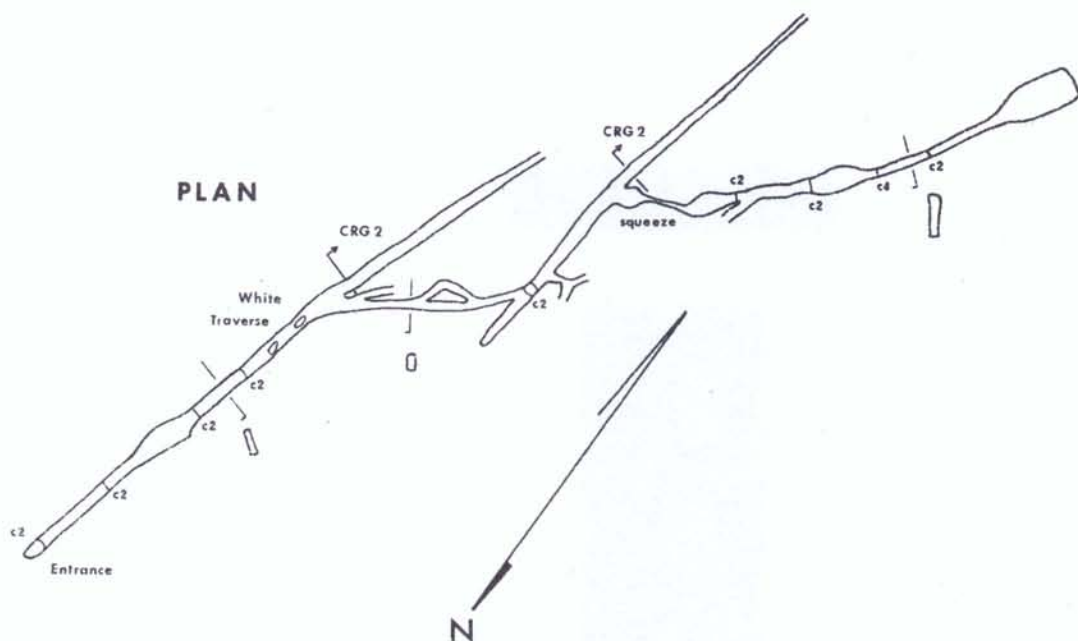
LA SIMA DE CALLASH PUNTA

The existence of caves on Callash Punta was first mentioned to us by Leonardo — a native of Shaca Marca. He was willing to show them to us so a few days later Julian, Roger, John, Leonardo, Modesto and several extras arrived on Callash Punta after a three hour walk from camp.

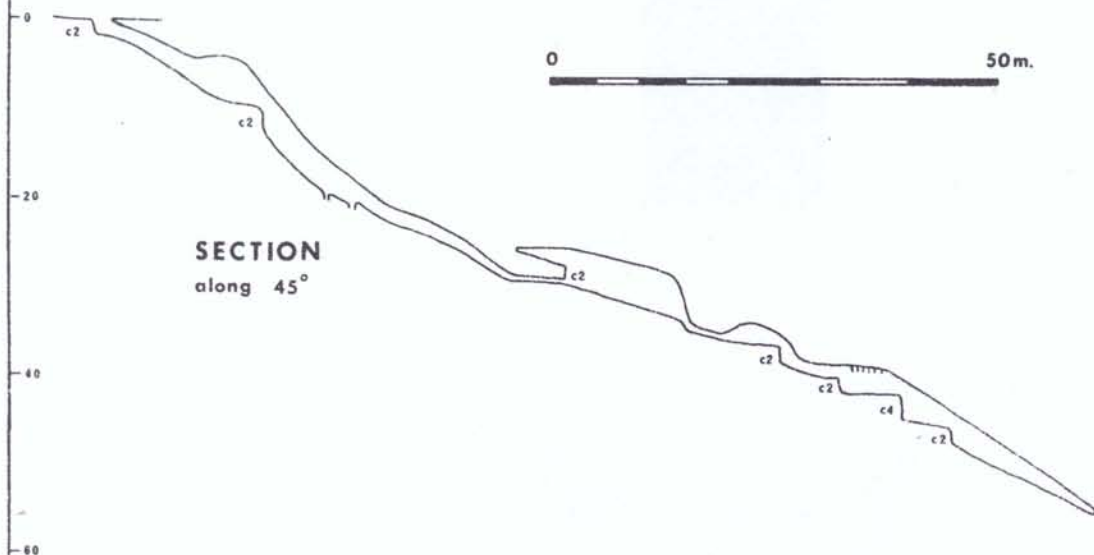
A promising looking shakehole at 4,455m a.s.l. near the edge of the plateau was the first to be investigated; unfortunately it choked completely after an eight metre pitch from the surface. Another shakehole at 4,420m suffered a similar fate. However, its neighbour at 4,430m proved more interesting. A six metre pitch was descended to a mud and scree slope leading to a second pitch of 13 metres with a ledge half way down. A passage sloping downwards in both directions was met here. That to the



PLAN



SECTION along 45°



LA CUEVA DE CONCHA LOMA

PALCAMAYO, PERU

alt. 4450m.

