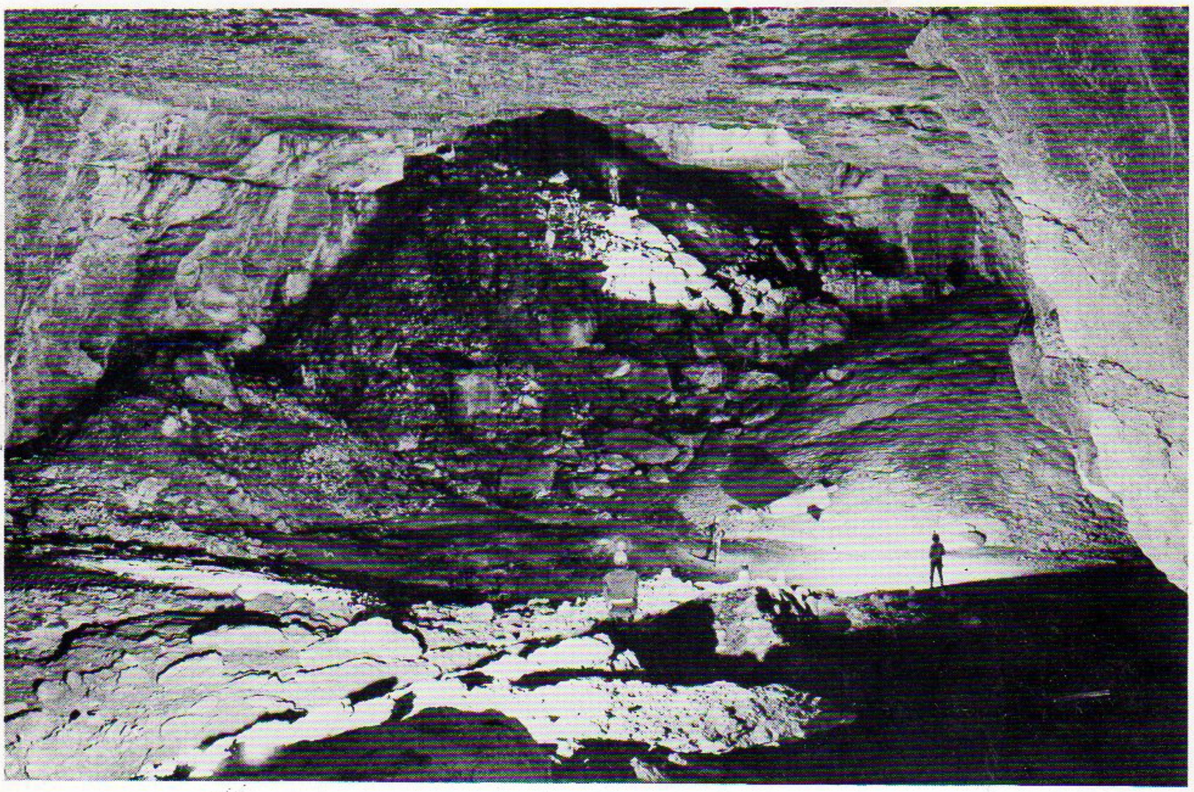
BCRA TRANSACTIONS

BRITISH CAVE RESEARCH ASSOCIATION

Volume 8 Number 2 June 1981



Cueva de Cellarón, Secadura

Matienzo

BRITISH CAVE RESEARCH ASSOCIATION

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TRANSACTIONS OF THE BRITISH CAVE RESEARCH ASSOCIATION

MATIENZO, SPAIN

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Cover picture: The massive high level segment of Cueva de Cellaron, Secadura : photo by J. Corrin

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GEOMORPHOLOGY OF THE MATIENZO CAVES

L. D. J. Mills and A. C. Waltham

ABSTRACT

The Cretaceous limestones of Matienzo include massive, Urgonian facies, and the whole sequence has been gently folded into an anticline and parallel syncline. Major features of cave geomorphology are described. Drainage paths of Matienzo's early development are not clear but the large volume of the modern closed depression infers a karstic history back at least as far as the early Pleistocene. Since then the Matienzo valley has drained underground and created a sequence of caves many of which are now fossil. Sandstones, marls and synclinal structures have influenced cave development, but the overall controls have been available resurgence levels in adjacent valleys.

Las calizas cretáceas de Matienzo comprenden enormes facies Urgoniana y toda la sucesión se ha plegado ligeramente en un anticlinal y sinclinal paralelos. Describimos las caracteristícas principales de la geomorfología de las cuevas. No se destacan los primeros cursos de drenaje de Matienzo pero el gran volumen de la depresión cerrada actual indica un pasado karstico que se remonte por lo menos hasta el principio de la epoca Pleistocene. Desde aquel entonces el valle de Matienzo se ha vaciado bajo tierra y ha creado una sucesión de cuevas entre las cuales muchas son fósiles. Piedras areniscas, margas y estructuras sinclinales, todas han inflenciado la evolución de las cuevas pero en realidad han sido los niveles de resugimiento disponibles de los valles contiguos los que han controlado todo.

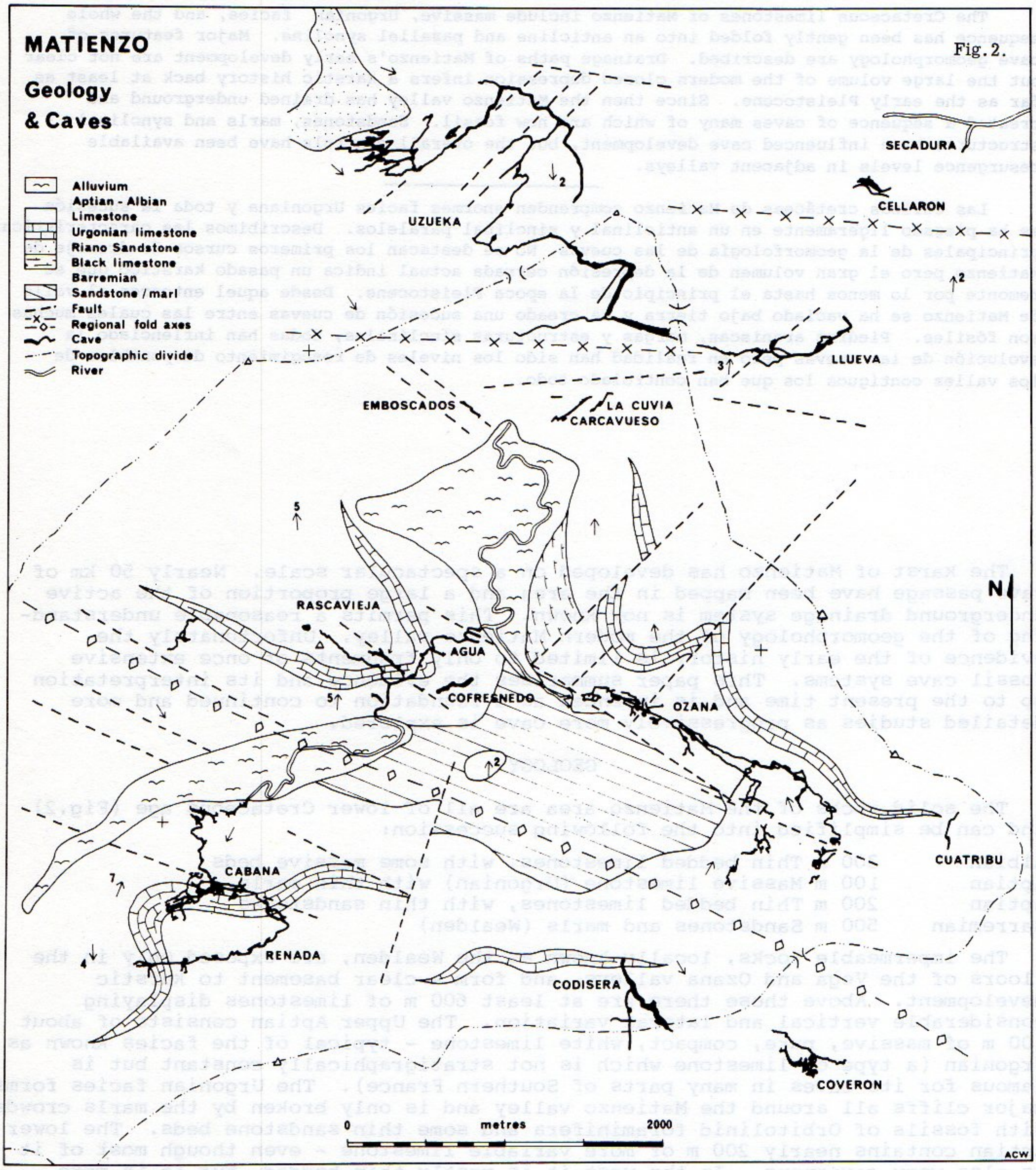
The karst of Matienzo has developed on a spectacular scale. Nearly 50 km of cave passage have been mapped in the area and a large proportion of the active underground drainage system is now known. This permits a reasonable understanding of the geomorphology of the modern Matienzo valley. Unfortunately the evidence of the early history is limited to only fragments of once extensive fossil cave systems. This paper summarises the evidence and its interpretation up to the present time and is intended as a foundation to continued and more detailed studies as progressively more cave is explored.

