XINGWEN
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中国洞穴

China Caves Project

XINGWEN

China Caves Project
1989 - 1992

Edited by
A C Waltham and R G Willis

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British Cave Research Association

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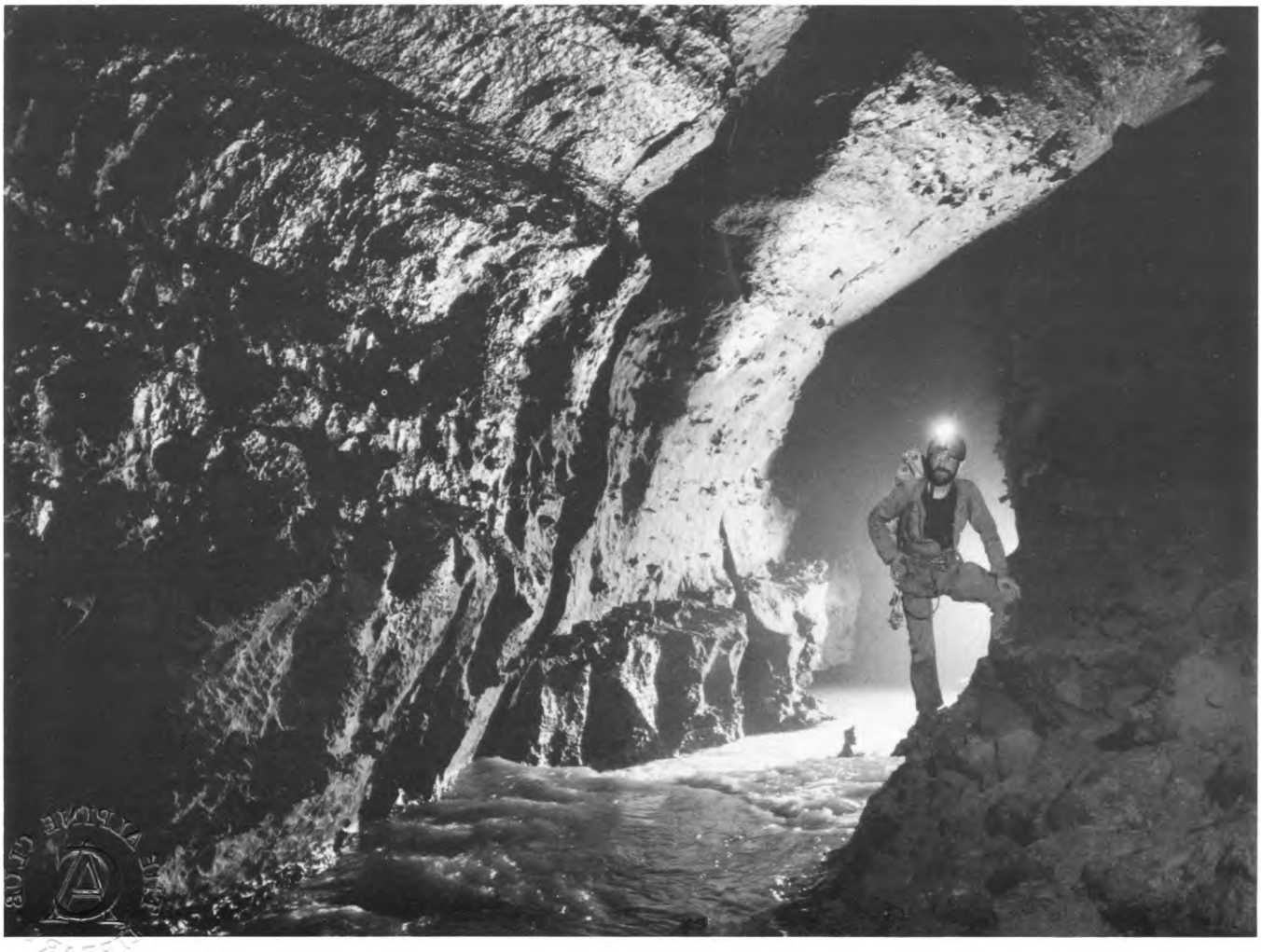
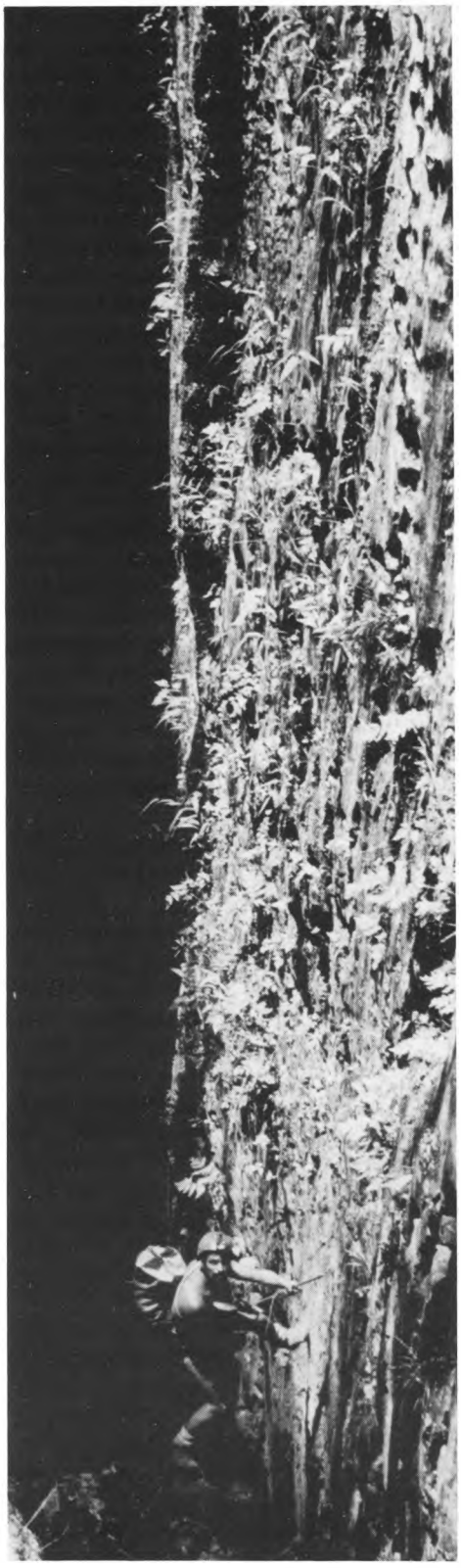
Above: Xiao Yan Wan doline with the Tiencuan cave exit, Xingwen

Below: Tiencuan Dong streamway, Xingwen



XINGWEN



Contents

The China Caves Project is an informal programme of cooperation between a variable team of British cavers, under the auspices of the British Cave Research Association, and members of various Chinese institutions.

This report covers the expeditions of 1989, 1991 and 1992, all of which were with colleagues from the Institute of Karst Geology in Guilin. Two earlier reports in the series cover the expeditions of 1985 and 1987-8 to Guangxi and Guizhou.

Cover photographs:
Front : The approach to Red Lake in Zhucaojing.
Back : The Xingwen escarpment, Shun He and Xia Dong.

THE CHINA CAVES PROJECT

Caves and karst in China

China's vast area and huge diversity of landforms contain caves and karst in abundance . The huge outcrop of limestone is geological good fortune, while the unequalled range of China's altitude and latitude has provided the climatic contrasts which create the spectacular variety of the karst landscapes.

The solutionally formed landscapes which constitute karst are best developed in warm and wet climates. So Guangxi province, in SE China, has the most mature karst, where the landform evolution reaches its zenith with fenglin tower karst. These are the rock towers with steep or vertical sides reaching hundreds of metres above a flat plain which form the uniquely spectacular landscape around Guilin and Yangshuo. This owes its origin to a special coincidence of erosional and geological processes, and occurs almost nowhere else. With the fenglin towers of the Guangxi lowlands, the fencong cones of the Guizhou Plateau, the doline karst of further north and the arid non-karst of the Tibetan Plateau, China has it all, and can easily claim to be the world's number one karst nation.

Caves are a part of the karst landscape. So again, China has more than its world share. The large accessible caves were explored by local people many generations ago, yielding the cave sediments mined for their nitrate, and also the profusion of tourist caves in China. In contrast, exploration of long, deep, wet, difficult caves is the preserve of sport cavers, who produce the maps which become the basis of any cave studies. As this is largely a Western sport, China's deep caves remain largely undiscovered.

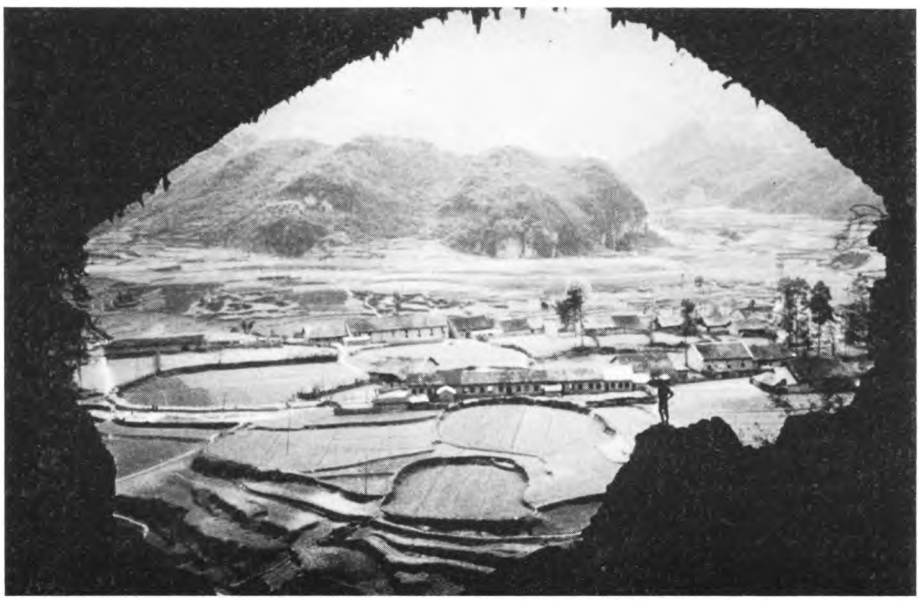
For many years, China lay hidden behind the bamboo curtain; British cavers could only look eastward and dream. Now that exploration has started to unfold the secrets, it is clear that China does have caves which are long, deep, very large, very beautiful and very, very spectacular.

Add to this the special features of China itself. A fifth of the world's people, an ancient civilisation, a unique culture, fantastic landscapes, huge distance: China is an amazing place. Everything is different and every visit is absolutely unforgettable. In truth, the caves may be a reason to go to China, but they are only a tiny part of the China experience.

Fenglin tower karst at Yangshuo, Guangxi

Village children at Xingwen

Mike prospecting at Xingwen



Tianping village in the Bama karst

The expeditions

When the bamboo curtain first yielded, the China Caves Project was born. A double expedition launched the Project in 1985. Four British cavers joined four members of the Geography Department of Guizhou Normal University to visit some caves on the Guizhou Plateau. Then with six more from Britain, they joined a team from the Institute of Karst Geology in Guilin, to explore and map some of the caves in the Guangxi towers.

Both these programmes of collaborative exploration and research were successful and led to the establishment of firm friendships, further invitations to visit China and reciprocal visits to Britain by Chinese colleagues.

The winter of 1987/8 saw both a return trip to Guizhou, to the caves of the Fala River, and also the first visit to the huge cave systems of Bama County in southern Guangxi. These trips consolidated the pattern for the Project - teams of British and Chinese speleologists working together not only to explore and survey caves but also to obtain data of specific practical use to local civil engineers, hydrologists and tourism departments.

On a footpath in Xingwen

Terraced paddy fields in the Shun He valley, Xingwen

The Project has now coordinated a total of eight expeditions. Bama was so impressive that a team returned there in 1989. In 1991, another team visited Mengzi County in Yunnan. Then 1992 marked another double expedition, with the full team going to the diverse and spectacular caves of the Xingwen Park in Sichuan, and a smaller group making a brief survey of the limestone of the Tibetan Plateau; again this was with colleagues from the Karst Institute in Guilin.

Even now, work in China is only just beginning. Bama still hides vast unentered caves, while in Xingwen the jigsaw puzzle of the interconnecting systems is far from complete. Recce visits have shown that other parts of Sichuan promise to yield equally impressive caves, we know that much of the Guizhou Plateau has yet to be looked at, and the limestone around the Yangtze Gorges has major caves ...

So much to do!

XINGWEN, SICHUAN

The limestone karst of the Xingwen county park lies close to the southern edge of Sichuan province, 70 km southeast of Yibin. Nine hours by train south from Chengdu crosses the Yangtze River at Yibin to reach a railhead at Gingshawan. It is then three hours by road, across rolling farmland, through the county town of Xingwen, and uphill into the mountains of the Xingwen karst.

The terraine of Xingwen is dominated by a dramatic limestone scarp, with vertical walls over 100 metres high facing north, and a dipslope of limestone cones and pinnacles falling gently to the south. Above this, steep vegetated sandstone slopes rise another 500 metres. The Daba He valley cuts through the escarpment and provides the regional base level, with the main resurgence cave on its floor at an altitude of 420 m. The main karst is around the 700 m level, and the limestone rises to over 1400 m at the Xianfeng sinks 16 km northwest of the resurgence.

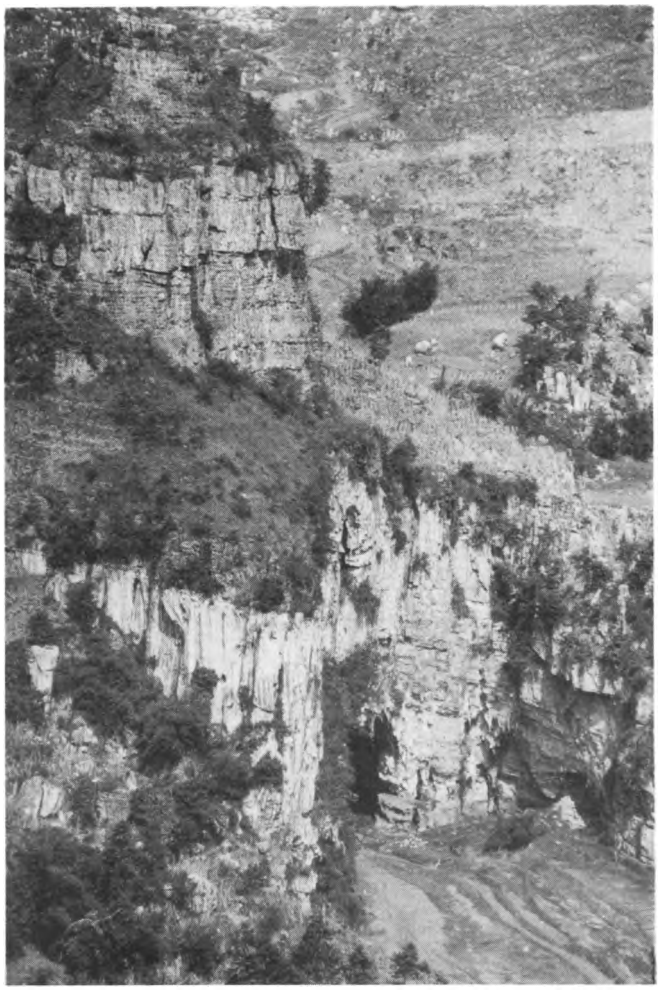
Xingwen has a warm damp climate with rather too much cloud, mist and drizzle. An annual rainfall of 1280 mm falls mostly in the hot summer months of July and August. The low altitude keeps the winters mild and rather drier.

Almost all the land is farmed, and crops are even planted in soil-filled joints in the bare limestone. Rice is always favoured on flat or terraced land, while tobacco and maize are grown on the steeper and rougher ground, and there is more woodland left in the higher country to the west. No good soil is wasted, and thatched farmhouses of timber and stone are scattered throughout the limestone; on a sunny day, the rural landscapes are absolutely beautiful, with that air of timeless serenity which characterises so much of the Chinese countryside.

Farming occupies about half the local population, while the other half work mostly in a number of sulphur factories and their associated mines. Around these have grown the larger villages, including Xingyan and Daxue. These are linked by a single road which winds tortuously across the steep slopes of both limestone and sandstone. Sideroads number just a few. But there is a network of footpaths linking the farms and rural settlements; some are solidly built with flights of stone steps, others merely wind along thin field terraces, and others are good for packhorses.

The local people are Han Chinese, who have had little or no contact with westerners. Curiosity draws large crowds when any outsider arrives in a village and a lone western caver is invited to drink endless cups of tea on a walk through the countryside. The welcome and the genuine friendliness are never lacking.

The British and Chinese members of the 1992 expedition team took over much of the Xingwen Shilin Fandian, the Stone Forest Hotel, set right in the best of the karst landscape. This has good rooms and excellent food, with a helpful and long-suffering staff, whose hospitality was only exceeded by that of the local government who hosted some memorable banquets.



The cliffs and fossil sink at the end of the large doline just east of the Mulangu sink

A footpath winds between the miniature limestone pinnacles which cover the plateau surface

The Xingwen karst seen from the sandstone hills to the south. Cone karst lies beyond the Xiao Yan Wan doline, and the Xingwen sulphur factory lies on the shale/limestone to the right

The Xingwen limestone

The karst and caves of Xingwen are formed in the Maokou and Qixia Limestones, which together are 350 m thick. These are the Permian limestones whose outcrops generally contain the largest caves and most dramatic surface karst landforms wherever they occur in southern China. The rock is a massive pure limestone, with beds varying 1–10 m thick separated by very thin shale partings. Some beds have spectacular algal banding, but most of the rock is a uniform, fine-grained grey, fortunately weathering to a white crust.

The Xingwen outcrop is in a corner of an eroded, domed anticline; this lies within a fold belt along the northern flank of the Guizhou Plateau, before the limestones dip beneath the Sichuan Basin. Westward, the cavernous limestone outcrop continues through the Longtan catchment and into the Gongxian karst, and eastward there are more large caves round the nose of the anticline. Much steeper dips leave only narrow outcrops of the limestone along the northern limb of the fold.

At Xingwen, the limestone dips south, mostly at less than 5° across the widest outcrop where the main caves have been found. The dips steepen all around and are about 25° at the resurgence in the Daba He valley. Overlying the limestone, Permian coal measures and Triassic sandstones provide drainage onto the karst mostly as small streams off very steep slopes. The anticlinal core of Silurian sandstones lies below the limestone scarp face, but does underlie the Shunhe basin with the largest single river sinking downdip into the limestone at Xia Dong.

The Xingwen karst

Exposed limestone surfaces have been dissected by the formation of enormous karren with solution runnels commonly over a metre wide; this reflects the warm climate and long time scale of evolution characteristic of the Chinese karst. Deepening of the karren and solutional opening of joint fissures has left remnant pinnacles, many over 10 m high in the massive beds of limestone. Some of this pinnacle karst is described as stone forest, the best of it being around the hotel named after it.

Scarp retreat by erosion is towards the south, so that the older outcrops are on the higher parts of the scarp, to the north. In that area a chaos of dolines and conical hills constitutes a type of fengcong karst, and there appears to be an evolutionary development from stone forest pinnacle karst into fengcong conical karst. This process probably involves a time scale of over a million years.

The Xingwen limestone is riddled with caves. Active streamway caves are entered at the sinkholes of Xia, Heping, Mulangu and Pucaowan and also at the Dong He resurgence. There are many smaller sinkhole shafts, active in wet weather, of which a number have been found just from below. The remainder of the water input to the karst is percolation, as most doline floors are choked with sediment.

There are numerous dry fossil caves, mostly fragments of large old trunk passage now wide open on the hillsides. Local nitrate miners have worked through many of their floor sediments in bygone years. The two longest cave systems, Zhucaojing and Tiencuan Dong, both have kilometres of large passages and also access to active stream passages at lower levels. The lower streamway in Tiencuan is a particularly exciting section of noisy cascading water passage - offering cave exploration at its best. All the known caves are marked on the area map (pages 24 and 25); more than 30 kilometres of passages have been mapped. Many of the survey ends are wide open - and there is a lot more cave to discover in Xingwen.

Two giant dolines are conspicuous features of the Xingwen karst. The larger, paradoxically known as Xiao Yan Wan, Little Doline, is 630 m across with an area of nearly 20 hectares, and is 200 m deep with vertical walls 100 m high around almost the entire rim. They are both ancient sinkholes formed at a past boundary of the limestone outcrop. Multiple shafts into a complex of large trunk passages coalesced by breakdown and solution, with wall retreat keeping to the vertical joints. They are not simple collapse feature, but they are very impressive.