Surveyed to CRG grade 4b

I.C.K.R.E.P.A. 1972

east choked after six metres, and the same distance to the west we arrived at the head of another pitch. Dropping stones down it soon established the depth at around 20m so having run out of tackle we departed for camp. The cave was beginning to look quite interesting; it is in vertically bedded limestone and has a potential depth of 500 to 800 metres.

Excited by this prospect we returned four days later with donkeys laden with 150m of ladder, 500m of rope, camping gear and several days' supplies. The top of the pitch was reached quickly and descended. It proved to be 18 metres deep and the end of the cave. The pitch ends in a chamber some 8m by 4m with no obvious way on, everything being choked with small boulders. The following day the cave was photographed, surveyed and detackled, and the expedition returned to base camp.

La Sima de Callash Punta is situated on the plateau below Callash Punta peak (4,520m). The plateau, undulating between 4,400m and 4,500m a.s.l., lies on the axis of the monocline affecting Huagapo (see fig. 3.2 and plate 3.1). The limestone is vertically bedded and shows minor solution features, mainly rillenkarren and regen-rinnekarren, with grikes cut down the bedding planes. Weathering by frost action has played a relatively minor part. The cave is in a distinctive location being virtually at the top of an isolated peak some 500m above the valley and 850m above the nearest resurgence of any size, Huagapo. The cave is solutional in nature and shows no evidence of frost shattering; collapse has modified the shape of the final chamber but the basic problem of transportation remains. No major solutional activity occurs at the moment; the catchment area can hardly be more than 200 square metres, so presumably the cave must be part of a larger system formed before the present valleys were cut. Whether this could be followed or not is debatable — it would certainly require a large dig in the final chamber. However, there are some other similar entrances 300m lower down, which were left unexplored due to lack of time; these could provide an answer. (R.J.B.)

LA CUEVA DE CONCHA LOMA AND LA CUEVA DE MATA PATLA

La Cueva de Concha Loma and La Cueva de Mata Patla are situated at 4,450m a.s.l. near the limestone-volcanic contact above Antacocha (see fig. 3.2). Although the caves were not taking a stream when we visited them in the dry season, they almost certainly do so in the wet season. The water would be expected to resurge at Huagapo, 880m lower down, giving them the largest potential depth we discovered in Peru.

In both cases the caves are of vadose origin and structurally controlled. The passages are generally joint orientated along the bedding planes, the overall trend being down dip.

La Cueva de Concha Loma

A small entrance a metre in diameter leads immediately to a two metre climb into a sloping passage. A further climb of the same depth is followed by a traverse over holes in the floor to a junction. The walls here are covered by white slippery mud, hence the name White Traverse. The left hand passage ends after 30m, the way on being the right hand branch. The passage soon forks again but the ways unite at the

entrance to a six metre long crawl which emerges from a hole in the floor into a walking passage. After 15m a side passage is met on the left becoming too tight after 30m. The main passage continues on the right, but degenerates into a tight crawl after a few metres. The crawl starts with a squeeze a metre high but only 18.5cm wide, drops down into larger passage and emerges after six metres into a small chamber. This is followed by two short climbs into a decorated chamber. Two further climbs of four and two metres lead to the final passage, a wide bedding plane going down dip which has become choked with boulders at the end.

La Cueva de Mata Patla

The cave has three entrances close together, all uniting after a few metres into a descending passage four metres high and a metre wide. The passage continues past two oxbows, under a natural bridge and down a series of small climbs into a chamber containing a dead llama. Further on some sheep bones are met before an awkward squeeze into a ten metre aven. The passage leads on down dip to a sharp bend where it follows a set of cross joints, round in almost a complete circle, ending with a three metre climb into a small chamber with a mud floor. The cave ends after a traverse over two pots in the dry stream bed and a short climb where the rift becomes too tight.

Both these caves have a great depth potential and end prematurely. Prospects for extending them seem reasonable though it would probably require the use of chemical persuasion. Many side passages in Concha Loma were not explored to a definite conclusion so there may be a chance there of an extension. (R.J.B.)

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