GEOLOGY

The solid rocks of the Matienzo area are all of lower Cretaceous age (Fig.2) and can be simplified into the following succession:

Albian	300 m	Thin bedded limestones, with some massive beds
Aptian	100 m	Massive limestone (Urgonian) with thin marls
Aptian	200 m	Thin bedded limestones, with thin sandstones
Barremian	500 m	Sandstones and marls (Wealden)

The impermeable rocks, locally known as the Wealden, are exposed only in the floors of the Vega and Ozana valleys, and form a clear basement to karstic development. Above these there are at least 600 m of limestones displaying considerable vertical and lateral variation. The Upper Aptian consists of about 100 m of massive, pure, compact, white limestone - typical of the facies known as Urgonian (a type of limestone which is not stratigraphically constant but is famous for its caves in many parts of Southern France). The Urgonian facies forms major cliffs all around the Matienzo valley and is only broken by the marls crowded with fossils of Orbitolinid foraminifera and some thin sandstone beds. The lower Aptian contains nearly 200 m of more variable limestone - even though most of it is also very cavernous. In the west it is mostly thin bedded, but it is more massive towards the east and could be described as Urgonian in the base of the hill of Muela. It contains many thin discontinuous sandstones which have had a major effect on cave development. Its base represents a marine transgression onto the Wealden, and as such may be highly irregular.



MATIENZO
Geology
& Caves
Fig. 2.
Alluvium
Aptian Albian
Limestone
Urgonian limestone
Riano Sandstone
Black limestone
Barremian
Sandstone / marl
Fault
Regional fold axes
Cave
Topographic divide
River
SECADURA
CELLARON
UZUEKA
LLUEVA
EMBOSCADOS
LA CUVIA
CARCAVUESO
RASCAVIEJA
AGUA
COFRESNEDO
OZANA
CUATRIBU
CABANA
RENADA
CODISERA
COVERON
N
0
metres
2000
ACW

The wedge of black limestones in the eastern wall of Secada appear to represent a trough of impure basal Aptian of no great lateral extent. The overlying Albian limestones are mostly thinner bedded than the Urgonian, and are broken by thin marls and sandstones.

The rocks of the Matienzo area were caught up in the edge of the Alpine fold belt along the Cantabrians. The limestones now occur in a series of gentle folds in which the dips are normally around 5^{o}, but the structure is complicated by large numbers of faults. The upper, southern, end of the valley is crossed by an anticline which brings the Wealden shales up to the floors of the Ozana and Vega branches. The beds do not arch smoothly over the fold, for much of the deformation is absorbed by the faults, many of which are rotational. Particularly at its western end the anticline is largely a rising series of tilted fault blocks. To the south a major syncline runs into the Ason valley. There is an additional structure indicated by the northerly dip of the beds in part of the Renada cave. This is not seen on the surface above; it is most probably a small rotated fault wedge, but it could be a feature of an initial dip in the limestones. Most of the Matienzo valley is cut in the northern limb of the anticline and a shallow syncline cuts across the northern tip of the valley. Its easterly continuation appears to be displaced northwards in an en echelon fashion.

Faults in the limestone are abundant, though most have small displacements - none have been recognised of more than 120 m. Many are inclined well away from the vertical, and rotational movement took place on many of them. The few exposed faults contain considerable breccia zones. They largely fall into two systems - approximately NE-SW and between W and NW, though the entrance series of Cueva Uzueka show how complicated the patterns may be in detail.

Excepting the widespread but thin veneer of red soils, the only superficial deposits in the valley are the alluvial floors of the Vega and Secada branches. This sediment forms two separated outcrops and in each case the thickness is unknown but is probably not many metres.

SURFACE KARST

The major karst landform of Matienzo is the valley itself, which is entirely closed and drained underground. This can only loosely be referred to as a polje because, although large enough and closed, it does not have the completely flat floor with the sharp transition into the slopes diagnostic of a true polje. Matienzo is therefore best described as a rather spectacular, closed valley (Plates 2 & 3). In the wide sense the Vega and Secada branches, separated by a low col just west of the village, could each be described as poljes. They do have flat alluviated floors, are fed and drained by cave rivers and Secada is prone to partial inundation, but their slope edges are not all as sharply defined as in the classical Yugoslavian poljes.

Karst drainage has influenced the nature of many of the other valleys. The Ozana branch valley is largely dry due to its underlying cave system, and the Cubija valley is closed by a low col before it joins the Vega branch. The Llueva valley, an easterly outlet to the Matienzo area, contains an underfit stream, probably due to karstic capture. There are many other much smaller valleys and gullies on the slopes into the Matienzo depression; few are sharply defined and nearly all are dry for most of the time as underground drainage can cope with all but the wettest weather. Doline karst is not extensive in the Matienzo valley. There are fields of depressions on the northern shoulder of Enaso hill, and on the Muela ridge, and within the latter there is one massive doline 500 m across and 100 m deep. Over most of the area, slopes are too steep for ready development of large dolines. However, many of the cave entrances in the Ozana valley are at the foot of sizeable dolines or blind valleys. Lapiaz is restricted to the more gently sloping non-alluviated areas, which essentially means the crests of the ridges. Even then it is only extensive on the southern ridges, along Trillos, Piluca and Muela. Limestone pavements do not occur, as there has been no glaciation. Instead the surfaces are extremely inhospitable, deeply dissected, very sharp lapiaz perhaps best described as a mixture of spitz-karren and kluftkarren. Relief within the lapiaz is commonly 5 m and there is little vegetation cover on the main fields. It is fortunate for ease of access that most of the slopes are partially covered in limestone rubble, though steeply inclined slabs scored by smaller solution grooves do occur on the more massive limestone beds.

HYDROLOGY

The great majority of the rainfall landing in the Matienzo valley sinks straight underground, the major exceptions being that falling on the impermeable valley floors and that in wet weather which temporarily occupies steep gullies in some limestone slopes. Once underground most of the drainage is in discrete systems separated by surface courses across the main valley floors. The main headwaters are in the Renada cave system, from which they resurge to flow across the floor of the Vega valley and disappear into the open entrance of the Agua cave cutting through the corner of Enaso hill. They then resurge to form the Matienzo river flowing across the floor of the Secada valley. This surface section is joined by the drainage from the Ozana valley most of which is underground all the way down the valley to the springs near the Tiva cave. Unlike the Agua outlet for the Vega depression, the exit from Secada is through a boulder pile which at high stage results in ponding and flooding at the lower end of Secada - in the worst recent case deep enough to reach head height in a number of houses.