ZHUCAOJING

The cave entrance was well known to the local people, so already had its name. Unfortunately, the translation to Pig Trough Well hardly does justice to a splendid cave system, with nearly 9 km of passages already surveyed and open leads at all extremities.

A spectacular canyon in the floor of a rambling doline provides the easiest way in. A 20 m pitch in the canyon had in the past been negotiated by nitrate miners who had climbed bamboo stemples spanning the 4 m between the canyon walls; hewn pockets for the bamboo ends are all that remain. Below, the canyon winds down and beneath the arch 50 m wide and 15 m high into the entrance chamber.

Largely in twilight, the entrance scree slope descends to a mud floor which reaches left and right into darkness. The eastern end is flat with large gour pools and a calcite bank up to a blind wall. Westwards, channels wind through the old nitrate workings and past the remains of a stone building, eventually to a soakaway. There is no nitrate digging today, but the chamber regularly resonates due to the blasting in the pyrite mines above.

West from the soakaway, sediment slopes and cliffs rise up to a passage leading further into the system. The sediment floor gives easy walking and the diverging walls of the passage soon leave the caver with no reference features. The sound of water ahead is the only marker. Through a boulder field, a small stream runs across from left to right following the cross piece of a massive T junction. Upstream in broad mud, sand and cobble floored halls, stalactites curve like scimitars, suggesting strong draughts, and within 300 m the stream is found entering the cave down a 60 m daylight shaft. All ways on through these ancient fossil conduits are blocked by breakdown and sediment.

Downstream of the main T junction the stream runs between sediment slopes in a passage 45 m wide and 20 m high. On sunny days dramatic beams of light break the darkness ahead. They penetrate the passage through a series of skylights named by the Chinese as the String of Pearls; the shafts lie on a major NE-SW joint also traceable through the entrance chamber. Just beyond, the stream cuts down into a young canyon passage, while directly above a fossil canyon appears to have been breached on a sharp bend. On the first exploration, three open passages lay ahead, all unvisited by the nitrate miners.

The narrow winding canyon below has a thixotropic mud floor as its natural deterrent. But this does not last long, and the canyon eases and widens before the stream drops over a series of cascades. The last pitch drops into a larger active passage, but bad air precluded any further exploration in 1992.

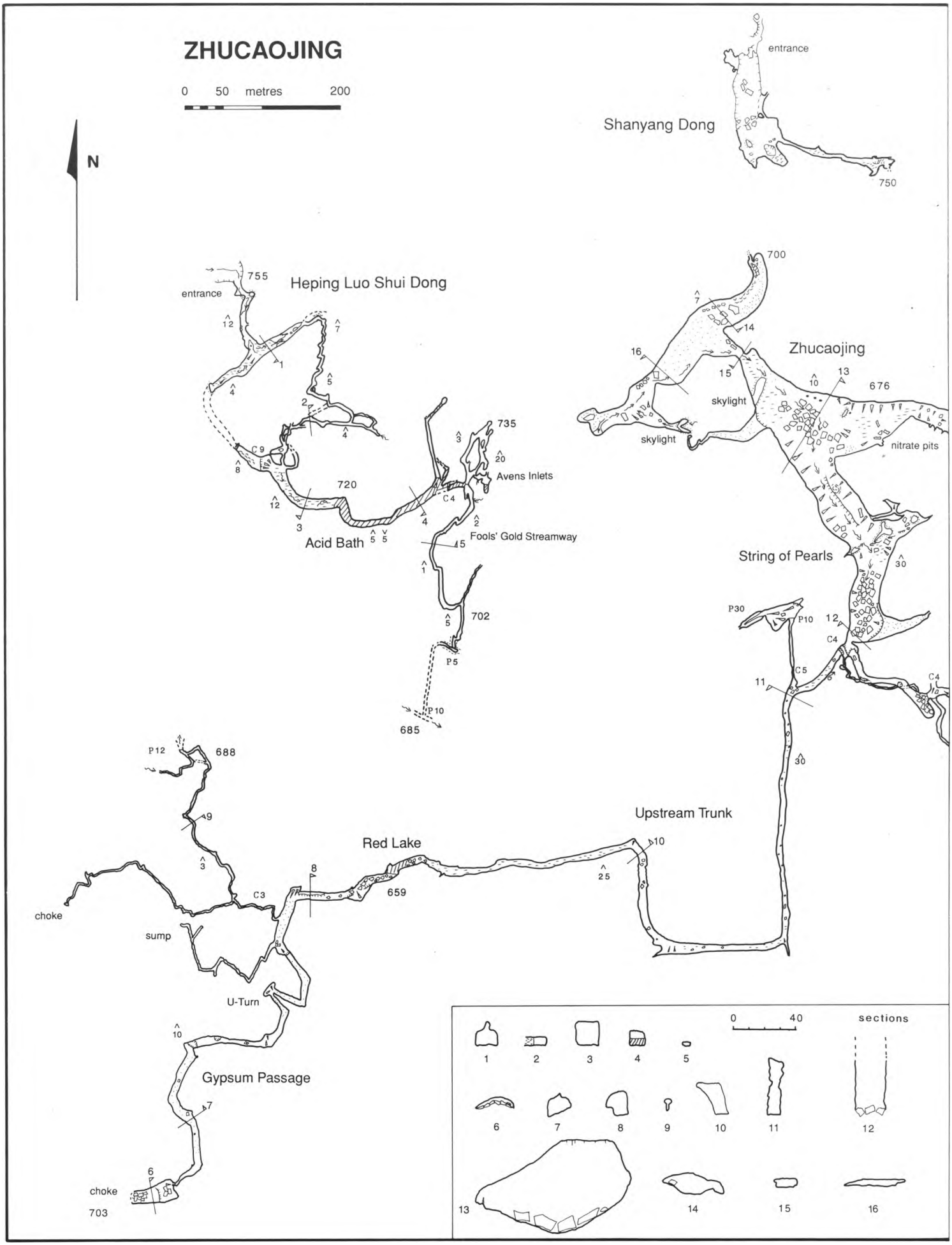
A rift climb leads into the high level canyon with scallops indicating the downstream route to the southeast. This major fossil trunk passage eventually splits, with a massive joint-controlled chamber off to the right. To the left, the passage decreases in size over masses of calcite, until a maze of smaller rifts leads to a 26 m pitch down into a muddy flood zone. At low water, deep canals lead through the link to the downstream end of Xiang Shui Dong. The main chamber of this cave leads out over piles of breakdown to the archway into the Xiao Yan Wan doline. Northwards, very muddy bedding passages and rifts lead to a long, deep canal which leads off, unexplored as yet, towards the Xia Dong river. After even moderate rainfall, these passages and the connection canals remain totally flooded for weeks at a time.

»p14

The massive fossil trunk passage which now forms the entrance chamber of Zhucaojing

Iron staining marks the flood level in the passage to Red Lake in Zhucaojing

The entrance chambers of Tian Shizi Dong


ZHUCAOJING
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N
Shanyang Dong
entrance
750
Heping Luo Shui Dong
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Avens Inlets
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Acid Bath
Fools' Gold Streamway
702
685
Zhucaojing
700
676
skylight
skylight
nitrate pits
String of Pearls
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659
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U-Turn
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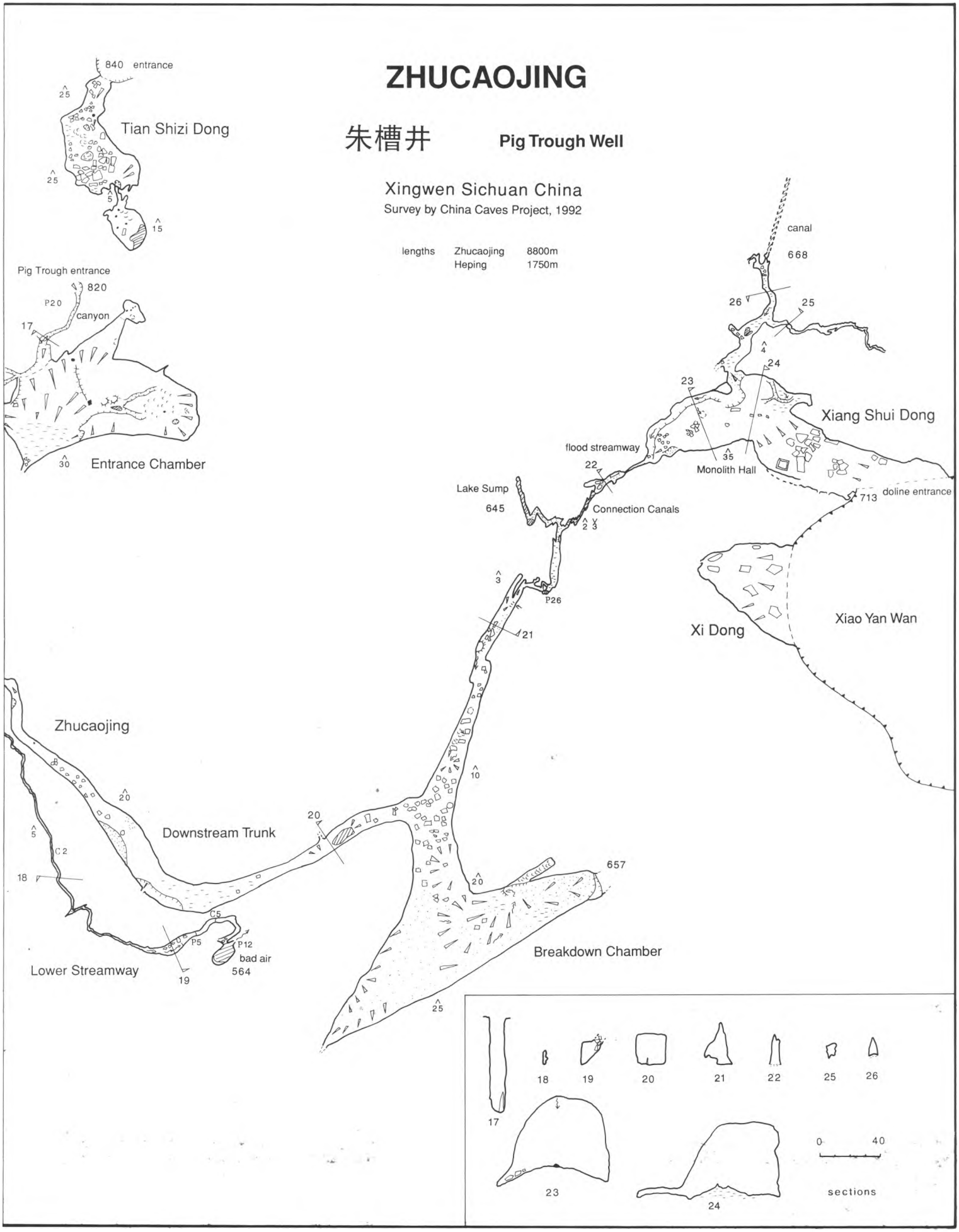

ZHUCAOJING
朱槽井
Pig Trough Well
Xingwen Sichuan China
Survey by China Caves Project, 1992
lengths Zhucaojing 8800m
Heping 1750m
840 entrance
Tian Shizi Dong
Pig Trough entrance
820
P20
canyon
Entrance Chamber
canal
668
Xiang Shui Dong
flood streamway
Monolith Hall
Lake Sump
645
Connection Canals
713
doline entrance
Xi Dong
Xiao Yan Wan
Zhucaojing
Downstream Trunk
Lower Streamway
bad air
564
Breakdown Chamber
657
sections
0
40

Farms tucked away into the Xingwen karst around Pucaowan

Deep in the fossil passages of Zhucaojing

The upstream, western section of the fossil canyon is also reached by a climb. This beautiful passage turns south and runs perfectly straight for 350 m, maintaining a clean profile 10 m wide and 30 m high. After three joint-controlled bends, it has a mud floor with splendid desiccation cracks, and then descends to the Red Lake. Beyond the lake, the main passage eventually ends in a breakdown chamber after passing a zone decorated with phenomenal gypsum crystals with single blades up to 50 cm long. Side passages to the north include one ending in an undescended pitch which has excellent prospects of providing a connection through to Heping Dong.

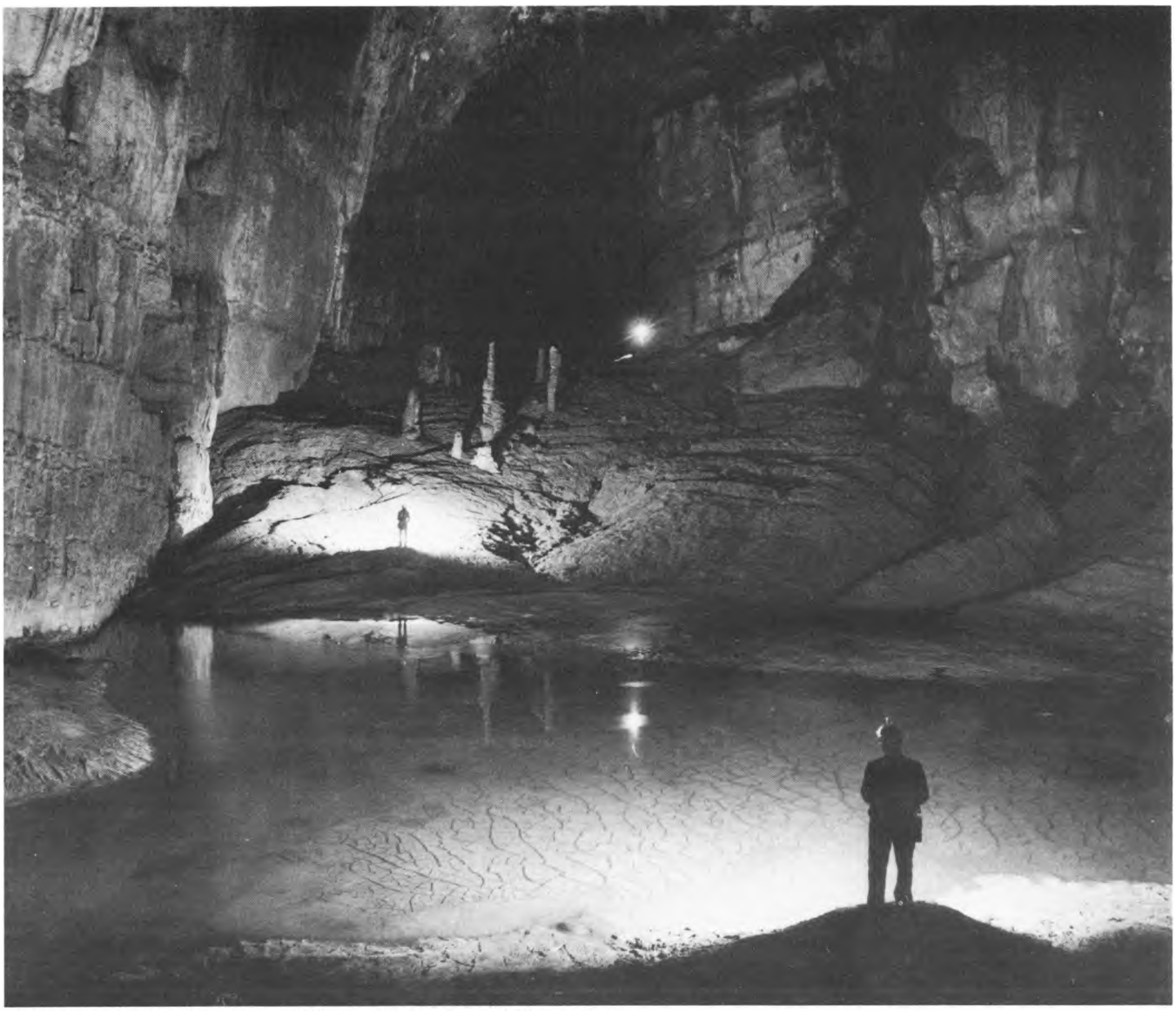
Zhucaojing appears to contain the remains of two fossil trunk passages, both of which drained from west to east. The older, larger, northern route through the entrance chamber was fed by sinks from the north now represented by the main passage of Heping Dong and the fossil fragments of Shanyang and Tian Shizi. Both routes appear to have converged on the zone since collapsed and modified to form the Xiao Yan Wan doline. The later streamway draining south has fortuitously linked the two older trunks. The bad air at its downstream end suggests that it there joins the contaminated water from the Heping sink and also probably a lot more bad water draining in from the west.

Heping Luo Shui Dong

The open sinkhole near the tiny village of Heping, swallows the contaminated stream which drains down the fault guided valley from the mines and sulphur works at the eastern end of Daxue. Beyond the entrance breakdown zone, the large passage descends gently, then swings up and away to mudchokes on the right. The underfit stream drains into a much smaller winding canyon which eventually breaks back into the larger old passage. The Acid Bath is a deep lake 150 m long with an aggressive pH of 2.6 and banks encrusted with red sulphate crystals.

At the far end of the lake, the large old passage is lost in the roof, while the outflow cascades down into a youthful passage fed by avens beneath the edge of the limestone outcrop. This drains south with a shallow canyon cut below a bedding plane roof; it is most noticeable for its floor of almost pure pyrite gravel washed in down one of the inlets. Exploration finished in 1992 at shafts dropping into a continuing passage.

The larger passages in from the entrance of Heping are almost certainly the upstream end of the northern trunk route in Zhucaojing. In total contrast, the much younger Fool's Gold Streamway drains directly down the shallow dip; it appears to be heading for a modern main drain which collects numerous inlets as it heads eastward.



The massive fossil passage in the northern zone of Zhucaojing

TIENCUAN DONG

The backbone of this intriguing cave system is a vast fossil passage, 30 to 50 m high and wide, and 1400 m long, linking the Xiao Yan Wan doline to the main limestone scarp face. The escarpment entrance is right beside the road into Xingwen; a cutting through a great bank of scree leads into a vast open area which forms a car park with small cafes and shops around it - all beneath the lofty cave roof.

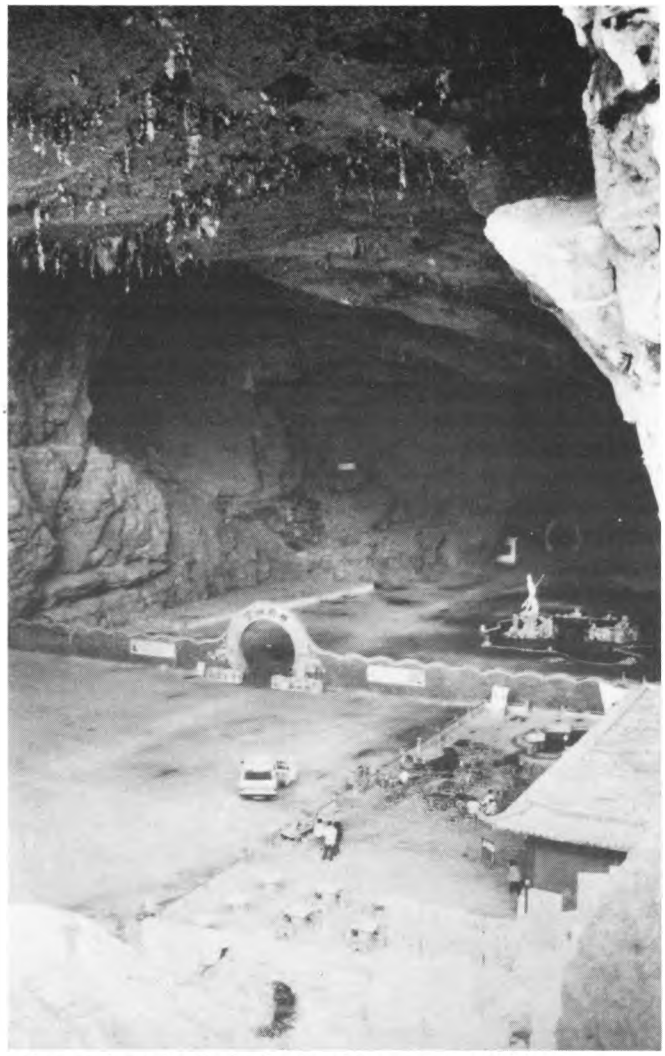
Passages high in the south wall loop round through rift chambers not fully surveyed, though the first one is kitted out for disco evenings. The main passage sports a wall with obligatory moon-gate, an ornamental pond, and a statue of a goddess who appears to have no relevance at all to the cave. All these welcome the tourists into a high arched passage boring its way into the mountain. Minimal lighting in the first section is adequate, since the floor is as flat as a road - an inheritance from its past use as a factory during times of war.