The northern end of the Matienzo valley is a classic example of karst drainage having a complete disregard for surface topography. Underground the water from Secada joins the drainage from the southern portion of the Riano valley, flows under the head of the Llueva valley without emerging on the surface and finally resurges at the Secadura rising as one of the headwaters of the Claron river in the Secadura valley. The existence of this 'Four Valley System' has been proved by dye-testing, but so far the 17 km of cave explored within it have not yet been connected into a single entity. The Secadura rising yields a mean flow of around 0.5 cumecs and is the final outlet for the Matienzo drainage.

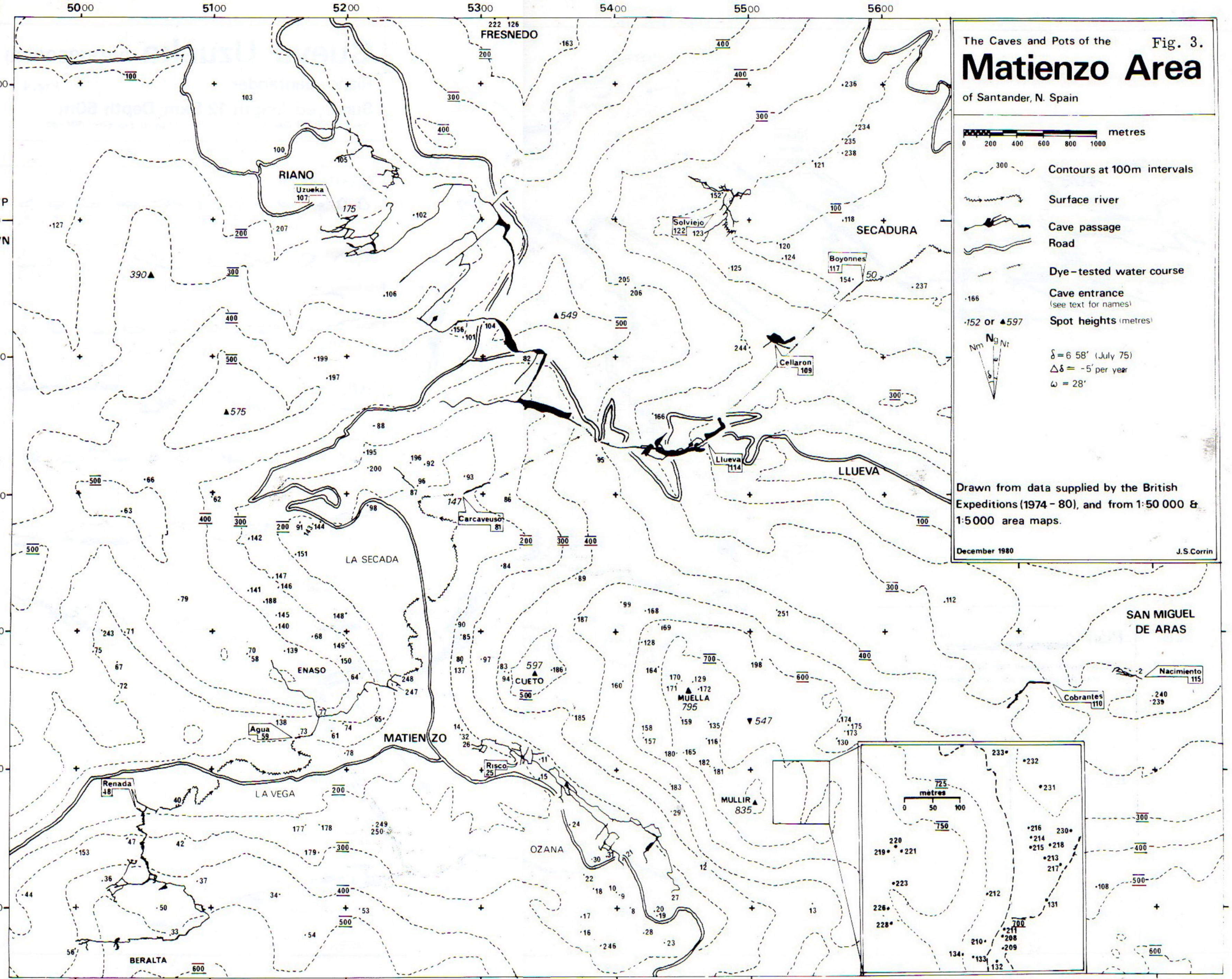
CAVES

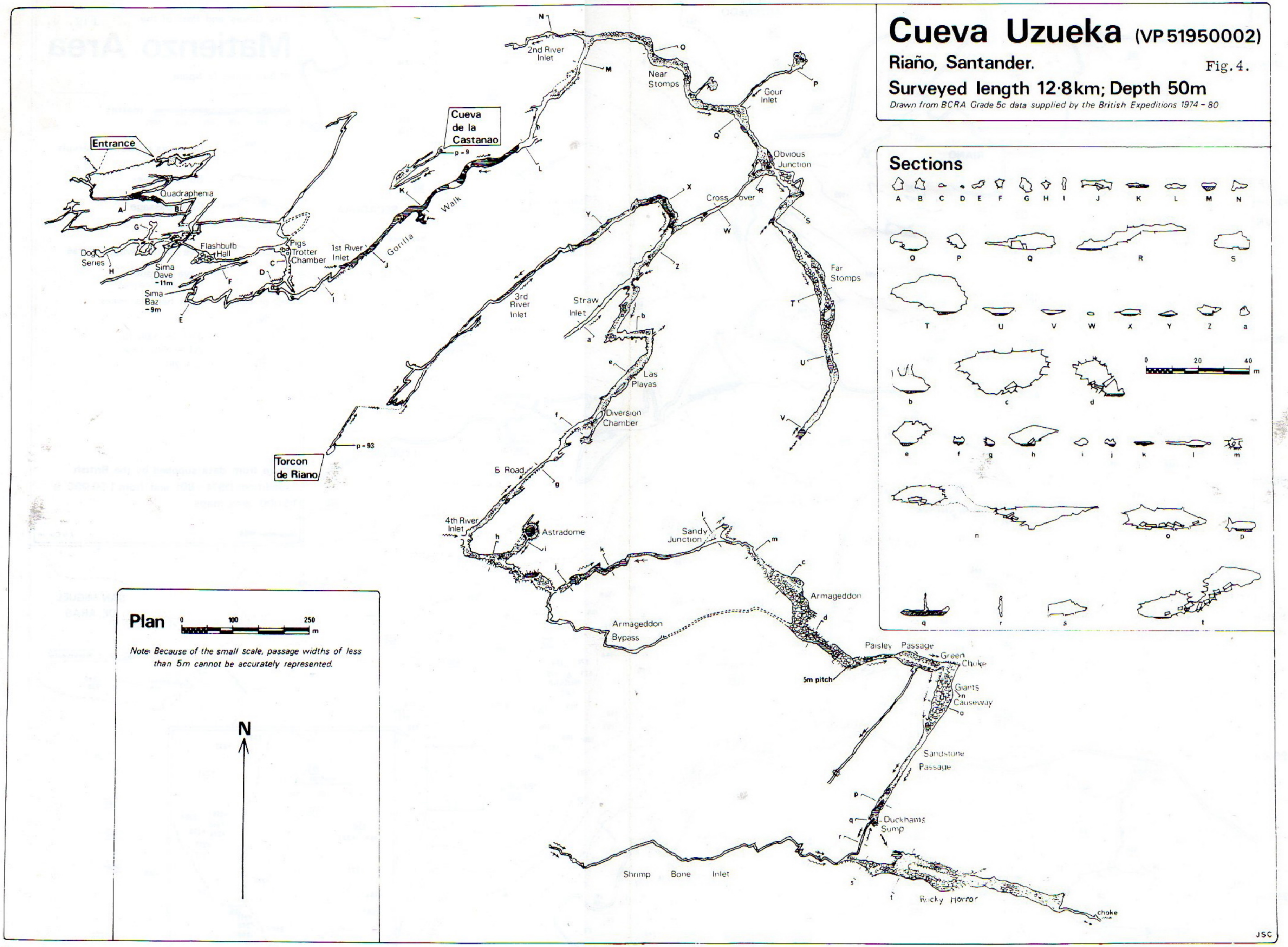
There are now over 45 km of explored cave passage at Matienzo (including the whole Four Valley System but excluding caves which drain away from Secadura (Fig.3). Many of the large old dry caves have been known from time immemorial, but all the major exploration of the wetter caves is quite recent. The Ozana caves have been explored practically from sink to resurgence, and the major parts of the principal active caves through the valley are also explored. The main gaps in present knowledge are the upstream end beyond the Renada cave, and the segment of the Four Valley System between Llueva and Secadura. Obviously the fossil cave systems are not as completely known; nearly all the major passages end in great stalagmite, sediment or breakdown chokes, and their continuations remain untrodden. In addition there must be segments of old abandoned cave of which no hint has yet been found, and the unexplored inlets in Cueva Uzueka give an indication of what young immature streamways must penetrate the hills as tributaries to the main cave drains.

The following descriptions of the caves are only intended to outline their main geomorphological features. Full descriptions of all the caves, and of many smaller discoveries, may be found in the expedition reports and publications of M.U.S.S., and brief descriptions form 'Matienzo Underground' by J. S. Corrin and P. Smith in the same volume as this paper.

Active caves of La Vega

Although it provides the main headwaters of the Vega valley the Cubio de la Reñada (Fig.5) is not an essentially active cave. Most of its 6.1 km of passage are abandoned phreatic caves which happen to have been intersected in a few places by the modern stream now mostly at a lower level. The main water emerges from a sump in Reñada 2, occupies half a kilometre of gallery downstream and then disappears in a choke. After passing through an aquatic series in the middle of the cave the watercourse is next known in the short resurgence cave of Comediante, separated from Reñada by a stalagmite choke. The rest of the Reñada cave is a phreatic complex ranging in altitude from 170 m at the rising to around 240 m excluding various vadose shafts breaking the roof. Spectacular joint and fault control is conspicuous in the entrance series, whilemost of the development in the central area (around Blood Alley) was enlarging on bedding planes which contain some magnificent anastomoses. Collapse is considerable in the larger passages, though there are also extensive sand deposits and some fine calcite formations, notably the red crystal pools which adorn Blood Alley. Much of the Stuffed Monk Gallery has a phreatic cross section in excess of 20 m^2, but flow directions are unclear and the patterns of phreatic movement are open to interpretation.


The Caves and Pots of the
Fig. 3.
Matienzo Area
of Santander, N. Spain
metres
0 200 400 600 800 1000
Contours at 100m intervals
Surface river
Cave passage
Road
Dye-tested water course
Cave entrance (see text for names)
Spot heights (metres)
δ = 6 58' (July 75)
Δδ = -5' per year
ω = 28'
Drawn from data supplied by the British Expeditions (1974 - 80), and from 1:50 000 & 1:5000 area maps.
December 1980
J.S.Corrin
FRESNEDO
RIANO
Uzueka 107
SECADURA
Solviejo 122
Boyonnes 117
Cellaron 109
Llueva 114
LLUEVA
Carcaveuso 81
LA SECADA
SAN MIGUEL DE ARAS
Nacimiento 115
Cobrantes 110
ENASO
CUETO
MUELLA
Agua 59
MATIENZO
Risco 25
Renada 48
LA VEGA
MULLIR
OZANA
BERALTA



Cueva Uzueka (VP 51950002)
Riaño, Santander.
Fig. 4.
Surveyed length 12·8km; Depth 50m
Drawn from BCRA Grade 5c data supplied by the British Expeditions 1974 – 80
Sections
Plan
Note: Because of the small scale, passage widths of less than 5m cannot be accurately represented.
N
Entrance
Quadraphenia
Dog Series
Flashbulb Hall
Sima Dave -11m
Sima Baz -9m
Pigs Trotter Chamber
1st River Inlet
Gorilla Walk
Cueva de la Castanao
p - 9
2nd River Inlet
Near Stomps
Gour Inlet
Obvious Junction
Cross over
Far Stomps
3rd River Inlet
Straw Inlet
Las Playas
Diversion Chamber
Torcon de Riano
p - 93
Б Road
4th River Inlet
Astradome
Sandy Junction
Armageddon
Armageddon Bypass
5m pitch
Paisley Passage
Green Choke
Giants Causeway
Sandstone Passage
Duckhams Sump
Shrimp Bone Inlet
Rocky Horror
choke
JSC