A grotto pool with multi-coloured lights lies at the foot of steps which rise to a col on top of a massive boulder pile. Further steps climb to a balcony viewpoint overlooking the largest cavern in the system. Southwards the balcony leads into a high level tunnel, which scallops indicate was once an outlet. Now it is floored by breakdown and heavily muddied gour terraces, with trenches cut through deep banks of sediment. The way on is lost after a descent into a muddy cross chamber.

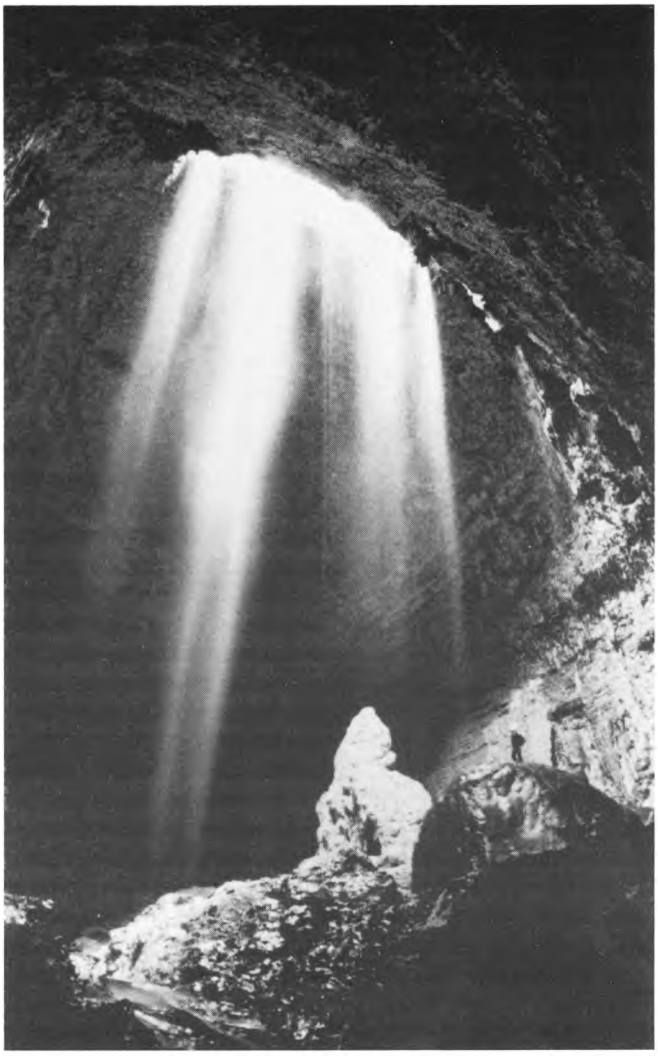
The tourist trail continues west across the large chamber. It winds across piles of breakdown slabs matched by the overhanging beds in the roof arch; this was once a very large passage at a lower level then its present breakdown profile, and there may be another outlet to the south or east obscured beneath the debris. Over another breakdown pile, the flights of steps lead to the spacious Junction Chamber with its skylight illumination.

The ancient Southeast Passage can be followed to a spectacular forest of stalagmites - slender columns 2–5 m high, illuminated by an incredible array of coloured neon lights. Beyond them, the cave has no tourist path and the floor of breakdown slabs and sediment slowly rise to meet the roof. Only the draught finds its way out to the surface which is close above in a shallow doline. Yuguang Dong is a passage fragment across the doline, truncated by surface lowering, but choked with sediment and stalagmite not far in.

Westwards across Junction Chamber, the tourist path climbs beneath a dramatic skylight formed on a cross fault. Dripping water from the fault has formed a single massive stalagmite, often beautifully lit by a shaft of sunlight. The massive cave tunnel with its flat breakdown roof continues dead straight to daylight in the wall of the Xiao Yan Wan doline. Steps climbs the usual pile of blocks under the entrance arch, but a high wall and locked gate end the tourist trail.



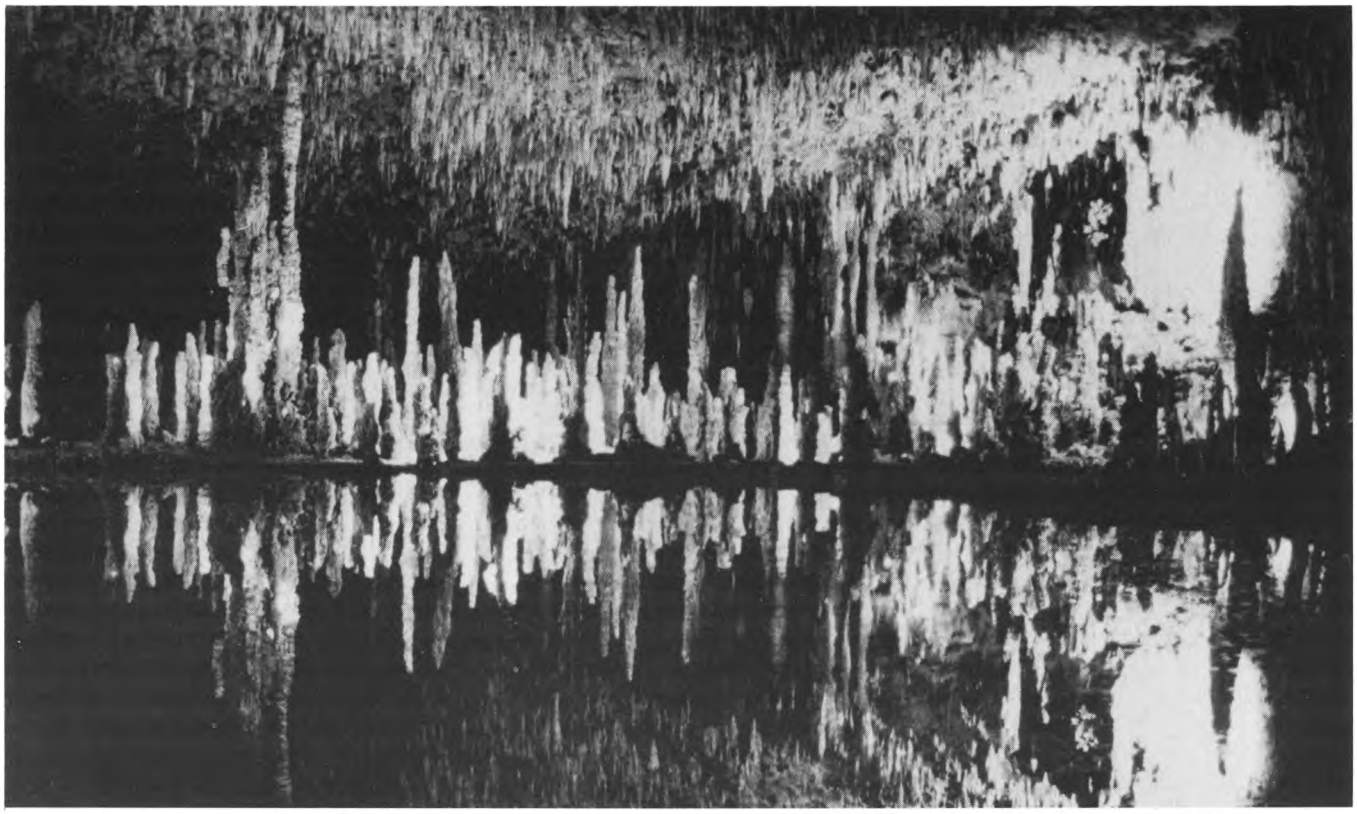
Car park and cafe in the tourist entrance of Tiencuan



The skylight midway through Tiencuan Dong

The River Passage in the lower reaches of Tiencuan Dong

Following the water in Dong He Dong



Stalagmite forest at the end of the tourist route in Southeast Passage, Tiencuan Dong

Spider Cavern and the River Passage

Almost beneath the skylight, the way into the lower series lies in the south wall. A spiral route behind an upright slab drops onto a slope into the impressive Southwest Cavern. At its base is a way into a small streamway, but the way forward is up and over a great mound into a continuation of the cavern, where three routes radiate. One loops back to a choke under the tourist cave, another rises through and over chaotic boulders into the vastness of Spider Cavern, and finally a rift passage straight ahead runs south and then turns southeast for 600 m. It ends in two branches, one becoming too low over mud, and the other dropping into a muddy sump pool.

Spider Cavern is a rather confusing place with passages radiating in all directions. Two at the western end are terminated by chokes (one draughting strongly) which are under the Xiao Yan Wan doline. Against the south wall are deep holes with the sound of the roaring river 70 m below. It is best reached by a spiralling route onto a large flat ledge and a 20 m pitch. A further pitch down to the river can be avoided via a steep slope down to the torrent.

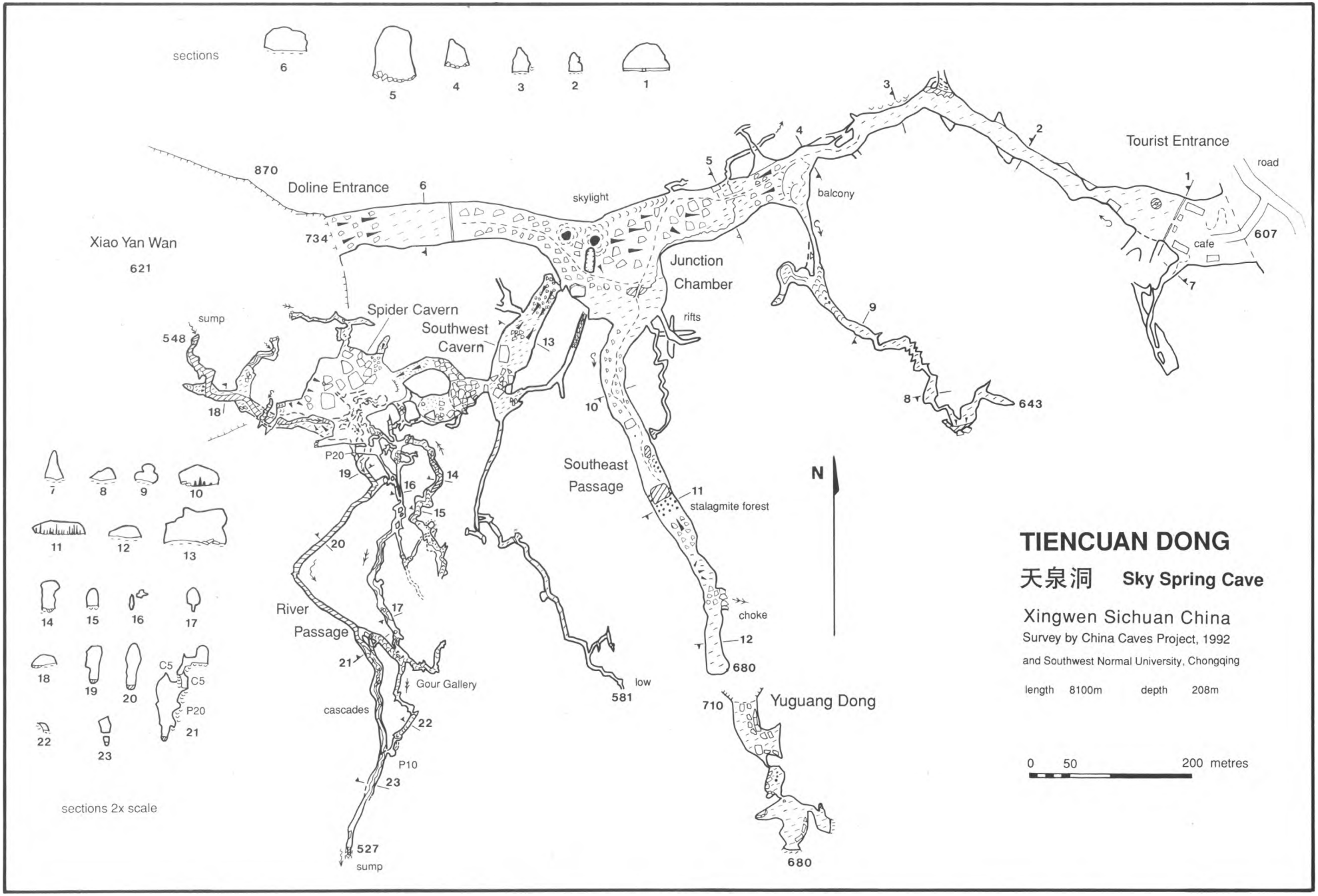
Upstream, the river cave is wide and with a gentle gradient, so shingle banks provide an easy route past the deeper pools. After 500 m of passage, mostly 10 m high and 20 m wide, the river pours from a sump with a muddy boulder choke in the roof above it.

Downstream offers exciting exploration with the river compressed into a canyon 2–4 m wide. Cascades, deep pools and fast moving water demand traverses and rope climbs, and an easier option is provided by high level passages whose exploration leapfrogged ahead of the slow progress in the intimidating canyon. From the top of the 20 m pitch, a passage heads south and up a climb to a junction into a fine dip tube. Updip lies a complex of passages, with another route into Spider Cavern and a long inlet to a high aven. Downdip, the untouched tube plunges on for 300 m with only one notable side passage floored by a glacier of calcite ice. A rope climb then drops 10 m into Gour Gallery, with its floor of deep dry gours in a 6 m wide passage.

Fossil route south of Spider Cavern in Tiencuan Dong

Onwards, two routes follow the noise back to the river passage. The easier has two 5 m cascades and a 20 m pitch down flowstone into an oxbow just above the river - where a long loop could be closed in the survey. Downstream, the river passage is even more dramatic, with cascades and deep whirlpools eaten into a cleft only a metre wide. Bolted rope climbs are needed for progress, and after another 300 m the raging torrent hammers into a wild and intimidating sump. More high levels are likely to lie in the canyon roof; they may be reached more easily from an offshoot of Gour Gallery, but some serious climbing will be needed to follow the Tiencuan river further downstream.

Southwest Cavern provides the link between the tourist cave and the river passage in Tiencuan Dong


sections
6
5
4
3
2
1
Tourist Entrance
road
870
Doline Entrance
6
skylight
5
4
3
2
1
balcony
cafe
607
Xiao Yan Wan
621
734
Junction
Chamber
rifts
9
7
sump
548
Spider Cavern
Southwest
Cavern
13
10
8
643
18
P20
19
16
14
15
20
Southeast
Passage
11
stalagmite forest
N
choke
12
680
River
Passage
17
21
Gour Gallery
low
581
cascades
22
P10
23
527
sump
710
Yuguang Dong
680
7
8
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11
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C5
C5
P20
21
22
23
sections 2x scale
TIENCUAN DONG
天泉洞 Sky Spring Cave
Xingwen Sichuan China
Survey by China Caves Project, 1992
and Southwest Normal University, Chongqing
length 8100m
depth 208m
0
50
200 metres

SINKS AND RISINGS

The extremities of the Xingwen cave system are provided by the main sinks and the single resurgence, at each of which lie fine cave systems.

Xia Dong

A bold rock arch at the foot of the limestone escarpment spans the spacious entrance to Xia Dong; the name Low Cave describes its position and not its size. It engulfs the Shun He, the largest sinking stream in the catchment, whose warm clear waters make the cave a delight to visit.

The streamway soon contracts to 10 m high and wide, providing an easy walk over shingle banks between clean rock walls. Lower roof arches and deeper pools precede the inevitable sump, 860 m from daylight, with its usual collection of unwashed floating debris and hungry snakes. Joint mazes on both sides of the streamway are only partially explored and surveyed; they offer mostly walking in tall rifts, some with clean rock sculpture, some rather muddy. More passages await exploration, notably up some climbs, but the chances of major extension seem slim.

Not only is Xia Dong a lovely cave to explore, but it is also a classic of cave geomorphology,. The many parallel rifts have been solutionally enlarged along joints when they were in the flooded phreatic zone. They are connected by phreatic tubes which follow bedding planes obliquely across the dip, jumping from one rift to the next; the stream now follows the middle one of three main tubes recognisable on the survey. Unfortunately the guiding bedding planes dip more steeply than the drainage - hence the sump. Parts of the maze also have large block undercutting and collapse bounded by the bedding and joints; this is a major process of passage enlargement and is furthest advanced in the wide entrance chamber.

Yanzi Luo Shui Dong

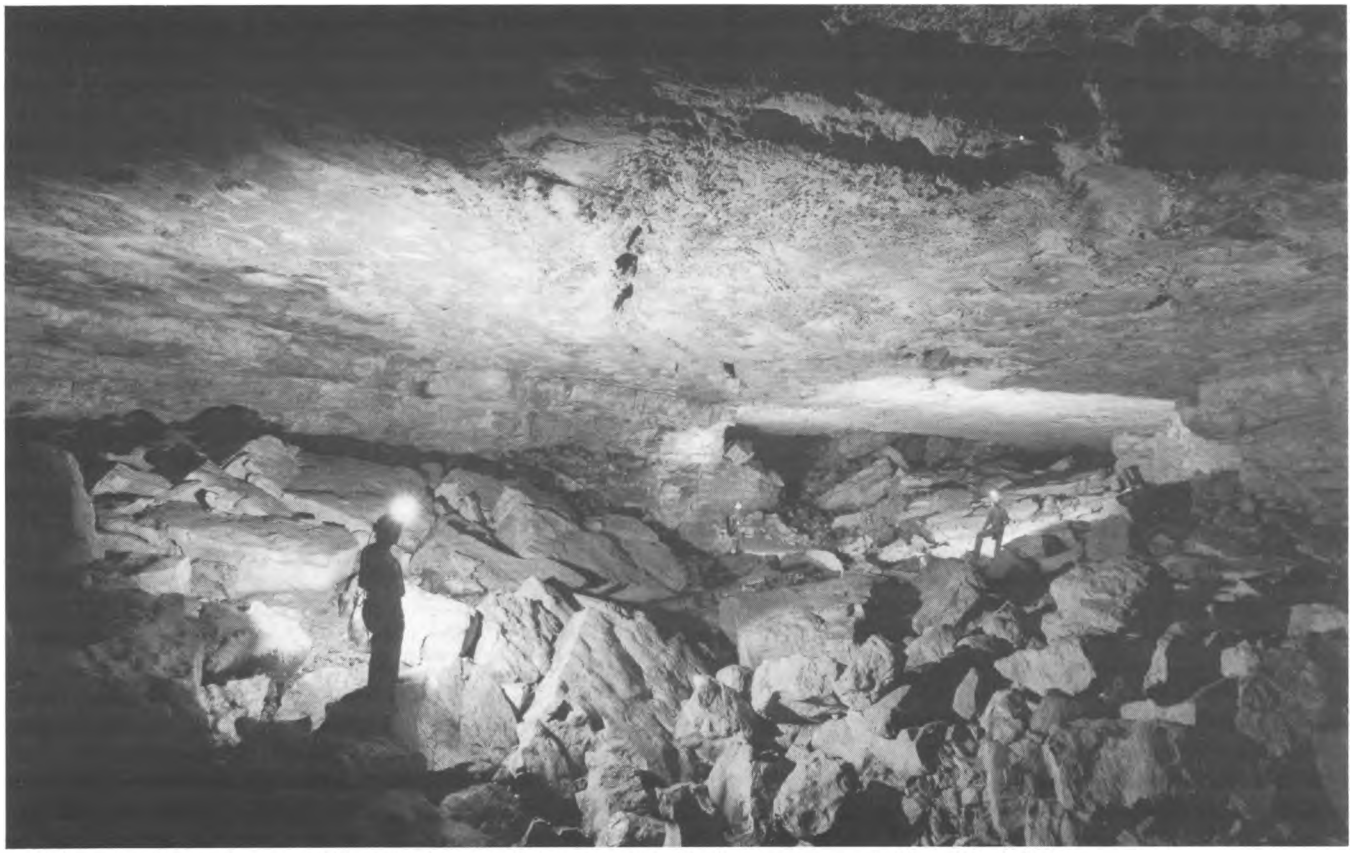
A number of sinks around the small town of Xianfeng were thought to represent the upper end of the Dong He catchment. The twin sinks of Yanzi lie in adjacent short blind valleys on the northern edge of the limestone outcrop.