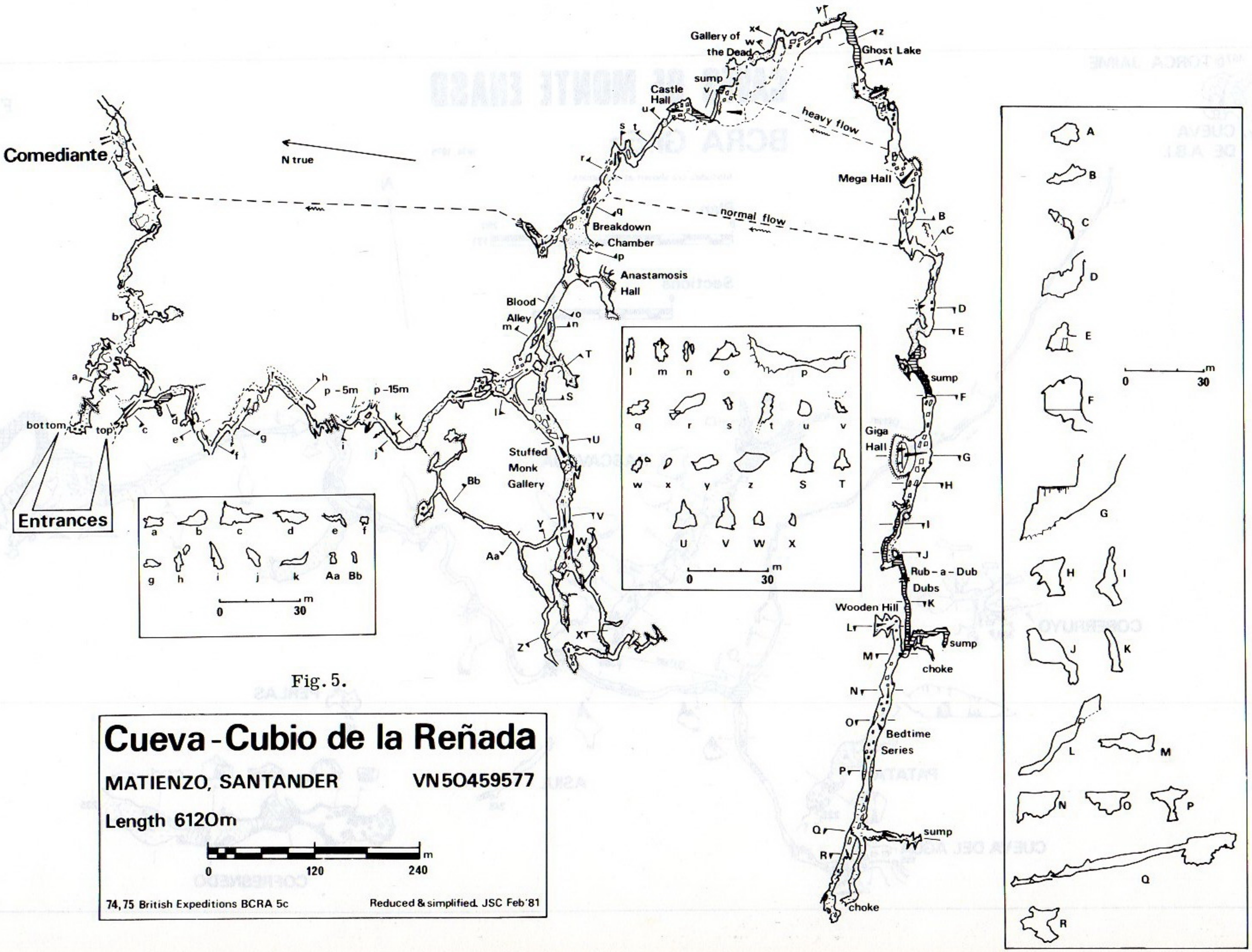

Comediante
N true
Gallery of the Dead
Ghost Lake
sump
Castle Hall
heavy flow
Mega Hall
normal flow
Breakdown Chamber
Anastamosis Hall
Blood Alley
Stuffed Monk Gallery
sump
Giga Hall
Rub-a-Dub Dubs
Wooden Hill
sump
choke
Bedtime Series
sump
choke
bottom
top
Entrances
p -5m
p -15m
Cueva-Cubio de la Reñada
MATIENZO, SANTANDER
VN50459577
Length 6120m
0 120 240 m
74, 75 British Expeditions BCRA 5c
Reduced & simplified. JSC Feb'81

Fig. 5.

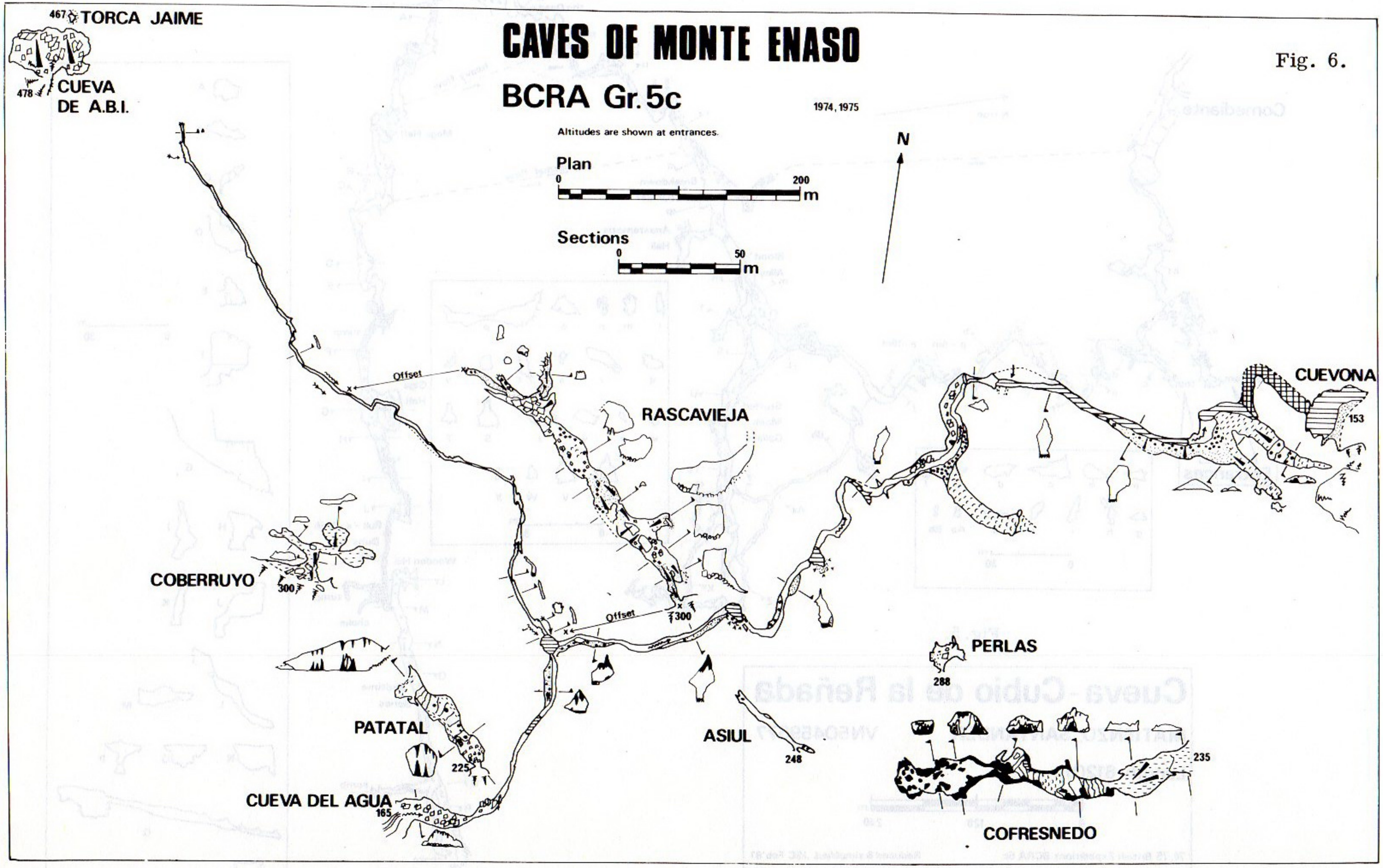

467 TORCA JAIME
478 CUEVA DE A.B.I.
CAVES OF MONTE ENASO
BCRA Gr.5c
1974, 1975
Altitudes are shown at entrances.
Plan
0
200
m
Sections
0
50
m
N
Offset
RASCAVIEJA
CUEVONA
153
COBERRUYO
300
Offset
300
PERLAS
288
PATATAL
225
ASIUL
248
CUEVA DEL AGUA
165
235
COFRESNEDO

Fig. 6.

Cueva del Agua (Fig.6) is a complete contrast as nearly all of its 1900 m are active. The main river gallery, 1300 m long from the wide sink entrance is clearly of phreatic origin. It is nearly all five metres or more wide and twice as high, with the river partly dammed by breakdown and in places entrenched in the floor (it is a very sporting, wet cave). Downstream the water passes through an 87 m sump to the impressive resurgence pool of Cuevona at an altitude of 153 m, 12 metres below the sink. Three inclined phreatic tubes leave the right bank of the river cave, one ending in a choke which extends to the surface, and the only other branch is the constricted vadose slot of the Rio Tuerto Inlet.

The Ozana Cave System

The active cave system draining beneath the Ozana valley has been almost completely explored from a number of sinks to the one resurgence (Fig.7). Some 11.1 km of cave are known over a vertical range of 80 m, in addition to some shorter isolated caves around the sinks. The main stream cave collects all its inlets from the left bank, or south side. From the Onite sink the essentially vadose canyon is gently graded except for an 18 m pitch where is crosses a fault. The Pinto and Tonto inlets cannot be followed to the surface but the Torca del Sedo is an open shaft, and the water is lost into a choke 200 m short of the resurgence. Old high level galleries are traceable for practically the whole length of the cave, and in the upstream minor caves, at levels between 10 and 30 m above the present streamways. Much of the fossil galleries in the upper part of the system are abandoned vadose canyon which fed down into a more complex phreatic zone which now form the roof passages at the lower end of the cave.