Da Yanzi Dong (Big Yanzi Cave) has a massive arched entrance 50 m wide crossed by a high fortified wall which dates from its occupancy by a notorious local gang of bandits. Beyond the entrance chamber, a thin path leads into a passage descending at a steady 14°; this is floored with large and small breakdown so that the small stream is rarely seen. It continues 4–5 m high and twice as wide, past side passages on the same bedding, to old nitrate workings and an impassable draughting choke.

Xiao (Little) Yanzi has a small wooded entrance below the road. A similar passage strewn with breakdown, and with another small stream, descends steadily. It is nearly choked at a number of points before breaking out into a larger passage which is the downstream continuation of Da Yanzi. Exploration ended at another draughting choke.

Da Yanzi had been explored by the local people who had worked nitrates from near its inner end. In a fruitless search for further nitrates, the locals had visited about half of Xiao Yanzi, as far as a choke which was only passed by a small, persistent, bespectaded Yorkshire caver.

Both caves were formed on shaley bedding planes at and very close to the base of the dipping limestone; sections of mudstone floor are exposed in parts of both caves. Extensive undercutting and bedding-guided collapse have modified the cross profiles of both passages. They drain directly down-dip, except for the obvious convergence, and have not been explored far enough to reveal any bend onto the strike, towards the resurgence, developed within either an ancient or modern phreatic zone



Fallen limestone slabs and the dipping breakdown roof typify the passages in Xiao Yanzi Dong

The delightful river passage in Dong He Dong

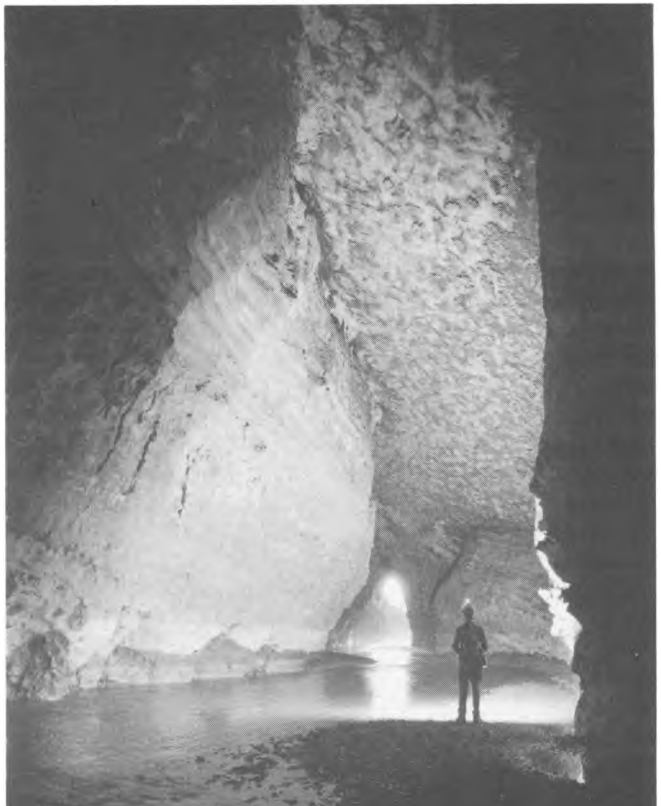
Dong He Dong

The resurgence for all the cave waters of Xingwen is a gaping hole 10 m high and wide in a limestone bluff at floor level in the Daba He valley.

Gravel banks and shallow pools provide an underground highway westward. Remnants of a high level tube lie above the wide river canyon, but thus turns south before the entrance, ending close to the surface at a choke pocked by nitrate diggings. After 630 m of easy walking the cave develops into a series of swims through roof rifts of the main tube, but even these sump. The high level, with plentiful stalagmites, offers a way on, up through boulders, to emerge in a small doline where the old cave is truncated.

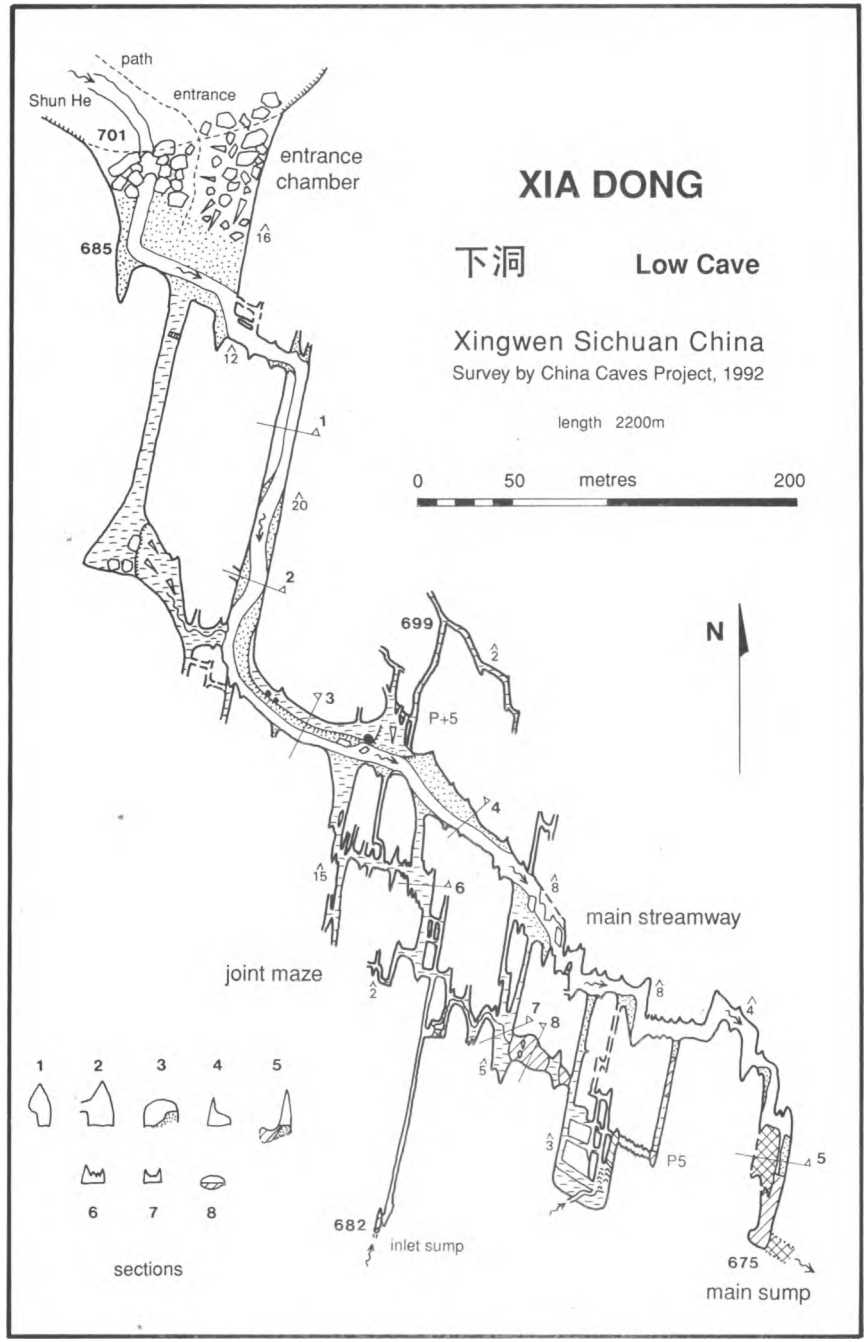
Another larger doline to the north has conspicuous entrances to three segments of old high level tubes, the largest with more nitrate diggings overlooked by stalagmites. The sink in the doline floor leads into Dong He Dong 2, down through boulders into a muddy passage with the roar of water ahead. The river is met cascading over boulders just above a sump. High shingle terraces on the south side offer an easy upstream walk for 400 m to where the roof lowers to a sump.

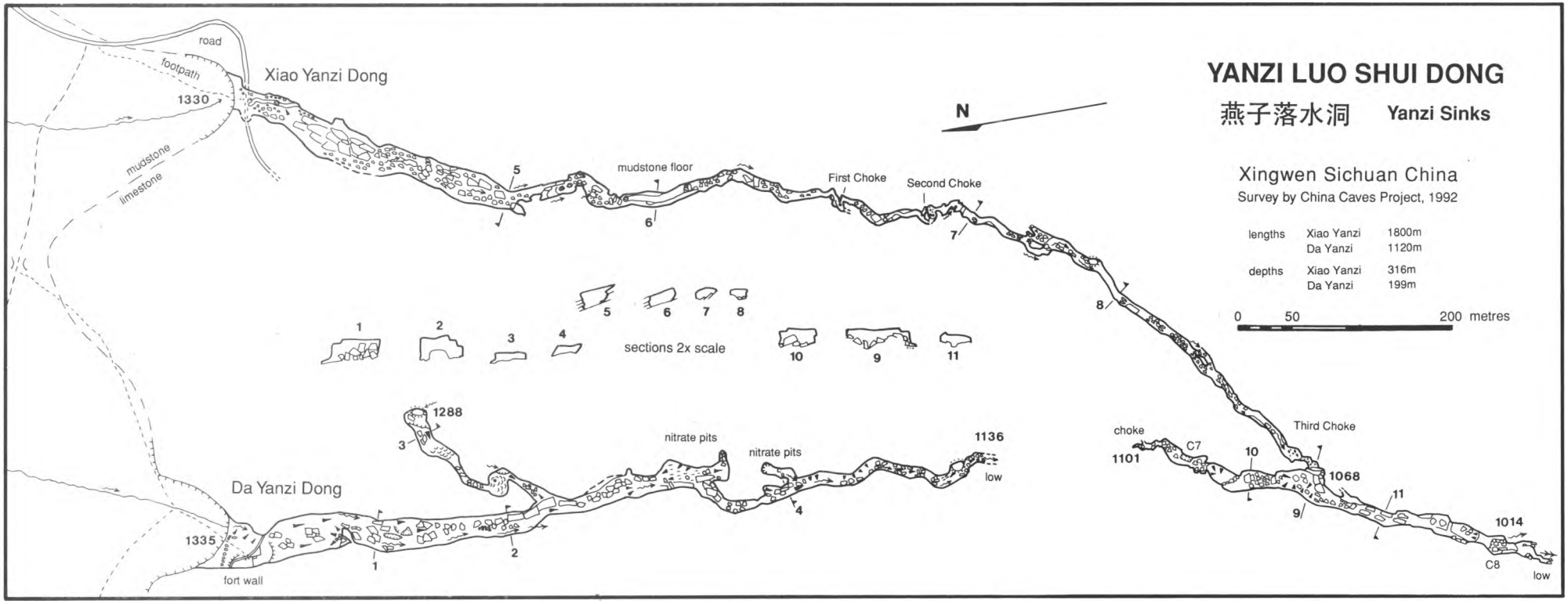
All these caves were first entered by local people. Stone steps, now largely washed out, gave easier access to the treasured nitrate workings. The resurgence cave is well ventilated, but Dong He Dong 2 has seriously bad air, due to pyrite oxidation, trapped below its single entrance.

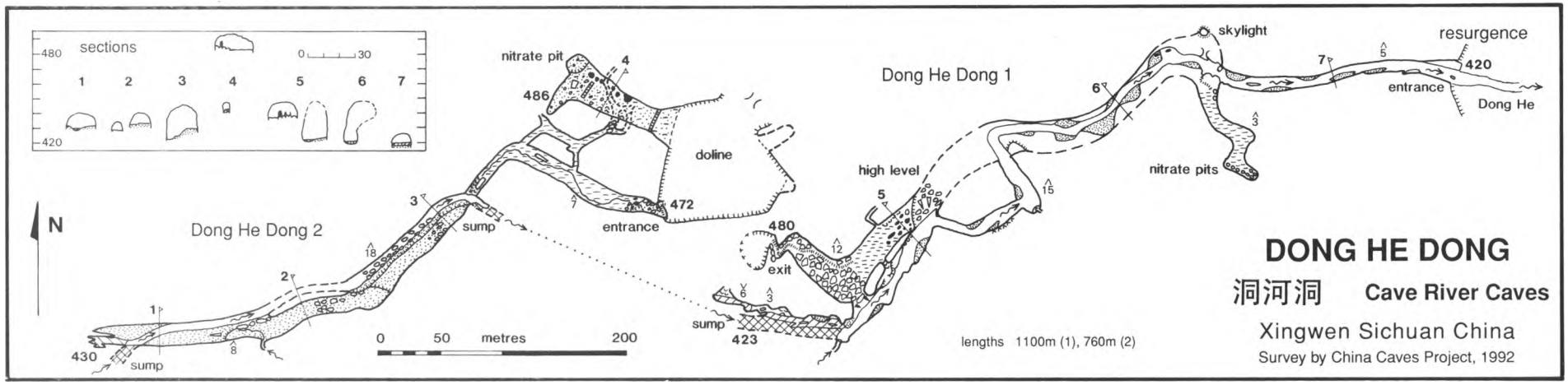


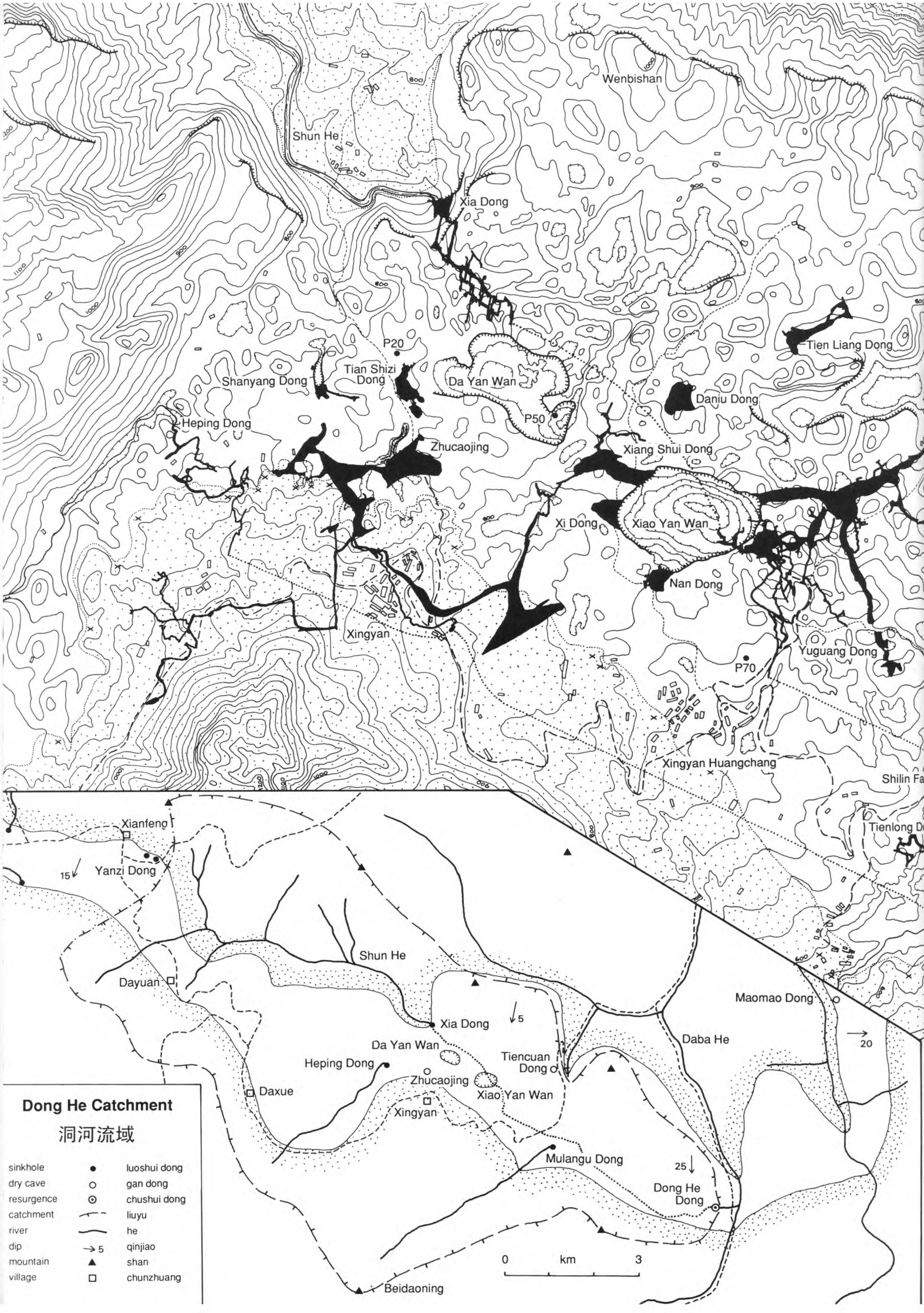
Above: bandit fort in the Da Yanzi Dong entrance

Below: the Dong He resurgence




road
footpath
1330
mudstone
limestone
Xiao Yanzi Dong
N
mudstone floor
First Choke
Second Choke
sections 2x scale
1288
nitrate pits
nitrate pits
1136
low
Da Yanzi Dong
1335
fort wall
choke
1101
C7
Third Choke
1068
1014
C8
low
YANZI LUO SHUI DONG
燕子落水洞 Yanzi Sinks
Xingwen Sichuan China
Survey by China Caves Project, 1992
lengths Xiao Yanzi 1800m
Da Yanzi 1120m
depths Xiao Yanzi 316m
Da Yanzi 199m
0 50 200 metres


sections
480
420
0 30
nitrate pit
486
doline
472
entrance
Dong He Dong 1
skylight
resurgence
420
entrance
Dong He
nitrate pits
high level
480
exit
sump
423
Dong He Dong 2
N
sump
430
sump
0 50 metres 200
lengths 1100m (1), 760m (2)
DONG HE DONG
洞河洞 Cave River Caves
Xingwen Sichuan China
Survey by China Caves Project, 1992


Wenbishan
Shun He
Xia Dong
P20
Tian Shizi Dong
Shanyang Dong
Da Yan Wan
P50
Tien Liang Dong
Daniu Dong
Heping Dong
Zhucaojing
Xiang Shui Dong
Xi Dong
Xiao Yan Wan
Nan Dong
Xingyan
Yuguang Dong
P70
Xingyan Huangchang
Shilin Fa
Tienlong D
Xianfeng
15
Yanzi Dong
Shun He
Dayuan
Maomao Dong
Xia Dong
5
Da Yan Wan
Daba He
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Tiencuan Dong
Heping Dong
Zhucaojing
Daxue
Xiao Yan Wan
Xingyan
Mulangu Dong
25
Dong He Dong
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Dong He Catchment
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sinkhole
luoshui dong
dry cave
gan dong
resurgence
chushui dong
catchment
liuyu
river
he
dip
5
qinjiao
mountain
shan
village
chunzhuang

兴文岩溶

KARST OF XINGWEN

四川中国

Sichuan China

小溪	stream	xiao he
河流	river	he
洞穴通道	cave	dong
竖井	shaft	shujing
水流	drainage	shui liu
等高线（25米）	contour (25m)	denggaoxian (25mi)
漏斗	doline	loudou
悬崖	cliff	xuanya
高程（米）	altitude (m)	gaocheng (mi)
村庄	village	chunzhuang
农场	farm	nongchang
采矿	mine	kuan
道路	road	lu
小路	footpath	xiaolu
煤层	coal measures	meixi
石灰岩	limestone	shihuiyan
砂岩	sandstone	shayan

Cave surveys by
China Caves Project
1992

Topographical details
from air photographs
compilation maps
by Sichuan Survey
1979

Tiencuan Dong

Daba He

Dapingzhi Dong

Pucaowan Dong

Mulangu Dong

Dong He

Dong He Dong 2

Dong He Dong 1

N

0 200 metres 1000

THE STORY OF THE CAVES

The Xingwen limestones provide an ideal environment for major cave development. Drainage water comes in from both sides of the limestone outcrop. Joints bring in water from the edge of the overlying sandstone, and then guide flows along major rift passages - both features being well formed in Zhucaojing. Water also flows downdip into and along the beddings - Yanzi Dong is the prime example.

Most of the passage development is initiated along a handful of inception horizons, which are thin shale partings on certain of the bedding planes within the limestone sequence. The main passage in Tiencuan Dong changes level to follow the same inception horizon on both sides of the fault through the skylight entrance. Subsequent roof collapse breaks up to other beddings and modifies many passage profiles.

Once through drainage is established, vadose enlargement is mainly downdip until the cave passages meet the flooded phreas where they have to turn along the strike towards the resurgence. Phreatic tubes follow the bedding across joint rifts, as in Xia Dong. And phreatic loops form where caves utilise joints to jump between inception beddings, or follow joints obliquely up and down dip within the same bedding plane; Dong He Dong shows the latter particularly well.

With all these features so well developed, Xingwen provides a classic example of cave geomorphology within a dipping limestone sequence.

Solution pockets in the roof mark the line of the fracture which guided the phreatic passage along the bedding in the Upstream Trunk in Zhucaojing

Evolution of the caves

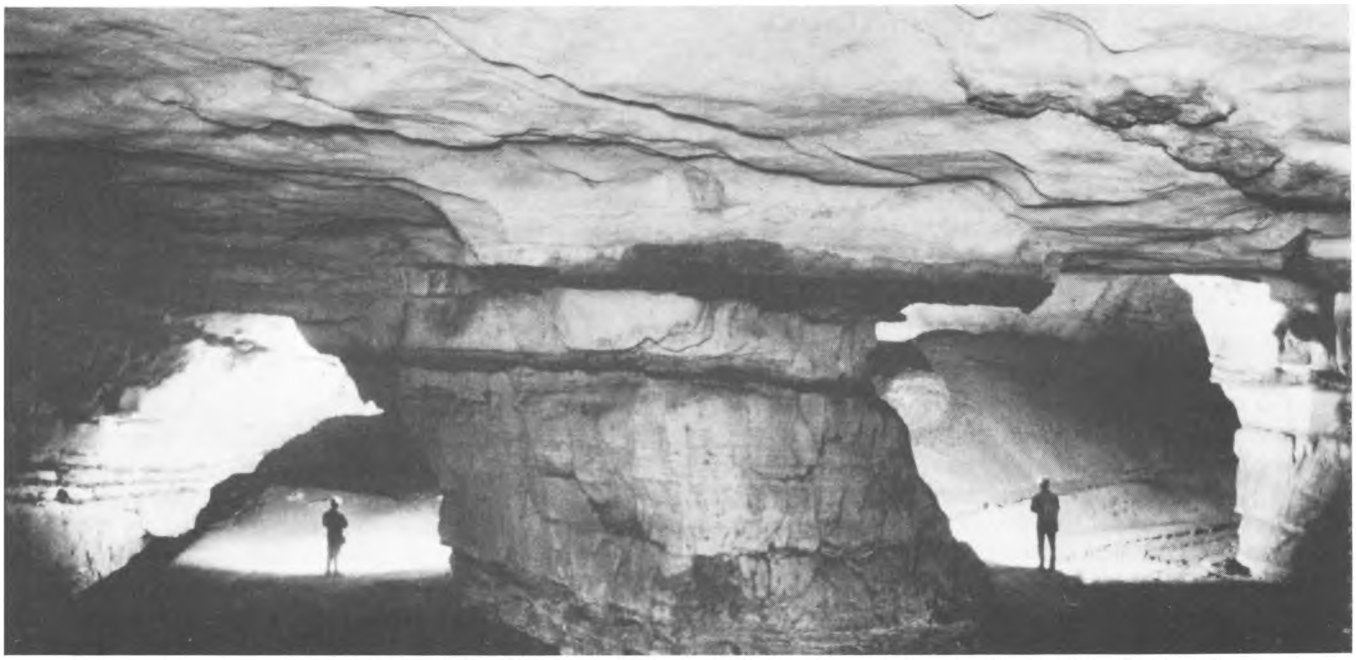
The cave systems evolved over time in response to valley downcutting, base level lowering and cover rock retreat exposing new limestone. The most obvious result was to abandon the fossil trunk routes along the strike, such as the main passage of Tiencuan. New passages developed further down dip, new phreatic trunk routes formed at lower levels, and the new vadose drainage invaded and used segments of older passage. The dip of the limestone ensured that many of the new phases started way beneath the sandstone cover. Some caves retained their streams which just entrenched the floor and cut out any rising loops, and Dong He Dong shows this process in various stages of completion.

These evolutionary changes took place in a multitude of sequences, and at the same time other processes were modifying the caves and acting towards their eventual destruction. Trapped sediments from the sandstone slopes blocked phreatic loops; some passages grew too large and suffered major roof collapse. When soil percolation water attacked limestone outcrops newly emerged from beneath the sandstone, stalagmite deposition decorated the caves below, but also helped block them up. Then surface lowering breached and truncated the caves, first in the dolines, leaving passage fragments in the hills; ultimately, scarp retreat saw the complete removal of the oldest, up-dip caves. From inception to final removal, thus inevitable evolution of each cave may have spanned more than a million years. The process repeats itself for each cycle of caves, and it continues today.

It is possible to recognise a rough sequence of cave development, even though the phases have huge time overlaps with different caves evolving through different stages at the same time. The oldest caves are now just passage fragments like Tien Liang out on the higher parts of the escarpment, and there is now no trace of their ancient resurgences.

The main phase of cave formation had important sinks at Heping, Shanyang and the two big dolines, all feeding a major trunk passage through the northern high levels of Zhucaojing, the main part of Xiang Shui and the Tiencuan main passage. Tiencuan may have been an outlet at its eastern end in its early stages, but wall scallops show that, later on, water flowed in from both ends and out downdip to the south, indicating that the Daba He valley was already deep enough to provide the resurgence site. Dong He Dong was formed but was totally flooded.

Gypsum crystals in Zhucaojing



The Zhucaojing passage swings round the U-Turn, but keeps to the same inception horizon within the limestone

A subsequent phase included development of the southern trunk passages in Zhucaojing, the intermediate levels in Tiencuan and probably the main part of Xia Dong. The story then becomes more complicated and will only be fully told after more exploration, mapping and geomorphological study. Certainly the lower streamways of Zhucaojing and Tiencuan are later phases, while the youngest caves of all are new dripwater shafts too small yet to explore, together with unseen flooded passages far beneath the sandstone cover.

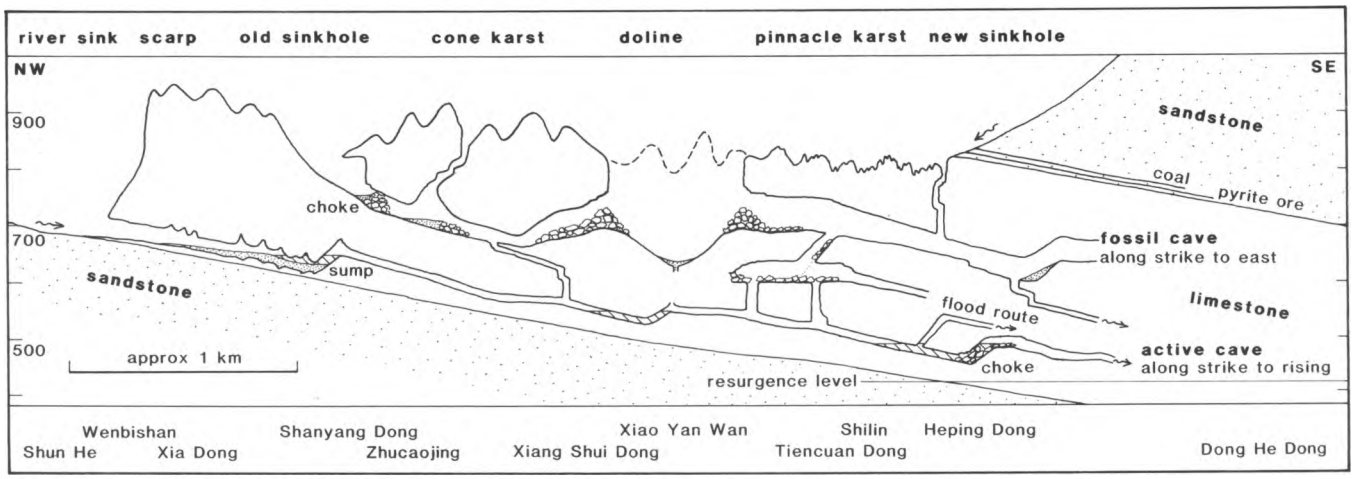
The drainage pattern

All the water draining into the Xingwen limestone ultimately finds its way back to daylight through the Dong He resurgence, which has a mean flow around 2 cubic metres per second. Seepages, trickles and streams coalesce into ever larger underground rivers. There is just one trunk route at the resurgence but there are two parallel routes through much of the area.

A northern underground stream drains from Xia Dong through the lowest level of Tiencuan, then probably via the Pucaowan streamway, before flowing into Dong He Dong 2. The southern system is even less known: the Heping sink drains through the lower streamways of Zhucaojing, and then appears to pass south of Pucaowan, before joining the northern water to emerge in the Dong He Dong sump. These links have not been proven by dye tracing, though flow rates and water chemistry do provide the evidence.

Estimations of flows suggest that water from the sinks around Xianfeng do not join the Dong He system, but must instead drain to the Longtan (Dragon Pool) resurgence further west. Percolation water on the limestone below Daxue accounts for all the extra flow to Dong He, and appears to join the Heping water below the undescended shaft at the present limit of exploration.

Flooding of the Xingwen caves is spectacular. A number of boulder chokes and sediment blockages appear to act as partial dams so that floodwater cannot pass, is ponded in the caves and is diverted into new routes. The effect is severe flooding of some passages and a reduced flood peak at the resurgence. Most significant is a blockage on the northern stream route which diverts floodwater southwest through normally dry passages in Xiang Shui Dong and into the southern route. Other changes include the filling of most of Xia Dong, extensive ponding in the Tiencuan low levels, the Mulangu sink turning into a lake with water diverted into the next doline east, and a torrent flowing into the normally dry entrance passage of Pucaowan Dong. All this occurs after a quite modest rain storm; there is much to learn of the Xingwen cave hydrology.



Diagrammatic profile through the caves and karst of the Xingwen limestone escarpment

THE XINGWEN SULPHUR FACTORIES

For the people of Xingwen, life, work and economy revolve around either farming the land or producing sulphur. The sulphur factories are located at the source of their raw materials - iron sulphide as the mineral pyrite, and coal for fuel - both found in the Permian rocks just above the limestone. Unfortunately, industry creates pollution. Xingwen therefore has a conflict between growth of the sulphur industry and any tourist development of the limestone and caves, with the farmers caught in the middle.

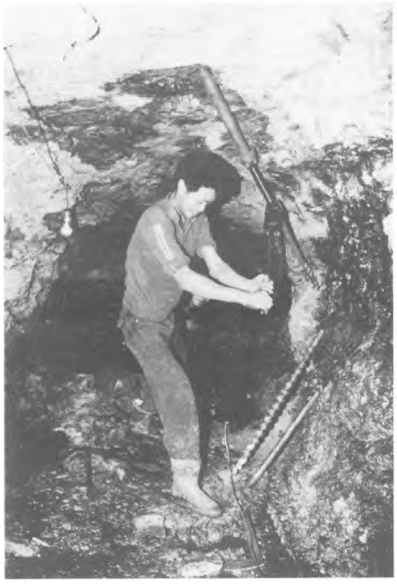
Mines and mining

The pyrite occurs in a bed of mudstone 2 metres thick less than a metre above the top of the limestone. All the way along the outcrop, there are small pillar and stall mines, each digging out the pyritic mudstone but leaving enough behind as pillars to support the roof. Holes are driven by hand, the rock is blasted out, and the rubble is carried to the surface in yoke baskets or handcarts. There it is either sorted by hand, or is run through crushing and washing plants to remove some of the waste, before it heads for the furnaces.

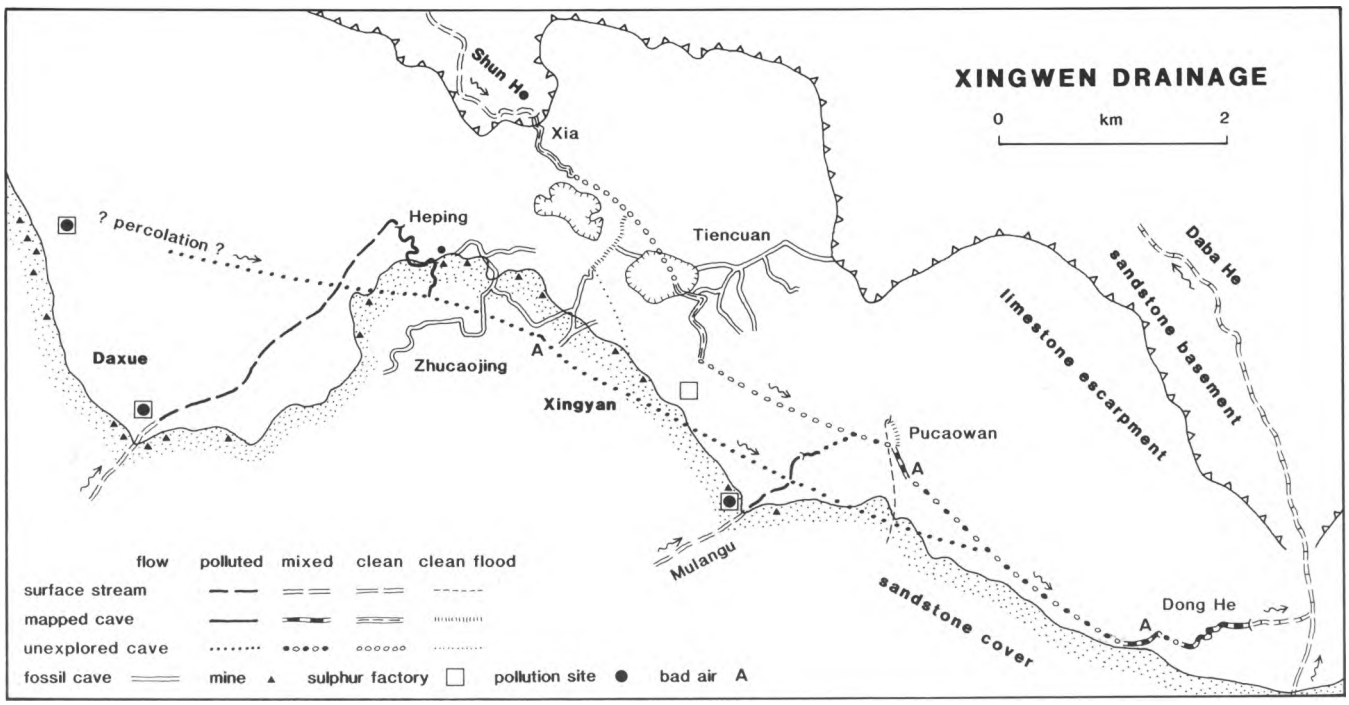
Just 4 metres above the pyrite bed is the first of a number of coal seams. Most of the coal mines are further west around Daxue, but there are a few in the thinner coals around Xingyan. The coal is hacked out without using explosives, and the larger mines have small rail tracks so that tubs loaded with coal can be pushed out to daylight. There are no shafts, because the mines just follow the beds in from outcrop, and, like in the pyrite mines, pillars are left behind to support the roof.

From pyrite to sulphur

Long rows of furnaces, each a couple of metres high and wide, form the hearts of the sulphur factories. Each furnace is charged with coal and pyrite ore and is then fired, so that the roasted pyrite produces a sulphur vapour. This feeds into condensation rooms and flues where it deposits the sulphur on the cool walls. When the furnace is burned out and cooled, the thick layers of sulphur crystals are scraped out of the condensation rooms and carried to open vats. There the sulphur is remelted, to refine it and cast it into blocks ready for dispatch across Sichuan. The furnace



Above left: hand drilling a shot hole in the hard pyrite mudstone
Above right: opening out a room in a Xingyan pyrite mine
Left: sulphur furnaces and condensation rooms amid the slag heaps and karst at Xingyan Huangchang (Sulphur Factory)
Below: refined sulphur is cast into blocks at the Xingyan factory



slag, of waste rock, iron and ash, is scraped out and dumped on ever-growing heaps below the main plants.

Both the mines and the factories are fascinating examples of basic industry driven by manpower; the pyrite is sitting in the ground, the coal provides the heat for the furnaces, there is minimal electric lighting in the mines, and motor transport only appears to carry away the end-product. However, these admirably simple techniques are not efficient, and it is the pyrite which is lost in the various waste products that provides the damage in the caves.

Pollution in the caves

The problem for the caves lies in the drainage from the factories and mine plants, which flows down onto the limestone and sinks into the stream caves. Some of the water is opaque with suspended sediment, including pyrite, with the worst coming from the newest plants which crush the ore finest. Coarser pyrite is also carried in; a pure pyrite gravel in the Fool's Gold Streamway of Heping Dong is derived from a little, old-style mine plant almost directly above. Clinker, still containing some pyrite, is washed in from the factory slag heaps, most visibly into Mulangu Dong.

Inside the caves, the iron sulphide pyrite oxidises to sulphate and in turn creates sulphuric acid. The Acid Lake in Heping Dong has pH 2.6, but dilution takes place within the cave drainage systems, and the resurgence water has pH 4.7. The acid reacts with the limestone to produce carbon dioxide - and incidentally accelerates cave erosion, though with limited effect over the short time scales involved.

Bad air is then created by the oxygen depletion, where it is lost into the pyrite oxidation, and also by carbon dioxide production. The effect of this on cave explorers is similar to rapidly going to high altitude without any acclimatization. And the difficult breathing and headaches are accompanied by sore eyes and throats due to an acidic aerosol mist formed as a byproduct of these underground reactions. The bad air is heavy, and accumulates to dangerous levels above downstream sumps in polluted and unventilated streamways.

The southern stream route suffers the worst of these problems. The lower streamway of Zhucaojing was not explored because of the bad air, and serous bad air was also encountered in Dong He Dong 2, though the well ventilated resurgence cave produced no problems. The northern stream route is clean at Xia Dong, and only slightly contaminated in Tiencuan, through it is well polluted before it reaches Pucaowan. The dry fossil caves are unaffected.

Improving the cave environment

The source of the pollution is not the mines and factories themselves, but the waste heaps. The furnace slag, the waste from inefficient mineral plants, and worst of all the waste fines from the newer crushing plants, all contain pyrite. Most waste is just dumped downslope, at many sites directly into streams. There is now no control over waste tipping, and the debris, with the pyrite, is washed into the caves which act as giant sediment traps. The worst sites appear to be the Mulangu factory and some of the Daxue plants, while smaller sites such as the little crushing plant above Heping Dong make their own contribution to the cave pollution.

A little planning of the waste tipping, with simple sediment traps and settling ponds on the surface, would eliminate most of the cave pollution. Leachate from the spoil heaps, and mine drainage, could easily be channelled through beds of locally quarried limestone gravel. This would neutralize its acidity, and precipitate any heavy metals, prior to its release to the environment. Costs would be fairly minimal, and even a partial clean-up of the water would benefit agricultural use downstream of the Dong He resurgence.

There is no reason why the sulphur industry and the tourist development of the caves and karst cannot co-exist at Xingwen. The main tourist potential is in the northern sector, away from most of the pollution. Xingyan is the nearest sulphur factory, and its splendid and very photogenic old-style works have almost no effect on the caves below. The mines themselves create no problem; acidic drainage from them, and similar drainage from well-sited settling ponds, is likely to be little worse than natural drainage across the pyrite ore outcrops. Both tourism and sulphur production are important to the local economy, and neither need preclude the other. With both, Xingwen should survive and prosper.

Rice stubble and the karst west of Xingyan

The 60 metre drop into Shanyang Dong

TOURISM IN THE XINGWEN PARK

The presence of hotels and a major showcave indicate that Xingwen already has its own tourist industry and the rudiments of an appropriate infrastructure. Indeed, the vast underground coach park in Tiencuan bears witness to the area's popularity with Chinese tourists.

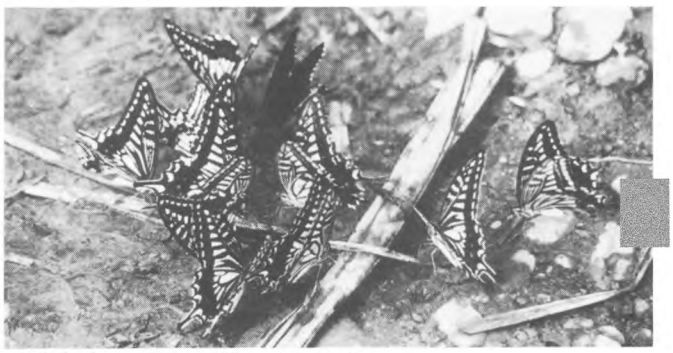
The existence of this infrastructure makes the potential for further development very good. The disadvantage from the perspective of western tour groups is the poor access, with an uncomfortable three hour road journey at the end of a ten hour rail trip from Chengdu. Properly handled however, even this disadvantage could be turned around. The rail trip is carried out on steam trains, which have their tremendous nostalgic attraction for travellers from the West, and the road journey passes through some lovely farming country before approaching the spectacular limestone escarpment of Xingwen.