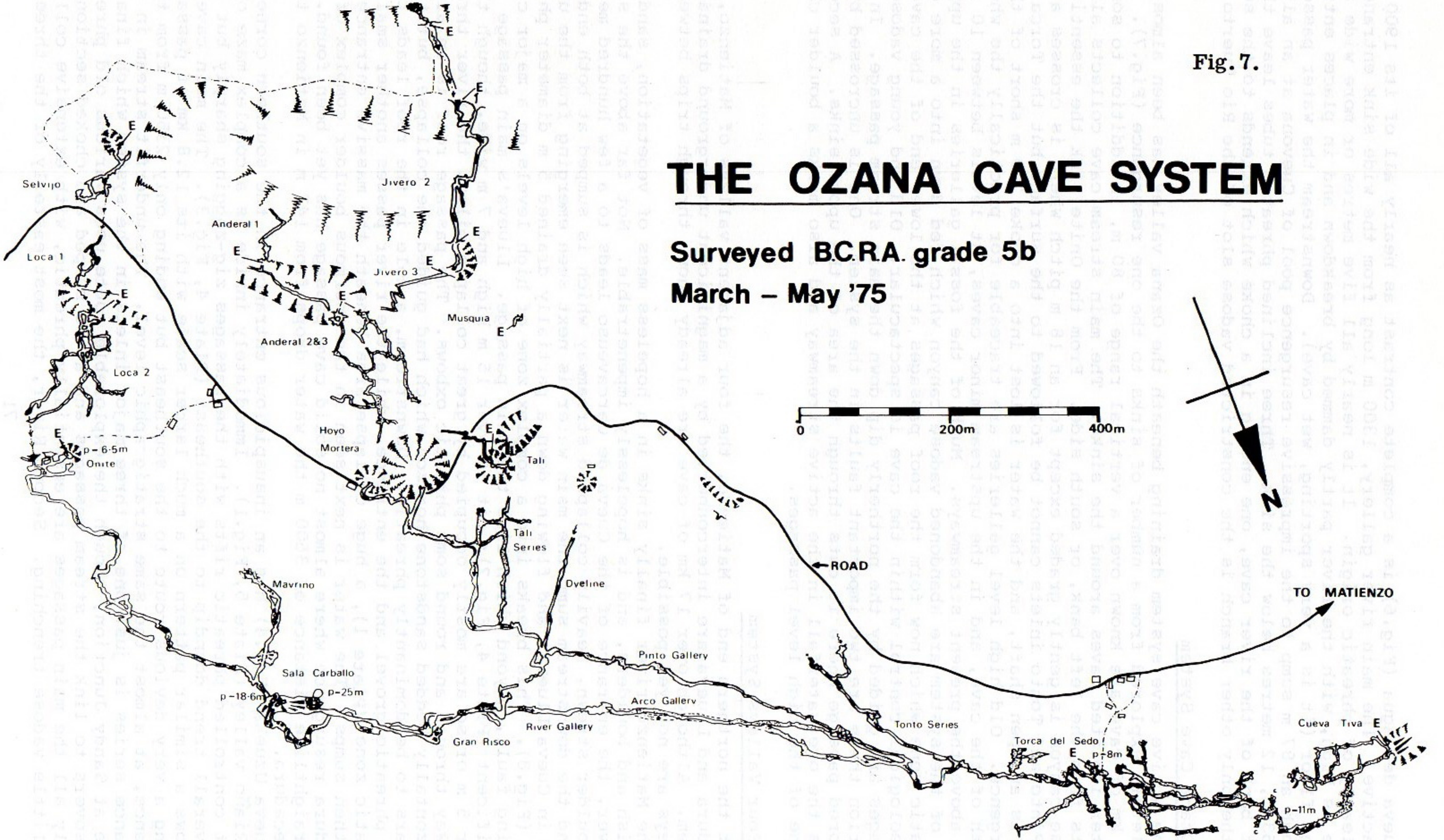
Geological control within the cave is spectacular. Old and young vadose passages are guided by the northerly dip down the main stream passage. In addition there are two important faults in the system. One is uncrossed by any explored passage where it cuts through the area of the upper sinks. A second marks the one waterfall in the active streamway and also marks a boulder choke in one of the high level passages.

The Four Valleys System

At the northern end of Matienzo, the four adjacent valleys of Matienzo, Riaño, Secadura and Llueva are interconnected by a magnificent underground drainage system. Although over 17 km of cave are already known through trips between the valleys are not yet possible.

The Matienzo river finally sinks in a hopeless mass of vegetation, sand, mud, rubbish and boulders, and is hopelessly impenetrable. Not far above the sink however, the entrance of the Cueva de Carcaveuso leads to a few hundred metres of boulder strewn, heavily collapsed streamway which is sumped at both ends. Beyond the downstream sump the main water is next seen emerging from the upstream sump in Cueva Llueva, and flowing down a partially drained 5 m diameter phreatic tube (Fig.8). This breaks into a complex zone of high levels on a major cross cutting fault, beyond which lies the main passage. Llueva's main passage is magnificent (Plate 4, Fig.2); it is over 15 m high and 7 m wide, though the lower 5 m or so are mostly occupied by great collapse piles, the river threading its way through and round some phreatic oxbows. The passage roof is an almost horizontally bedded sandstone horizon which had guided the collapse, but the cave appears to be dominantly phreatic. Downstream, a hole in the roof leads to a tiny phreatic grovel and the entrance, while the river passes another smaller phreatic zone (Plate 1), a huge collapse area beneath the massive entrance doline and then sumps. The water is next seen in the enormous boulder complex of the Secadura resurgence where almost no solid cave passage has yet been found. Over a straightline distance of 3600 m the water drops from 147 m in Matienzo to 50 m in Secadura.

Cueva Uzueka (Fig.4) has an inauspicious entrance in the southern corner of the Riaño valley (Plate 5, Fig.1). Immediately inside is a complex maze of joint controlled phreatic rifts with the passages zig-zagging sharply but keeping an overall trend downdip to the southeast (Plate 4, Fig.3). The main cave follows a similar pattern on a much larger scale with its 12.8 km of passage taking a very devious route to the southeast but ending only 2350 m from the entrance, at almost the same stratigraphic level. The underfit stream in the entrance series is just one of three major inlets in the system which finally unite at Sandy Junction, though the explorable route uses various old phreatic crossovers to link the stream passages and avoid sumped and choked sections. Nearly all the main passages are essentially phreatic, with extensive collapse and little vadose trenching. Second River, the most easterly of the three,



THE OZANA CAVE SYSTEM
Surveyed B.C.R.A. grade 5b
March – May '75
N
0
200m
400m
TO MATIENZO
ROAD
Selvijo
Loca 1
Loca 2
Anderal 1
Anderal 2&3
Jivero 2
Jivero 3
Musquia
Hoyo Mortera
Onite
p–6·5m
Tali
Tali Series
Dveline
Mavrino
Sala Carballo
p–18·6m
p–25m
Gran Risco
River Gallery
Arco Gallery
Pinto Gallery
Tonto Series
Torca del Sedo
p–8m
Cueva Tiva
p–11m
E

Fig. 7.

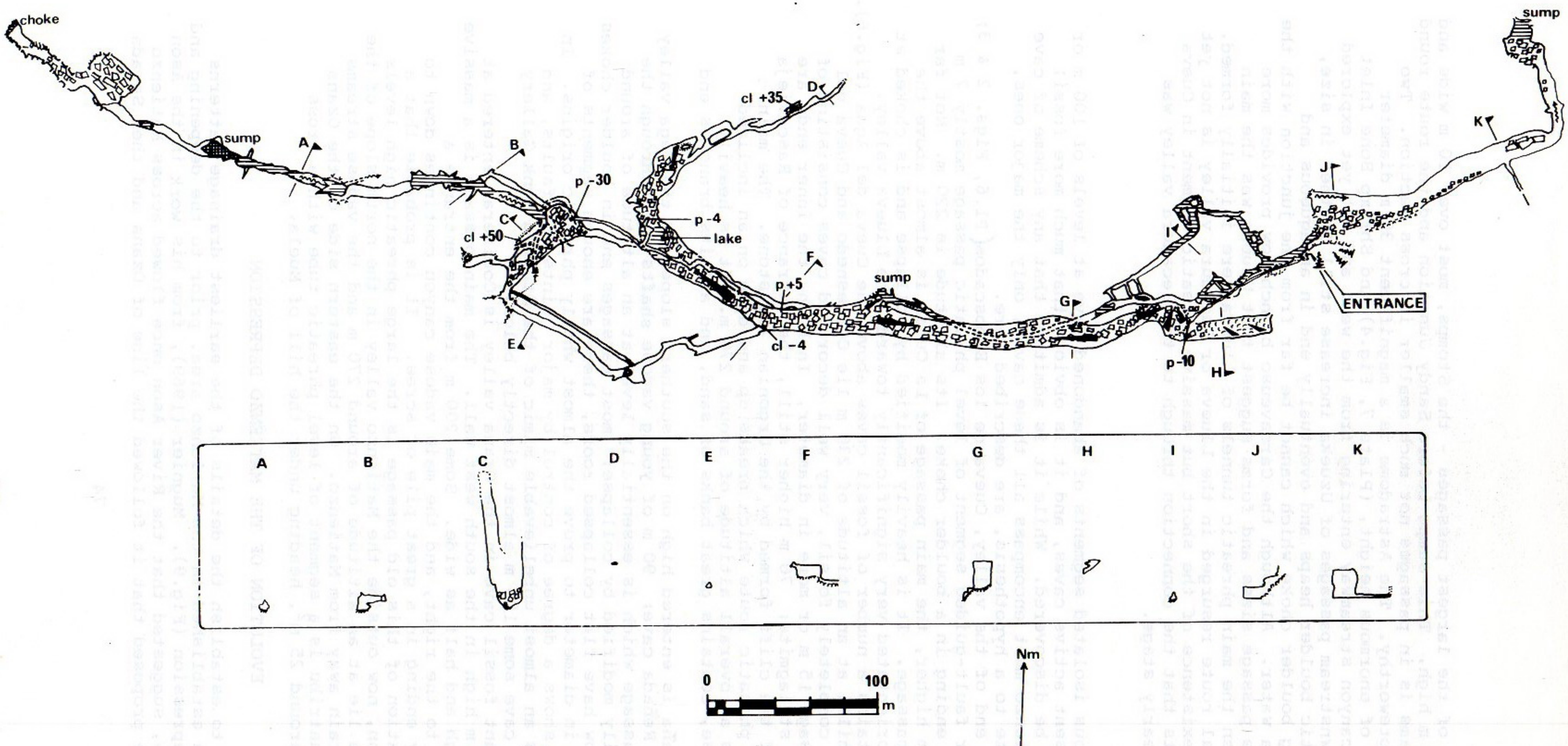


Fig. 8.

CUEVA LLUEVA

Llueva, Santander

(VN 54689839)

Length 2·8km **Depth 44m**

Simplifed survey. Drawn from BCRA Gr.5b data. 1976 & 1980

JSC

flows through some of the largest passages - the Stomps, most over 10 m wide and rarely less than 5 m high. This sumps before Sandy Junction and the route round via the other streams is in passages not much smaller in cross section. Two other inlets are noteworthy. The Astradome is a magnificent 30 m diameter smooth-walled aven of enormous height, (Plate 7, Fig.4) and Shrimp Bone Inlet is a young vadose canyon streamway entering from the west and not yet explored to an end. The downstream passages of Uzueka increase still further in size, contain some gigantic boulder heaps and eventually end in an aqueous and strongly draughting boulder choke which cannot be far from the junction with the Carcaveuso - Llueva water. Although the Carcaveuso branch now provides more water, the relative passage sizes and forms suggest that Uzueka was the main upstream feeder when the main phreatic tunnels of Llueva were initially formed. Whether this initial route resurged in the Llueva or Secadura valley is not yet known, though the existence of the short but massive phreatic segment in Cueva de Cellarón suggests that the connection through to the Secadura valley was established at an early stage.

Fossil Caves

There are numerous isolated segments of abandoned cave at levels of 100 m or more above the present active caves, and it is obvious that much more fossil passage remains to be discovered. While it is admitted that any scheme of cave development in Matienzo must encompass all these caves, only the major ones, which can contribute to a hypothesis, are described here.

At the northern end of the valley, Cueva de los Emboscados (Pl.6, Figs. 2 & 3; Pl.7) is a joint- or fault-guided segment of level phreatic passage mostly 7 m or so in diameter, ending in a boulder choke. Its altitude is 220 m. Not far away and about 20 m higher, the main passage of La Cuvia is almost above the Carcaveuso stream passage. It is heavily modified by collapse and is choked at both ends, but is orientated very significantly towards the Llueva valley.

Monte Enaso contains a number of fossil caves above the Cueva del Agua (Fig.6). About 65 m up the hill, at an altitude of 230 m lie Cofresnedo and Cueva del Patatal. Both are completely fossil, very well decorated caves consisting of phreatic trunk passage 15 m or more in diameter. In both, the inner ends are blocked by massive stalagmite: 70 m higher still, the entrance of Rascavieja lies at the foot of the cliff formed by the Urgonian limestone. The main passage is a large phreatic route which breaks up and down on an inclined fault but maintains an overall altitude of around 270 m. It is heavily modified by collapse, contains great banks of sand, and all its branches end in major chokes.

Torca de la Cabaña is entered high on the southern slopes of the Vega valley directly above the Reñada cave: 90 m of young vadose shafts drop through the roof of the main passage which is essentially level at an altitude of around 360 m. It is heavily modified by collapse; most passages end in boulder chokes and, though many now have flat collapsed roofs, there are enough segments of tube, some 3 - 5 m in diameter to prove the almost wholly phreatic origins. In plan form the cave shows a degree of control by major joints and faults, and overall constitutes an almost unbelievable mimic of the Stuffed Monk Gallery area of the Reñada cave some 100 m almost directly below.

The most important fossil cave in the Ozana valley is Codisera, entered at an altitude of 420 m high in the south west wall. The main passage is a massive dry canyon 20 m high and half as wide. Some 200 m from the entrance a distributary rises to the right, and the main vadose canyon continues down to the left eventually ending in a great pile of scree. It is probable that a downstream continuation of this old passage is the large phreatic high levels in Cueva del Coveron, now outside the Matienzo valley in the north slope of the Ason valley. These lie at an altitude of around 270 m and the vadose streams beneath them now drain away from Matienzo. On the eastern side of the Ozana valley, Cueva de Cuatribu is a segment of level phreatic tube with a cross sectional area of around 25 m^2, heading under the hill of Muela.

EVOLUTION OF THE MATIENZO DEPRESSION

It is difficult to establish the details of the earliest drainage patterns that must have been established in the Matienzo area, prior to the deepening and isolation of the depression (Fig.9). Mugnier (1969), from his work in the Ason region to the south, suggested that the River Ason once flowed across Matienzo from Arredondo; he proposed that it followed the line of Ozana and then Secada and continued northwards to the coast via the Solorzano valley. This route would then have been abandoned with river capture and the diversion of the Ason into its present course down to Ramales. Evidence for this is a little tenuous - in graded profiles constructed from remnant segments and some terrace sediments apparently lacking imbrication. Furthermore it would seem more reasonable for the early drainage to have been based on a consequent river on the Gandara - Lower Ason line through Ramales, with a major subsequent river synclinally located flowing eastwards from above Arredondo to Ramales. This would then have had two secondary consequent tributaries - the Upper Ason off the San Roque - Ramales anticline and a southbound stream off the Matienzo anticline. Which of these two patterns dominated (for they could both have occurred in sequence) is open to speculation, but the end result was exposure of the massive limestone in the core of the Matienzo anticline.

An early consequence of the exposure of the limestone was the diversion of the drainage underground. This karstic river capture can only have developed when adjacent valleys had cut deep enough to expose the limestone away from the anticline axis; this would at the same time have given favourable underground hydraulic gradients. Being closer to the anticline, the Ason valley would have had a structural advantage in the process, encouraging early development of southward draining cave systems. Some time later it would have been followed by northward capture into either the Riaño, Llueva or Secadura valleys. The subsequent development of the different systems of caves is considered further below, but at this stage it is useful to attempt an understanding of the chronology of the early events.