The existing tourist cave of Tiencuan provides an obvious attraction. Its main passage is unusually large, with some impressive rock architecture, and the daylight zones, including the midway skylight, are truly spectacular. A through trip out to the main doline, using the path already in place, would make any visit memorable. This would then link into the well established footpaths which wind through the stone forest from the doline to the main hotel. The network of paths also extends far further, through some dramatic karst, and provides an opportunity for tourists to walk at their own pace, not necessarily with any guides, and experience the sensations of exploring a new landscape.

Both farming and traditional mining offer tourism opportunities. The landscape is much more than the product of a set of geomorphological processes since it has been, and continues to be, moulded by the people who live in it. Simple, easy to follow maps, with good interpretive information, would allow tourists to explore the area for themselves, seeing traditional agricultural practices and accessible, fascinating processes associated with the sulphur industry. This could be achieved at minimal cost. It would also take very little to develop the splendid traditional style sulphur works at Xingwen, and perhaps also one pyrite mine, which could become major attractions in their own right.

Such a strategy would increase local revenue from tourism without seriously affecting the hundreds of people presently working in farming and mining.

In the longer term the Park offers tremendous potential for specialist activity groups. The Park's caves, with their variety of underground landscapes, will attract speleologists in pursuit of both geomorphological study and also the pure excitement of underground exploration; and back in daylight, there are the clean limestone walls of the great dolines which offer unparalleled opportunities in the development of sport climbing.



Butterflies in the Shun He valley

Clockwise from top left:
Rice harvest in the Shun He valley
Ducks being driven along a road in the Daba valley
Tobacco planted along the soil-filled fissures between ribs of bare limestone near Shanyang Dong
Cracked mud floor in Zhucaojing
The limestone walls of Xiao Yan Wan
Among the stalagmites of Zhucaojing

BAMA, GUANGXI

In the western part of Guangxi province, the Bama karst lies between the You and Hongshui Rivers, some 230 km west of Liuzhou. Spectacular fengcong tower karst, typical of Guangxi and among the finest in the province, contains some very large and very extensive cave systems.

The massive limestones are Devonian to Permian in age with a total thickness of many hundreds of metres. They occur in five broad domes, within which the limestones are further folded, separated by tight synclines of Triassic shales and sandstones; numerous faults cut through the structures.

Not surprisingly, the topography reflects the geology. The sandstones and shales form long high ridges with thick soils and good terraced farmland, and the few main roads follow their outcrops. In contrast, the limestones present a chaos of karst towers, with thin soils, poor farming opportunities, water shortages, and only rough tracks or footpaths. Some towers rise 600 m. In between, the dolines either reach down to base level with cave resurgences and sinkholes on opposite sides, or have sediment choked floors perched above the cave streams. The farmers have built stone wall terraces across the depressions in desperate efforts to retain soil and water, but the karst does not offer the easy life.

The Pan Yang cave systems drain two of the limestone domes. They all drain to the Beimo resurgence, with a mean summer flow of over 5 cumecs at the head of the Pan Yang River; it lies close to the village of Poyue, 20 km NW of Bama. The main drainage axis reaches north to the mountains of Donglan county; active and fossil caves intervene with short stretches of surface flow between a sequence of sinks and risings over a distance of 30 km. A second limestone dome to the west drains to Ma Wang Dong resurgence, from where a short surface river crosses the shale outcrop just north of the village of Yueli, before sinking into Da Yang Dong within the main Beimo catchment.

Both sides of the shale and sandstone ridge at Yueli, the limestones extend into an infinity of karst towers. These house vast numbers of caves, many of which have been dissected by surface lowering between the towers. This does leave rather fragmented cave systems, but underground journeys of a few kilometres are possible through some of the larger fengcong clusters of towers. The 1988 and 1989 expeditions mapped more than 50 km of cave passages. Many of these kilometres were in enormous caves, decorated with massive stalagmites. The caves of Pan Yang are truly spectacular, and many more await exploration.

The caves fall into distinct groups, and their control by geological structure is clearly recognisable immediately north of the resurgence. The main fossil system, including Hou, Qian and Beimo, lies down the axis of a syncline; these caves were largely mapped by the 1988 expedition. To its west a series of smaller caves is fed by streams off the sandstone and shale ridge southwest of Yueli. But the modern trunk drainage lies largely in the phreatic zone east of the fossil caves, having left its southeasterly course along the fault zone which collects the cave rivers east of Yueli.

Entrance to Qian Dong

Blocked fossil entrance south of Ma Wang Dong

Karst hills of Bama

Gour lake in Chuifeng Dong

THE PAN YANG CAVES

The 1989 expedition was based at Yueli and spent most of its time in four nearby cave systems.

Gantuan Dong

The entrance to this remarkable cave west of Yueli is most unimpressive from the outside. But the view from inside is awe-inspiring, with shafts of sunlight reaching across the entrance chamber to pick out towering stalagmites. Routes through the stalagmite forest trace either tracks polished glassy smooth by slithering snakes, or blackened calcite and sooty footprints left from a very early Chinese exploration. These forgotten explorers even negotiated a 30 m drop at one of the points where flowstone almost blocks the passage.

An ancient phreatic trunk route, the single passage reaches nearly 4000 m; for most of the way it is 20 to 60 m wide with a sweeping arched roof. A final forest of stalagmites stands in a circular chamber more than 120 m across. Every nook and cranny holds bits of charcoal ash dropped by the Chinese cavers as they explored. We, like them, found no way on.

Ma Wang Dong

Behind the gaping mouth of Ma Wang Dong lie more than 10 km of very large cave passage. The resurgence down below offers a pleasant trip on a bamboo raft through a series of emerald lakes, but the upper entrance beckons. A wide tunnel leads 200 m to the lip of a vast pit open to daylight, where a precarious bamboo bridge gives access to some ruined defensive walls and the real cave entrance on the far side. Backlit cloud layers make these entrances quite beautiful when seen from inside.

The first section of passage is over 100 m wide, but it soon contracts and a 40 m shaft in the floor demands a spectacular traverse to reach the way on. A climb down on the far side reaches back to the cave river, and a smaller active tributary can be followed upstream to the west for 2000 m to a sump. But this is a mere distraction, because vertical walls stretch into the distant darkness of the high level. Crystal gours and a floor littered with cave pearls the size of snooker balls add yet another touch of quality, then round a corner there is a stunning view ahead into daylight flooding the passage. Here the roof is 150 m above, and the cave emerges into a rocky doline ringed by vertical cliffs and floored with a lost world of virgin forest.

The main passage of Beimo Dong

Across the doline a large passage high in the cliff beckons, but remains unexplored at present. The main route doubles back to the southeast, down through rotting overhanging vegetation. After several fault controlled zigzags, daylight is reached in another doline 6 km from the resurgence entrance. Ma Wang is a truly spectacular cave of remarkable dimensions. Little more than the main fossil passage has yet been mapped, and there is clearly more cave to discover at both high and low levels.

The fault zone caves

A zone of fractured rock along a fault, just north of Yueli, guides both the valley through from Ma Wang and also a sequences of caves just downstream.

Da Yang Dong has 1200 m of large river passage, from sink through to rising, with lakes, towering sediment banks and internal cloud systems. The separate high level passage of Baotun Dong is shorter but has some of the finest stalagmites in the area.

The short resurgence cave of Chushui yields the main flow, of about 2 cumecs, from the norther karst; it joins the Ma Wang water with a similar flow having passed through Da Yang. The combined waters sink into the broad arch of Xiao Shui Dong, and flow for 500 m to a large sump pool. Here, an intrepid team from the 1989 expedition found an old man fishing by the dim light of a tiny oil lamp; hopefully his catch was worth the journey in. A fossil passage continues for another 1000 m to break out into the Weipo doline. On the far side, Dasuo Dong continues to another large entrance, but water is only seen in some deep pits.

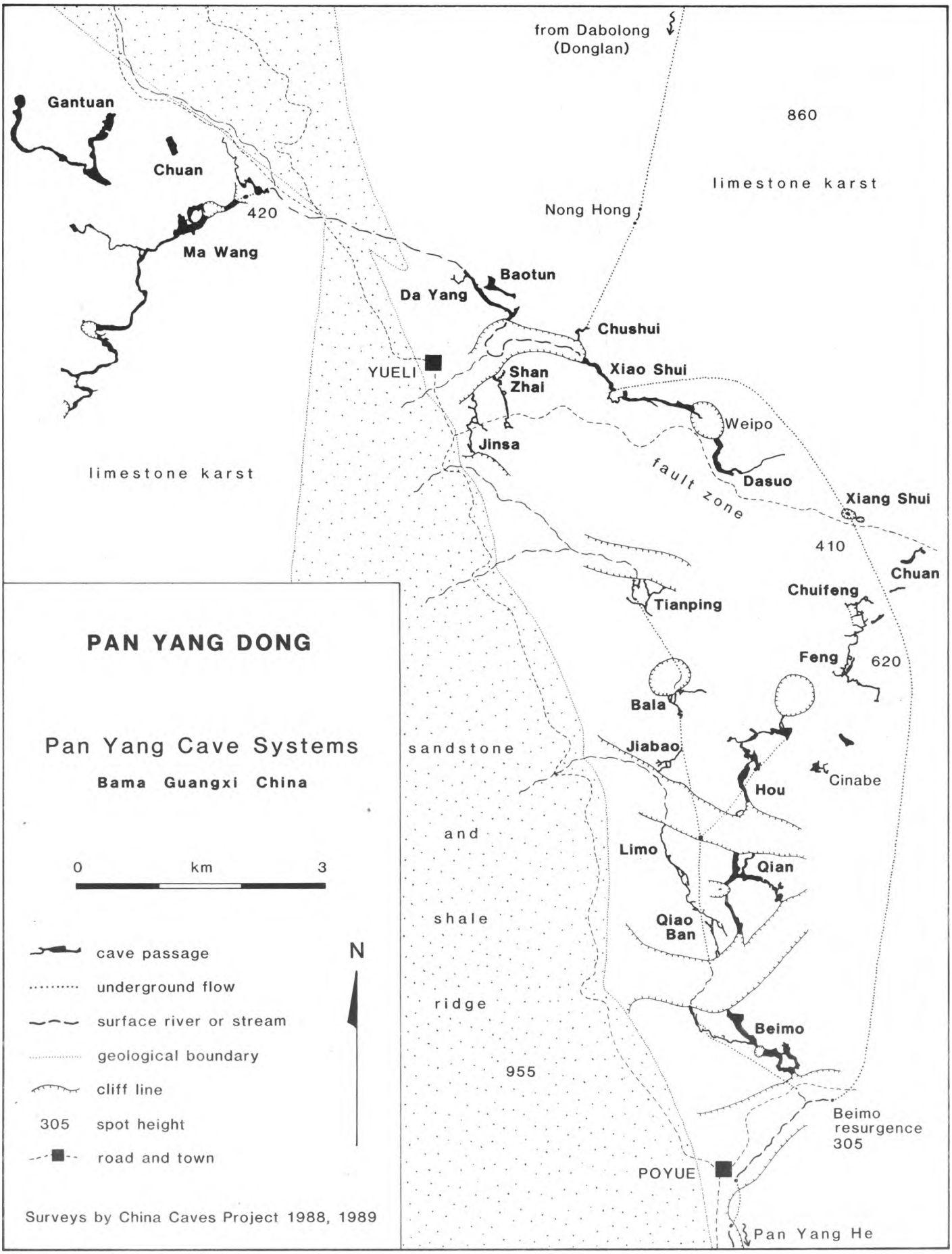
The river is last seen in the bottom of the huge shaft of Xiang Shui, before it turns off the fault and heads unseen for the Beimo resurgence.

Feng Dong

A very strong, warm, outward wind promises much at the entrance to Feng Dong, but only yields a rather gloomy shaft system some 250 m deep. This does drop into a 3800 m long horizontal system, which is much easier reached through the Chuifeng entrance.

The warm wind blowing from the lower entrance is used by the local women who visit the cave when they want to dry their hair (chuifeng means hairdryer). The cave is quite complicated, with the main line following a tortuous route through muddy phreatic tubes which loop up and down the bedding; downdip branches to the west all end in a flooded zone. Southwards, an inlet drapes stalagmite from the roof, and the route continues up beautiful crystal gours and across a blue lake.

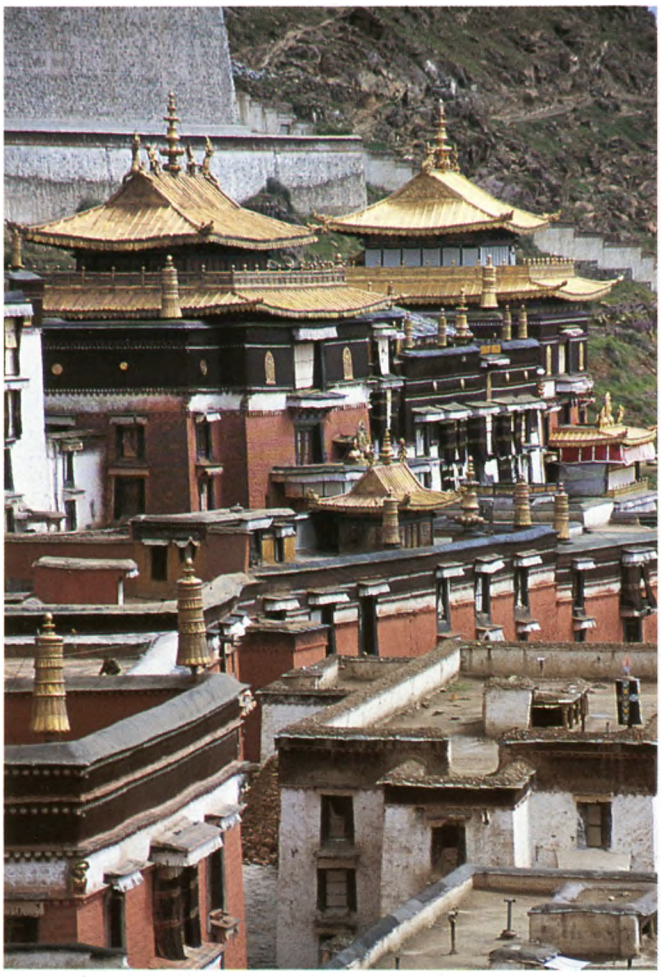
More muddy tubes eventually reach a zone of clean rock fretted to razor sharpness by the flow of sediment laden water. The Feng Dong shafts drop in through the roof, and the passage continues southeast down a series of clean pitches to where exploration was halted by a lack of rope. There is clearly more passage to discover, and the winds indicate the existence of another large entrance at even lower level. The cave acts as an overflow route for floodwater backing up in the main Pan Yang conduits, and a visit would be unsafe if the water level is seen to be rising in the Xiang Shui shaft.


PAN YANG DONG
Pan Yang Cave Systems
Bama Guangxi China
0 km 3
cave passage
underground flow
surface river or stream
geological boundary
cliff line
305 spot height
road and town
N
Surveys by China Caves Project 1988, 1989
from Dabolong (Donglan)
Gantuan
Chuan
420
Ma Wang
limestone karst
Nong Hong
860
limestone karst
Baotun
Da Yang
Chushui
YUELI
Shan Zhai
Xiao Shui
Weipo
Jinsa
fault zone
Dasuo
Xiang Shui
410
Chuan
Tianping
Chuifeng
Feng
620
Bala
sandstone
Jiabao
Cinabe
Hou
and
Limo
Qian
shale
Qiao Ban
ridge
Beimo
955
Beimo resurgence 305
POYUE
Pan Yang He

The trunk fossil passage in Ma Wang Dong, Bama

Crossing the lakes in the Ma Wang Dong resurgence, Bama

Wide open spaces on the Tibetan plateau: a yakherder's tent beside the salt lake of Nam Co



Tashilhunpo Monastry, Shigatse, Tibet

Yakherder's wife on the Tibet plateau

THE TIBET PLATEAU

There is nowhere else in the world quite like Tibet. An enormous plateau at an altitude of over 4500 m is broken by mountain ranges rising to around 7000 m and wide, shallow salt lakes. It is a high altitude wilderness, a harsh and bleak environment, but incredibly beautiful. Almost a desert in the north, its southern edge is more dissected, with the Yarlung Zangbo valley, and beyond that the mighty Himalayas. Geologically, it consists of slices of continental crust separated by strong fold belts, all rammed together by the collision of India and Asia; the plateau has been created by enormous uplift within the last ten million years.

Tibet is cold because of its altitude, and is largely dry because it stands in the rain shadow of the Himalayas. Amdo, in the north, has a mean annual temperature of 5°C and rainfall of less than 100 mm. Lhasa, further south, lower down, and just caught by the tail end of the monsoon, averages 9°C with 300 mm of rainfall. Temperatures can soar with high radiation from the summer sun, but most cloud and rain comes with the summer monsoon, and the winters are very, very cold. With frost on over 300 days per year, much of the ground is permanently frozen, and glaciers reach down to 5000 m: they would reach lower, for melting is not their main problem, except that they are starved of snowfall nourishment.

With temperatures, rainfall and exposure to the wind all so inhospitable, vegetation is, not surprisingly, rather minimal. Much of the plateau is endless grassland. At first it looks like the American Prairies - except that it is so high, so cold, grazed by herds of yaks, very empty, and usually with snow-covered peaks on the skyline. And even the green is not all grass, for most of the surface is just covered by mosses hardy enough to survive the climate. The high mountains are even more barren, and only the valleys east of Lhasa have much woodland cover. With so little natural vegetation, soils are thin, restricting both the scope for arable farming and also any chemical solution of limestones.

Nyainqentangla Mountains east of Lhasa

The Tibet Plateau is only thinly populated. Outside the Lhasa valley, towns and villages are far apart and even camps of the nomadic herders are separated by huge expanses of emptiness. Transport is not easy. Tar roads reach from Lhasa only to the north through Amdo and ultimately to Beijing, and west to Shigatse, while the remaining dirt roads are few in number, and are all too frequently impassable after the washouts or landslides in this harsh but splendid terraine.

Nilong village, above the lake of Comenkan

The Tibetans

Tibet has always held a fascination for western travellers, with Lhasa in particular becoming a focus for bygone explorers and modern travellers attracted by the country's isolation and extraordinary culture. Today, the isolation is more political than physical, but no visitor is less than enthraled by the Tibetans' unique way of life.

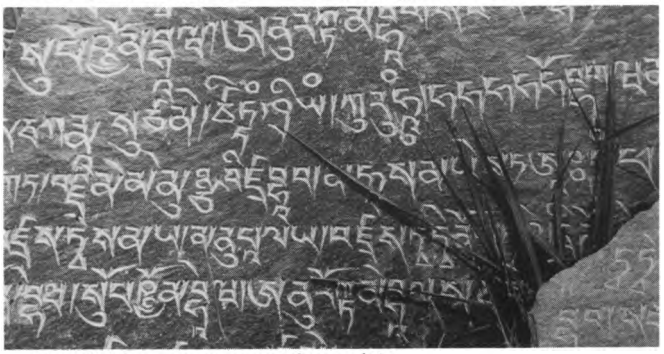
The history of Tibet has always been closely linked with that of China. However, whereas the Tibetans would argue that they are an independent country, with their own language, religion and culture, the Chinese see Tibet as just a province within China. This status was established in 1950 when the Red Army "liberated" Tibet, and was reinforced in 1959 when the Dalai Lama fled the country. Since then, the human face of Tibet has seen many changes, with massive reductions in the religious communities and the imposition of new agricultural practices, often with disastrous results.

The focus of Tibetan life for hundreds of years has been Buddhism. This blend of Indian and the previously existing native religions has created the unique culture of the country, exemplified by the buildings of the Potala and the Jokhang Temple, together with the once huge monastic communities. It is clear from the ubiquitous presence of religious material and practice that, although the monasteries may have declined since the Chinese armies entered the country, the vast majority of the Tibetan people are no less devout now than they were before the Dalai Lama took refuge in India. They are also hugely hospitable, full of charm and with immense good humour.

In the few cities and large towns, the traditional Tibetan houses have become swamped by the uniform concrete structures of the Chinese, but away from the main roads the vast plains are dotted with herders' tents and small, single story houses surrounded by walls of dried yak-dung. Tibet is reckoned to contain about four million yaks (that's twice as many as there are people), and they remain the mainstay of the traditional Tibetan economy. They are not only beasts of burden, but every part of their body is used for some purpose, a level of environmental efficiency which is essential for survival in the dramatically harsh environment of the Tibetan plateau.

Communal ploughing near Lhaze

Left: kids at Perochi *Above: yakherder at Nam Co*



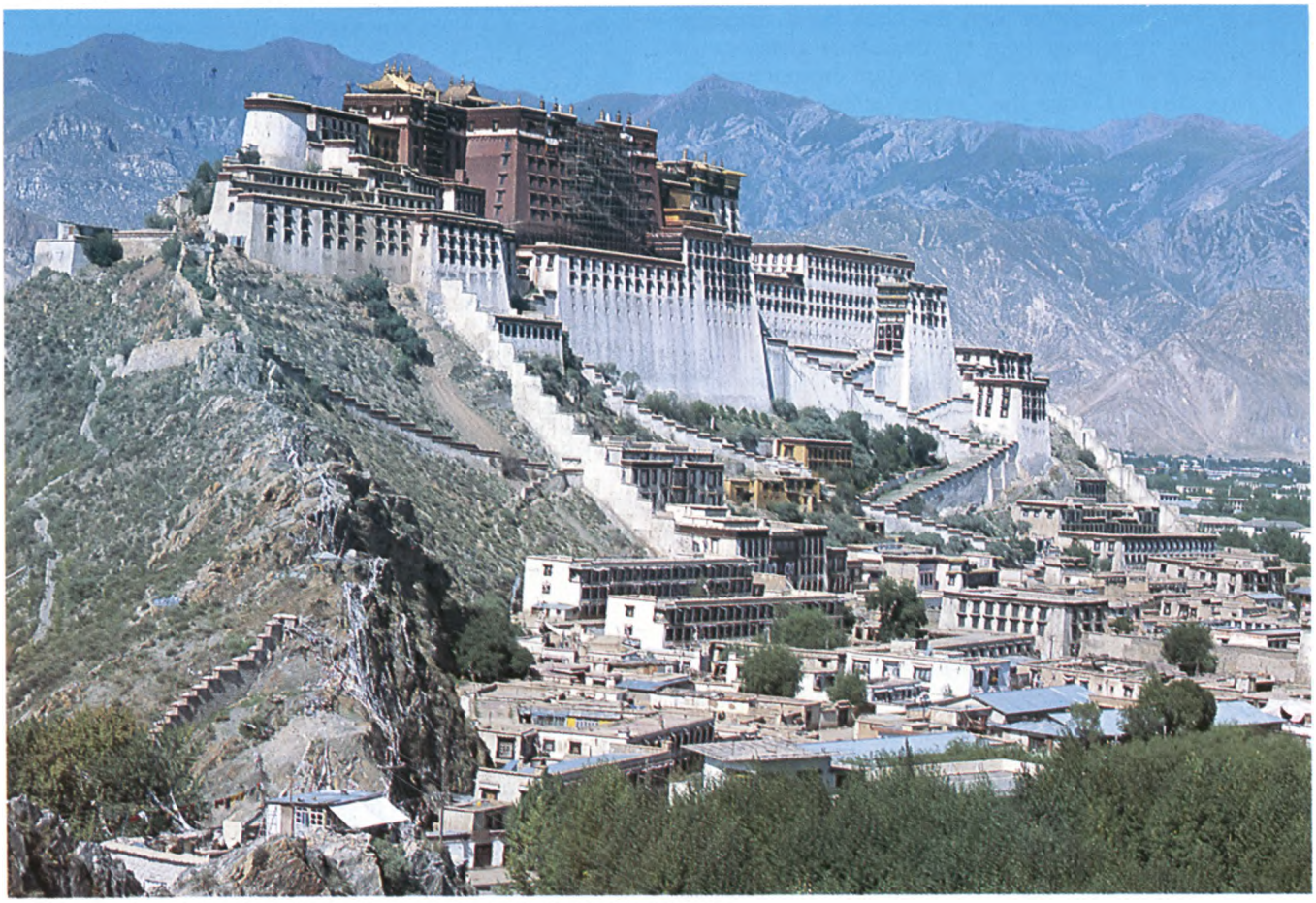
Buddhist prayers carved on slate

En route to Nam Co

Yak skin coracle ferry on the Yarlung Zangbo

Looking north from the pass between Tingri and Perochi

The entrance of Chagong Chimu in the cliff above Nilong



The magificent Potala palace on its rocky crag overlooking Lhasa

LIMESTONE AND KARST IN TIBET

Most of Tibet is formed of granite, slate and sandstone. Limestone occurs just as thin bands or fault slices, most of it complexly deformed, brecciated or even turned into marble. Due to its resistance to weathering, the isolated outcrops mostly form crags, scarps and ridges.

Karst features are minimal on the Tibetan limestones because the low rainfall, low temperatures, thin soils and reduced chemical activity are all so unfavourable. Non-karstic periglacial processes and landforms dominate, and the limestone outcrops are frost-shattered and draped with aprons of scree. This was found at all the sites in central Tibet visited in 1992; outcrops further west, and perhaps more interesting, were inaccessible as the roads were washed out.

Modern solutional activity on the Tibetan limestone is minimal; most outcrop surfaces ae either frost shattered or fretted by microkarren (these are tiny solution grooves only about a millimetre wide typically formed in cold and/or arid areas where chemical processes are very slow). Small areas of larger rillenkarren were found on softer limestone at Perochi, and at a few other sites where they have developed largely along bedding plane or fracture weaknesses.

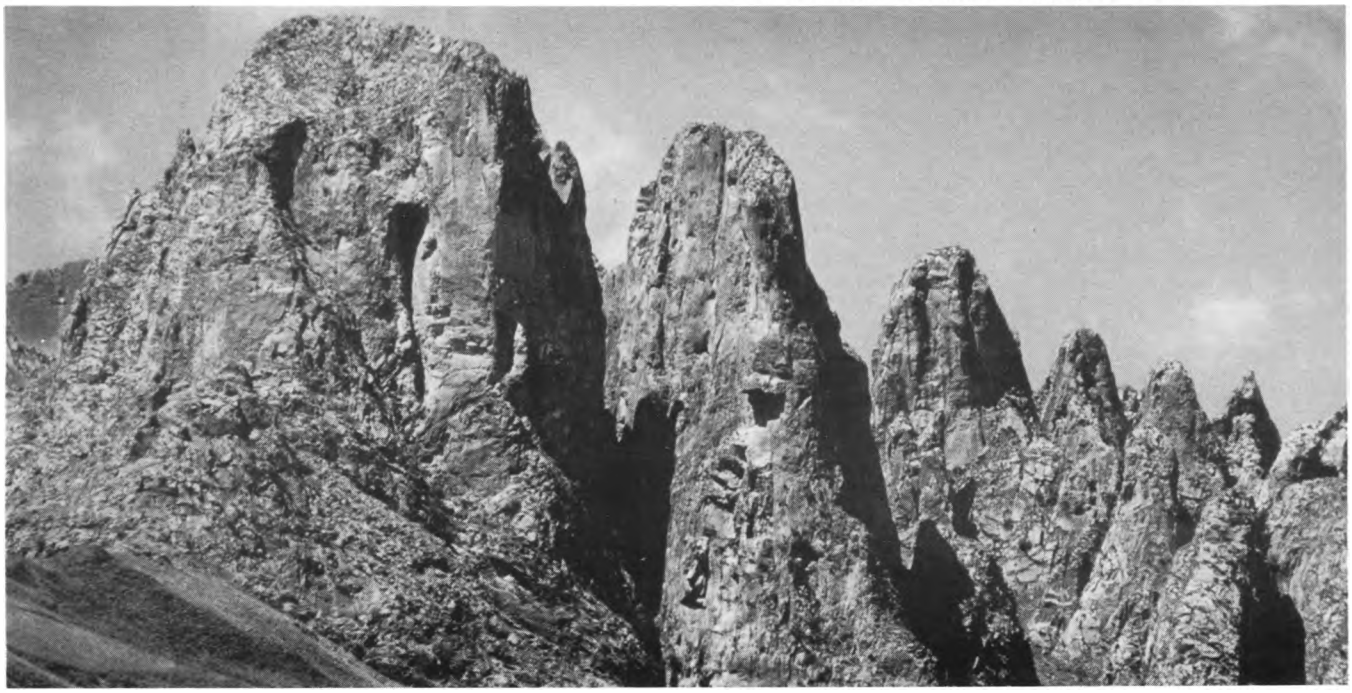
The exciting potential of the Tibetan limestones is that they may retain relict karst features. Less than five million years ago, Tibet was at an altitude low enough for it to support a thick woodland cover, nurtured by a high rainfall, as the Himalayas had not yet risen to block out the annual monsoons. In theory, karst features could have formed in this warm, wet climate and could have survived until today. But the reality is that no fossil features have yet been recognised.

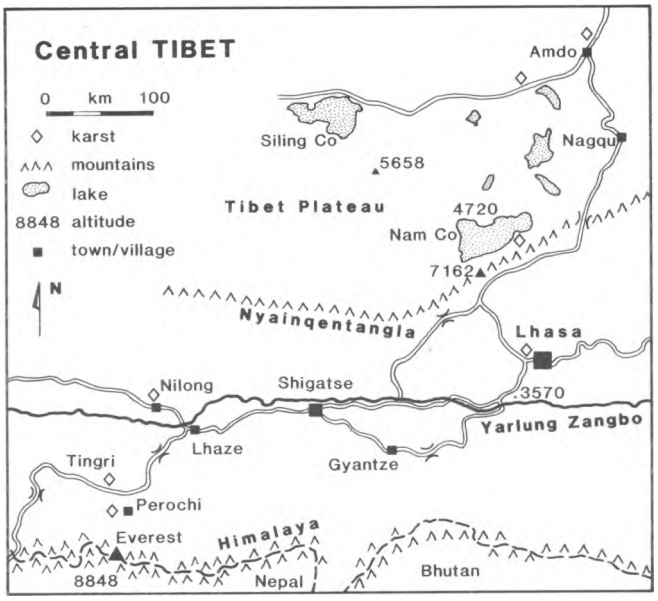
Towering pinnacles on the limestones at Lhasa and Amdo are not remnants of tropical karst. They are periglacial features, with relic blocks of strong limestone standing between gullies weathered back along vertical bedding planes, joints and faults; they occur on many rock types, not only on limestones. And there are no large fossil karren surviving as ghosts behind the modern microkarren; any larger karren that did exist have been lost to millennia of frost shattering. The concept of Tibetan fossil karst is still fascinating, but sadly it remains unproven.

Looking out from a small cave in the Nilong karst

Microkarren on the Lhasa limestone (pencil 5 cm long)

Frost shattered limestone crags just west of Lhasa



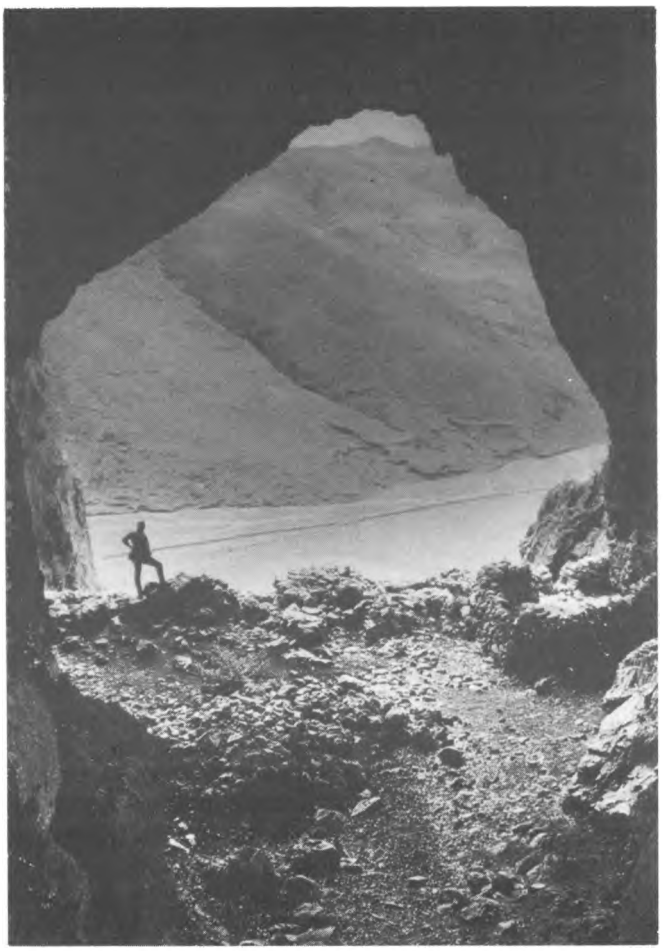


Limestone caves in Tibet

With such limited solutional activity on the limestones, it is not surprising that Tibetan caves are few and far between. Everything is against cave development - rainfall is low, streams cannot drain onto the upstanding limestone outcrops, and most of the limestone has been plasticly deformed leaving few fractures for cave inception. Small caves were found in 1992 at three locations, all at altitudes of over 4500 m.

North of Lhasa, the vast salt lake of Nam Co has a limestone headland on its southeast shore. The headland cliffs are pitted with caves above an old wave-cut platform. Some of the caves are breached phreatic solution rifts, reaching in up to 20 m along joint weaknesses, but their inner ends become too narrow to follow: a low stalagmite boss occurs in one rift cave. Wave action, when the lake stood at a higher level, has created more caves and arches, and has enlarged and modified the breached solutional features. The site is a minor Buddhist shrine, and a few reclusive individuals live in two of the larger caves.

The fissure cave and remains of the monastic buildings on the limestone hill just west of Perochi



Looking out from Chagong Chimu, above Nilong

West of Lhasa, the village of Nilong and the lake of Comenkan are overlooked by a scarp of Triassic limestone. At the eastern end, Chagong Chimu, Big Cave, cannot be missed, as its entrance is 15 m high and wide. Sadly, its walls close in and its floor rises until 50 m from the entrance there is just a narrow fissure with solid rock walls. The cave has formed on a pair of inclined faults and most of its enlargement has been due to frost action; there is minimal dripwater in the cave, along with some very thin flowstone coverings. Further west on the scarp, another cave 20 m long has formed on a thrust plane; it has four entrances where surface lowering has reached the thrust and breached the cave. This is clearly a solutional cave in origin, but it is very old and is now heavily shattered. Some other very small caves in the hillsides are just washouts of scree beneath an upper layer cemented by tufa; the tufa itself is the most conspicuous feature of at least some relatively recent solutional activity.

Further south, the approach to Rongbuk and the north side of Everest crosses some limestone near the village of Perochi. Thin beds of limestone stand nearly vertical, forming sharp ridges on the hillsides; in one of these there is a fissure cave only 10 m long and a few metres wide but some 30 m high. Solution has played a role in this cave's development, but so has frost action, and fissure caves of these dimensions can form in almost any rock. The unremarkable features of the Perochi cave are unfortunately about typical of the caves so far seen in the limestones of the Tibetan plateau.

MENGZI, YUNNAN

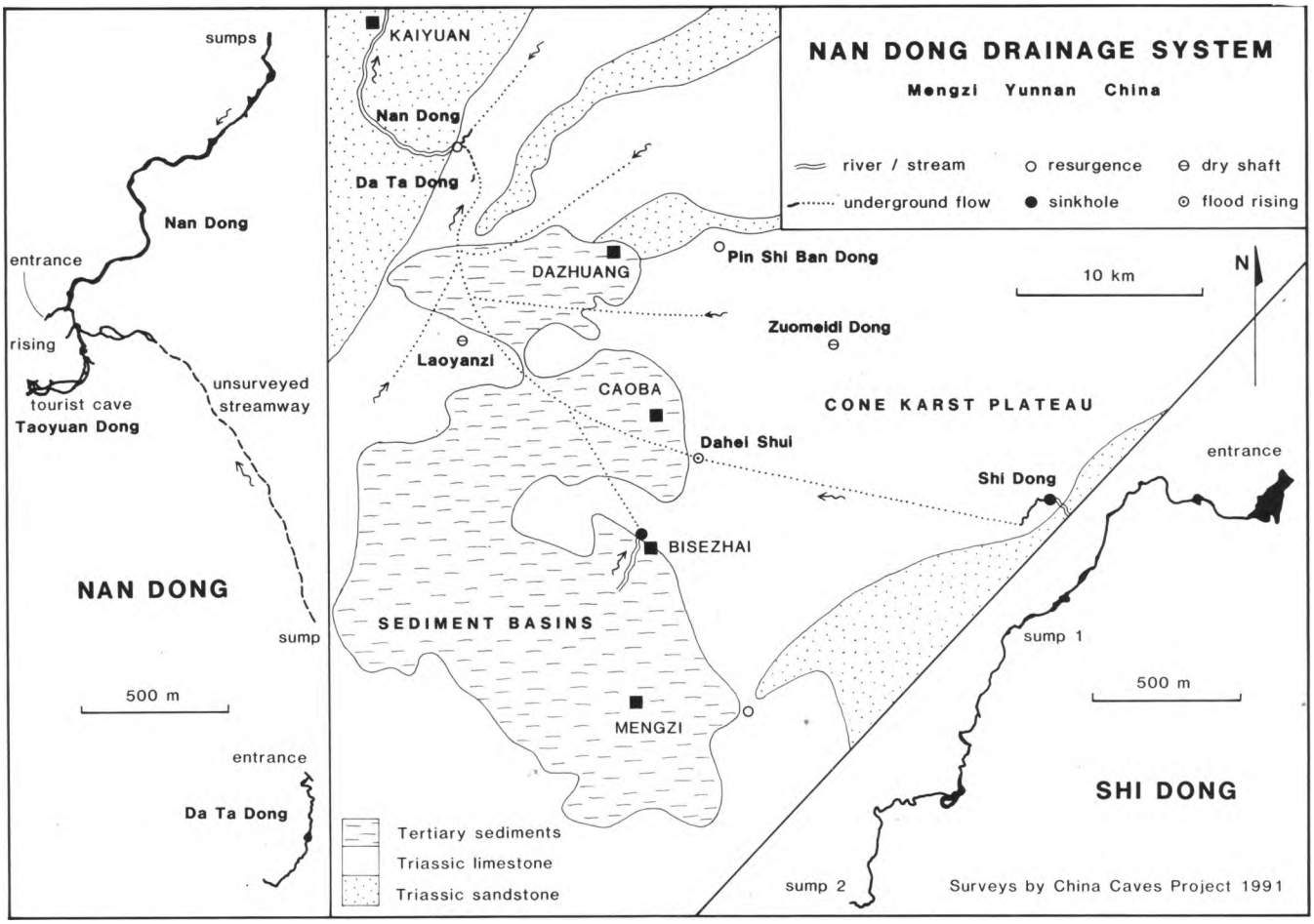
The Mengzi karst lies in southern Yunnan, just 50 km north of the Vietnamese border, around three broad basins floored by Tertiary sediments which provide good agricultural soils. Massive Triassic limestones form plateaux around and between the basins, and are also continuous beneath the Tertiary sediments except where they are interrupted by fold cores of sandstone.

The limestone plateaux are typical cone karst with thin soils. Farming is the economic heart of the area and relies on the basin soils, but output could be greatly increased if additional water supplies were available for irrigation. However, much of the water in the area flows through limestone conduits far beneath the basins, and is physically or economically inaccessible. In 1968, the Chinese traced the connection from Shi Dong, east of Caoba, to the major resurgence at Nan Dong, north of the basin complex.

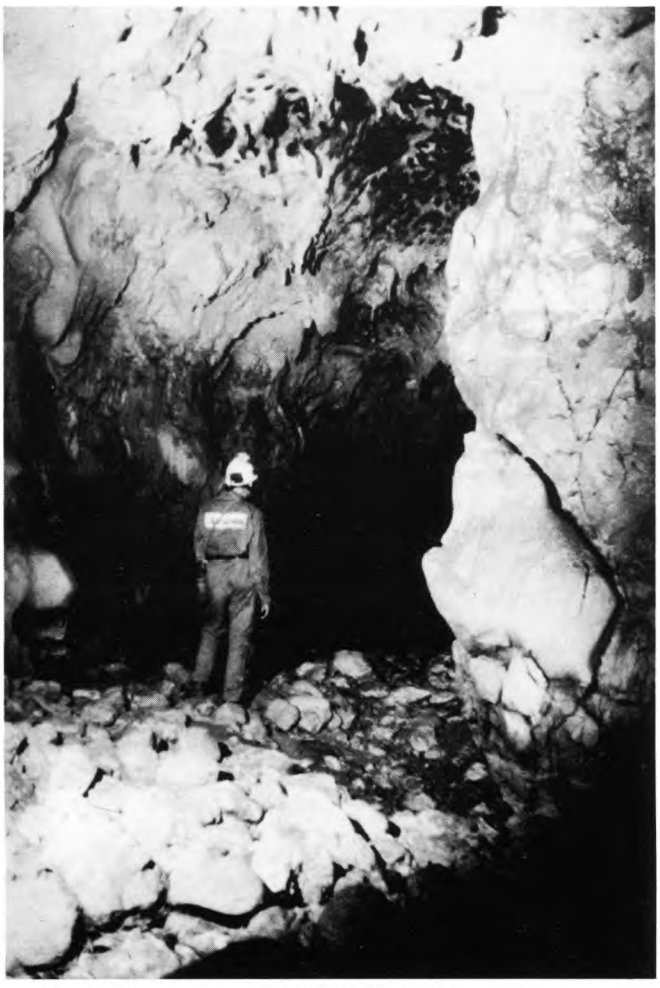
Spring 1991 saw a group of ten British cavers, together with colleagues from the Karst Institute in Guilin, come to explore the karst of Mengzi; they were based in the village of Caoba. It was hoped that exploration and survey of the caves could provide data to support the work of civil engineers in sinking wells. Accurate positioning of the cave passages where they pass between the sandstones south of Nan Dong would also provide the means to block the caves and so, possibly, raise the water levels under the basins and make more supplies accessible. In the wet season, water already overflows the underground passages to resurgences along the limestone scarp at Dahei Shui and other sites.

A choked sink at Bisezhai

Karst hills around the Caoba basin



Entrance to Da Ta Dong

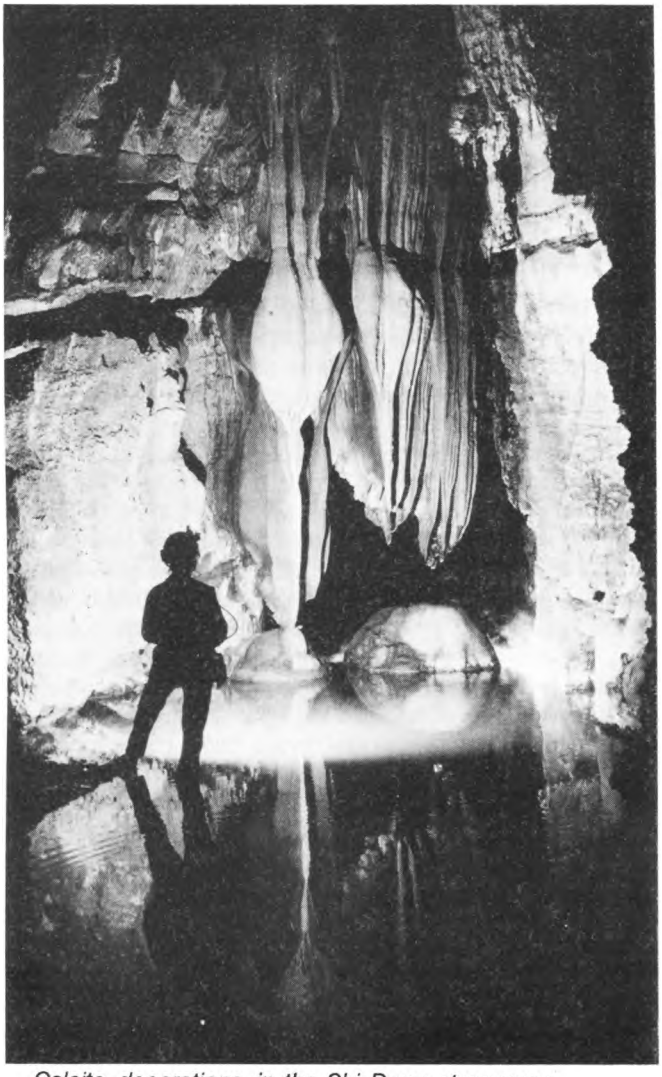


The single passage inside Da Ta Dong

Nan Dong, and the related show cave of Taoyuan Dong, were visited on several occasions and the survey covered 2500 m of passages. The main northward passage in Nan Dong was explored to a conclusion in a sump with zero visibility. Unfortunately, a full exploration of the main southeasterly passage was not possible due to problems of bad air. In Taoyuan Dong, a small mined passage of Ming vintage intercepts a stream which had also been breached further up the surface valley by civil engineering works. This upper site was dived in the hope that it would be possible to dive through upstream into the main river passage, but the force of water made this impossible. In the valley above, Da Ta Dong was surveyed to a conclusion in a tight muddy crawl below a surface shaft (later located from above). The cave hosts a substantial population of bats and was almost certainly the site in which one member of the team became seriously infected with histoplasmosis.

The main plateau sink of Shi Dong was explored through one sump into clean, spectacular passage with no evidence of previous visits. This was followed to a conclusion at a second sump which would merit further exploration by divers, given sufficient logistical support. The single splendid streamway was surveyed for 3330 m, to a depth of 173 m, but the sump is still 560 m above and 36 km from the resurgence.

Shafts were explored on the plateau west of Shi Dong. All were choked, though Zuomeidi Dong reached a depth of 208 m; if a shaft is open down to the cave river, it has not yet been found. South of Caoba, a reservoir overflow sinks beneath a concrete blockhouse below the old French style railway station at Bisezhai; the cave passage is choked with mud, but takes large flows of water in the wet season.



Calcite decorations in the Shi Dong streamway

Kath abseiling the spectacular Maoyin sinkhole

In the hills between the Caoba and Dazhuang basins, more shafts were descended, and again all are choked. The short resurgence cave of Pin Shi Ban Dong was also mapped, but the upstream sump was not passable; water from the cave feeds irrigation canals along the valley sides.

Over the watershed south of Mengzi, Chinese civil engineers are developing a major project to dam a valley for use as an intermediate reservoir in a scheme to lift water into the Mengzi basin complex. Unfortunately the valley has one limestone side and is drained by the cave of Wulicung. A massive programme of cement grouting is using boreholes drilled from adits into the hillside to seal the karstic limestone. A concrete plug is also intended to seal Wulicung Dong; it had been hoped that divers could map the inaccessible central section of the cave, but zero visibility in the constricted sump made this impossible.

In a brief visit to Luxi county, north of Mengzi, Alu Dong was visited; this system has been extensively developed as a tourist cave which includes a boat ride. Divers passed the first sump to a small, muddy chamber, where visibility was destroyed and the dive was abandoned. In a nearby valley, sinks and resurgences were examined without success; however they include Maoyin Dong with a torrent of water crashing down an 80 m deep shaft. Safe exploration of the wild river passage was not feasible, but the photo-opportunities were memorable.

EXPLORATION FEVER

FIRST DAY AT NAN TONG

Pam Fogg

Our Alexandra boiler suits were embarrassingly bright and too perfectly creased. Every inhabitant within a 20 kilometre radius had turned up to scrutinize us. Numerous photo calls and sound bite opportunities later, we were led to the cave perched in a hillside.

We were off. Roughy toughy speleos fearlessly heading into the unknown. By the time we had reached the bottom of the greasy entrance slope, I had fallen over twice. I glanced round to make sure no one could still see us. Hot on our heels was every inhabitant from a 20 km radius, the film team, the local TV crew, the local journalists, the Deputy Party Secretary, his lovely driver, and the Village Secretary (sporting a skilfully crafted beehive hairstyle complimented by immaculate silk blouse and pencil line skirt).

Like Pied Pipers we continued, up steep climbs, across streams, along a splendid river passage, until we reached the terminal sump. The hydrologist appeared at our side. She pointed enthusiastically at the water. A deathly silence, and then we had to explain that we were not cave divers. Not a good start; a distinct loss of face.

But then it was lunch time. "Wait here," they said. While we waited, we got into the entertainments. One beautiful village girl surprised us by singing Frere Jacques; Jon won a standing ovation for his music hall songs. Lunch finally arrived, led by the cook, resplendent in mini skirt, high heels and another magnificent bouffant. Behind her were sherpas bent double under two huge basins of hot baked potatoes, crates of mineral water and fizzy drinks, packing cases of apples, packets of pickles, sacks of bread, freshly roasted peanuts, meats, chop sticks, serviettes and of course steamed buns. It was a council jamboree gone wild.

Bloated, we waddled off to look at the other passages, if only to work off some calories. A climb and a squeeze and we were up into new stuff. We explored for a distance and then reported back. But they wanted to be there. The Deputy Secretary in his white shirt, shiny shoes and even shinier smile popped through the squeeze. A bit of hammering, and more surged up and on. They were only stopped at a flat-out constriction.

We emerged to darkness, some credibility restored; the cave was a kilometre longer than it had been that morning.

Dinner made lunch seem like a dieter's snack.

D B in Tiencuan

THE RIVER OF TIENCUAN

Dave Brook

Next morning we were back with a rope, our constant friends the Chinese video crew, and a show cave guide. A way between boulders spiralled down to a massive ledge about 15 metres square. The guide then announced that this was as far as anyone had ever been - they knew the river existed, but had never seen it.

From the healthy roar it couldn't be too far below, but we couldn't find a decent belay and cursed that we hadn't brought a bolt kit. Six metres back from the edge, a loop was thrown over a rounded buttress, and the rope promptly fell into a deep overhanging crack on the edge. Simon sat on the loop to stop it rolling off the buttress, and I put the rope sack in the crack and decided to worry about it on the way back up. The video crew solemnly filmed the whole madcap venture as I vanished into the abyss.

Twenty metres below was a landing and a further intimidating drop with the noise of the river now deafening. The rope was looped over a stalagmite, but there was only 13 metres of it left and the pitch was obviously far deeper.

The rope was now abandoned, but the search for the river had taken on a drive of its own, and a scramble up the floor of the rift opened into a steep slope with a fine display of formations - all untouched: the nitrate miners certainly hadn't been here. Across the foot of the slope ran the elusive river - a vision of roaring white water. An awkward climb was hardly noticed in the rush to reach it.

Downstream looked intimidating; but it was possible to stroll upstream for 300 metres, crossing and recrossing the fast flowing river on shingle bars. Leaving the passage wide open for another day with a survey team, I turned and headed for home.

LAST DAY IN ZHUCAOJING

Tim Fogg

I had been to the red crusted mud bank shores of the lake three times and each time retreated. The thought of lowering myself through the crispy skin into the acid water and swimming off towards the mud banks 20 metres away had been too much.

Now on the last day with Jon and Andy showing no apparent qualms, I had to do it. A pH of 2.9; how much would that hurt in cuts and piles, and would there be lasting damage down there? Doctor Buchan was half way across.

What was I worried about, no problem, an interesting experience! Now we were walking along wide, high, sandy floored passage, the Red Lake 500 metres behind us.

"We should have brought the camera. Look at these gypsum crystals." The floor, walls and roof were covered, one cluster 40 cm across like the wildest frizzy punk hair-do in white silver. Another single crystal half a metre long and as thick as a French loaf. Andy succumbed and set off back for the camera. Jon and I surveyed out from the final choke.

The photo session would only take the two of them, so I went to look at the two leads we'd passed. I was zooming along a young canyon, up a tight little climb, up one lead to a beautiful calcite chamber, down another to a muddy sump where I gasped in bad air. The climax of exploration fever.

In the twelve hour trip we had taken the photos, surveyed 1500 metres of new cave, and left two leads at a pitch and deep nasty pool. Twelve hours later we were well on the way to Hong Kong.

A quality last day.

摘要

中国洞穴计划

中国碳酸盐岩分布面积广泛，发育有数以万计的岩溶洞穴。许多人可通行的大型洞穴已被当地群众探测，而垂直陡深洞穴的探测目前则多由西方探洞者完成。中国洞穴计划就是一项通过中英双方的友谊与合作，把洞穴探险与科学研究集于一身的合作项目。英国洞穴探险队与地质矿产部桂林岩溶地质研究所在广西桂林、巴马、马山、都安、凤山等地，云南蒙自，四川兴文和西藏进行了六次卓有成效的合作，与贵州师范大学地理系在贵州安顺，水城进行了两次合作。

四川兴文

兴文岩溶发育在一向南缓倾的巨大灰岩陡崖上，其顶、底均为砂岩地层。绝大部分灰岩地层发育成峰丛地形，近顶部上覆砂岩的灰岩段发育为石林；这看来峰丛像是由石林发展而成。该区可见有大量的下层水洞和上层干洞；它们中的 30 公里长的通道被测绘。两个巨型漏斗是由古落水洞的边坡后退扩大而成并与其下的大型洞穴通道沟通。

朱糟井

这是一个重要的潜流型洞穴系统。其北部的大型通道因崩塌而成一系列的大厅；其南部的小型通道较为完整，三条幼年期的地下河由北向南流：一条源自和平洞；一条源自主洞口；而另外一条经过消水洞的泄洪道，尚未探测完毕。

天泉洞

旅游洞穴的主要通道是源自朱槽井的上层化石潜流洞穴，其下发育有往南去的支通道。崩塌大厅的底部有通道直达其下层水洞；水洞断面呈峡谷状，沿途多跌水，两端终止于没顶水塘。

落水洞与出水洞

顺河自下洞流入地下，形成一大型地下河通道。大、小燕子洞距先锋不远，均是沿倾向、层面发育而成；其通道早期相通，现被洞顶崩塌所堵塞。洞和洞为现代地下河出口，有上下两层通道，但上层化石通道已为地表漏斗所破坏。

地貌与水文

兴文为陡倾灰岩地区的洞穴发育提供了一个很好的实例。通道起始是沿层面形成，并在裂隙交会处溶蚀扩大较快。洞穴先是顺倾向往当时地下水位排水，然后转东、在季节变动带范围内沿地层走向发展。随着陡崖线和落水洞边坡因地表侵蚀而不断后退，新的通道系统往南发展。老的主通道是经朱槽井，小岩湾和天泉洞而补给一居于陡崖下的古地下河出口。新的排水系统有部分是在砂岩地层的覆盖之下。

硫磺厂

煤与黄铁矿的开采是在紧挨着石灰岩的上覆地层中进行的。大部分从事用焙烧黄铁矿来制作硫磺的厂家都是位于石灰岩地区。洞穴污染来自被污染的地表水，流入灰岩地下含水层后其 pH 值达 2.6，然后逐渐稀释。黄铁矿石与烧渣也被丢弃在洞穴中，其氧化过程能使深处未探测通道空气中的氧气减少。目前污染主要是来自硫磺厂，它们将废渣倾倒在伏流中。矿窑和兴晏硫磺厂本身只是小问题，而废渣堆放地的选址和控制其排放才是关键并能以极低的价格清除洞穴污染。

旅游事业

天泉洞已是一个大型游览洞穴。游人能漫步在筑好的小径上穿越岩溶区，欣赏美丽风景。子岩湾的景致很壮观，如有攀登者在其陡壁上攀岩将更受欢迎。农业耕作对西方观光客具有莫大的吸引力，而传统形式的兴晏硫磺厂也将成为一游览地点。旅游，农耕和硫磺工业应该相互连接在一块。

广西巴马

巴马的峰丛地形发育在三叠系石灰岩地区的背斜构造部位。盘阳河一百麽 水系集水面积广，百麽洞是其地下河出口。该区的洞穴测绘长度逾 50 公里；后洞，前洞和百麽洞实际上是一沿向斜轴部延伸的大型古洞穴系统的残余。

盘阳洞

干团洞是一早先就被中国人探测过的大型化石通道型洞穴；马王洞有长达 10 公里的大型廊道，一些精美的方解石沉积，和下层地下河通道。月里东南断层带上发育的洞穴群包括有大阳洞和消水洞的水洞，以及保屯洞的化石石笋洞。风洞进口为一陡深竖井，实际是一溢洪道。

西藏高原

西藏高原海拔超过 4500 米，属寒冷和半干旱气候，环境艰苦；是牦牛和牧牛人的世界。这是一片非常美丽的土地，动人的山峦前点缀着壮观的喇嘛寺庙。

石灰岩与岩溶

西藏中部的灰岩出露面积很小；喀斯特地形规模也很小，以小型溶痕为主。坚硬石灰岩的溶蚀受到了低降水量和低温的限制。这里没有证据显示古热带喀斯特的存在，而以冰缘地形占绝对优势。洞穴非常之少，主要由冰冻作用扩大而成；像近湖岸边的纳姆口洞；里龙的查贡契木洞（大洞）；和佩罗奇的小型裂隙洞等；所以它们都有较大的进口而无延伸通道。

云南蒙自

在蒙自县，岩溶峰丛高原由三叠系石灰岩构成，其水文系统自第三系沉积覆盖的盆地底部经过。石洞伏流洞穴和南洞地下河出口洞穴的通道总长达 6 公里。高原面上发育有许多竖井，其中左美底竖井深达 208 米，底部为沉积物所堵塞；没有办法下达现代地下河通道 — 有 35 公里长的地下河段无法追踪。

Young Zhang in Zhucaojing

THE TEAMS

China Caves Project:
The leaders: Andy Eavis and Zhu Xuewen.

Xingwen 1992:
Tony Baker, Mike Bertenshaw, Simon Bottrell, Dave Brook, Jon Buchan, Andy Eavis, Pam Fogg, Tim Fogg, Pete Francis, Kenny Taylor, Tony Waltham, Dick Willis; Fang Fengbao, Han Daoshan, Zhang Yuanhai, Zhang Ren, Zhu Xuewen; and the film crew, Gavin Crowther, Chris Goddard, Sid Perou, Graham Smith, Fiona Wailes Fairbairn.

Tibet 1992:
Pete Francis, Kenny Taylor, Tony Waltham, Dick Willis, Zhang Ren, Zhu Xuewen.

Yunnan 1991:
Steve Dickenson, Andy Eavis, Kath Force, Pete Francis, Dave Gill, Steve Jones, Gavin Newman, Paul Seddon, Kenny Taylor, Stu Whitney, Dick Willis; Fang Luzhou, Han Daoshan, Li Bin, Tan Pengjia, Wang Xunyi, Zhang Ren, Zhu Xuewen.

Bama 1989:
Dave Avescough, Dave Gill, Steve Jones, Ben Lyon, Gavin Newman, Steve Reay, Kev Senior, Kenny Taylor, Alan Thompson, Julian Walker; Chen Weihai, Han Daoshan, Hu Mengyu, Lian Yanqing, Tan Pengjia, Wang Xunyi, Zhang Ren, Zhu Xuewen.

CREDITS

All team members contributed to the exploration, documentation and surveying of the caves.

Text written by:
Dave Brook: 15, 17;
Andy Eavis: 4, 5;
Tim Fogg: 8, 14;
Kev Senior: 32, 34;
Tony Waltham: 6, 7, 20, 21, 26, 27, 28, 29, 38, 41, 42;
Dick Willis: 30, 39, 43, 45;
Zhang Ren: 47.

Maps drawn by:
Dave Brook: 19, 23l;
Tim Fogg: 10, 11;
Tony Waltham: 5, 22, 23r, 24, 25, 27, 29, 35, 42, 44.

Photographs by:
Tony Baker: 2b, 3, 8, 9b, 13, 14, 15r, 16, 17b, 18, 20, 21, 22, 31m, 31bl, 46, 47, 48t;
Mike Bertenshaw: Cover b;
Simon Bottrell: 2t;
Andy Eavis: Cover f, 9t, 26, 27, 34;
Pam Fogg: 4m;
Tim Fogg: 31tr, 31br;
Gavin Newman: 33b, 36, 43b, 45, 48b;
Kevin Senior: 4br, 32, 33t;
Tony Waltham: 4tr, 4l, 5, 6, 12, 15l, 17t, 28, 30, 31tl, 31tm, 37, 38, 39l, 39m, 40tl, 40b, 41, 42;
Dick Willis: 1, 7, 28tl, 39tr, 39br, 40tr, 43t, 44.

The Xingwen team

Standing: Mike, Graham, Pam, Tim, Sid, Kenny, Han, Fang, Tony B
Sitting: Jon, Pete, DB, Gavin, Andy, Dick, Simon, Zhang Y, Tony W, Fiona, Zhang R, Chris, Zhu

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This and the earlier publications may be obtained from:
BCRA Sales, 20 Woodland Avenue, Westonzoyland, Bridgwater TA7 0LG,
China Caves Project, Tidesreach, Redcliffe Road, Hessle HU13 0HA.