The high cols and clearly defined limits to the Matienzo depression, combined with the lack of Pleistocene glaciation, make it possible to assess the age of its development by means of extrapolating erosion rates. The lowest col out of the Matienzo valley is the one to the south at an altitude of 347 m, so at a very minimum the depression below this level must have been excavated and then transported away by the underground drainage. The volume of the valley below the 347 m level is around 1200 million m^3. Present erosion is dependant on an annual rainfall of 120 cm, of which about 50% is lost by evapotranspiration, over the basin area of 26.3 km^2. This gives an annual outflow of 15.6 million m^3 or 0.5 cumecs, which is a roughly estimated annual mean flow through Cueva Llueva - now the sole outlet of the valley. The water in Llueva and at Secadura has not been analysed but figures from resurgences in adjacent areas suggest an average calcium carbonate pick-up of 130 ppm. This would give an annual solute transport out of Matienzo, through Llueva, of 2000 tonnes. And taking the density of the limestone as 2.7, this means that present erosion rates would have taken 1.6 million years to excavate the closed portion of the Matienzo valley.

This calculation makes a number of assumptions: that the volume of the caves is ignored, as they are trivial in comparison; that the climate remained constant, whereas during the Devensian and other cold stages of the Pleistocene the area was one of tundra with expectedly much lower solution rates, which would more than compensate for any wetter or warmer phases than the present; that there has been no mechanical removal of the limestone, which seems reasonable as there is no sign of there ever having been totally vadose drainage of the valley devoid of major phreatic loops which would act as sediment traps; that the valley floor was level at the present 347 m altitude at the time of karstic capture, which is most unlikely and the volume of rock removed from above this level must considerably lengthen the calculated time given the same erosion rate.

A minimum age of 1.6 million years, around the beginning of the Pleistocene, therefore seems very reasonable for the onset of karstic drainage in Matienzo. Bearing in mind the last of the above assumptions, the depression can reasonably be dated back between 2 and 3 million years. Even older must be the phreatic caves at altitudes greater than 347 m and, preceeding even these, the establishment of the Ason valley in its present course must have been even further back in the Pliocene. It is this long period of karstic development, uninterrupted by glaciations, which has allowed the Matienzo valley to develop on such a spectacular scale unmatched in the glaciokarst regions further north in Europe.

A minor feature in the development of the Matienzo depression has been its division into the three sub-basins which now exist. This was probably fairly recent, even though other different patterns of surface watersheds may have existed at times well into the past. The present geography is merely a result of reduced surface lowering, and hence the development of cols, in the valley floor sections where the main drainage has been diverted underground into the Agua and Ozana caves.

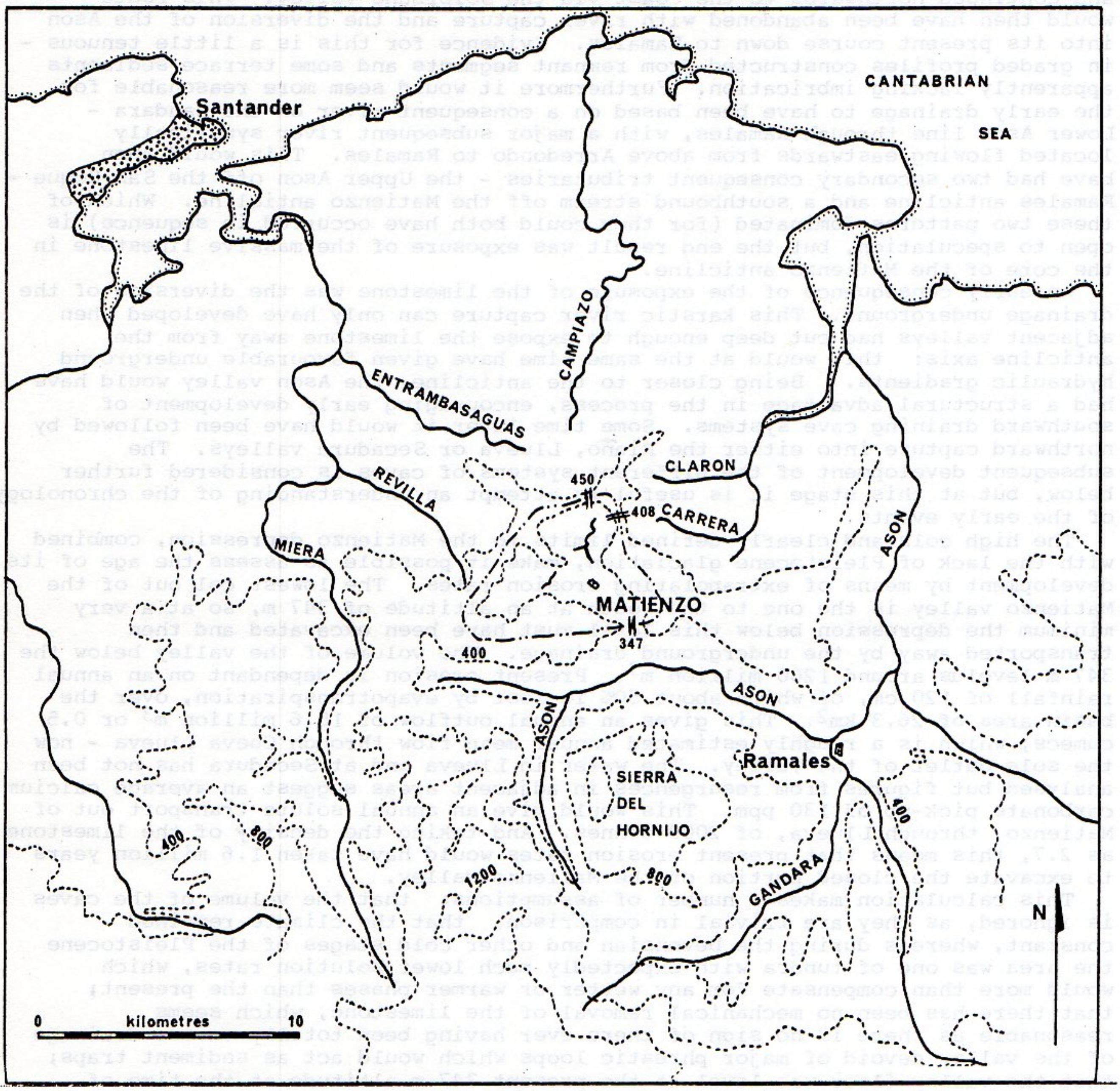


Fig. 9. Drainage Patterns around Matienzo.

SEQUENCE OF CAVE DEVELOPMENT

With its great, high altitude, vadose canyon, Codisera must be one of the oldest caves in the valley, dating back to the early stages of southerly drainage in the newly exposed Matienzo anticline. The subsequent development of phreatic caves in the southern end of the valley are not easily placed in a chronological sequence unless one subscribes to the theory that they were all developed as shallow phreatic routes - and there is little positive evidence for this. It is, however, reasonable to suggest that Rascavieja, the Cabaña and Reñada caves (whether separately or as one integral system) and then Cofresnedo, belonged to the earlier phases of development and were followed by development of the Agua cave and the high levels of the Ozana system. By no later than this stage the main karstic drainage of the anticline must have changed from southwards to northwards, and then later modifications included the vadose entrenchment in Ozana, Agua and Reñada. Superimposed on this outline sequence were many minor changes; the scale of these is only hinted at by the great number of false floors in all the caves which must correlate with differing rates of stalagmite deposition through the climatic fluctuations of the Pleistocene.

At the northern end of the valley, development appears to have started rather later. There are no high level caves, but the phreatic remnants of Los Emboscados and La Cuvia almost certainly pre-date the formation of both the Agua and Ozana routes. Where this early drainage from the north end of Matienzo was headed for, is difficult to assess, but a major early development in the area was the Uzueka cave. It would appear that the initial cave was an entirely phreatic system incorporating Uzueka and Llueva and so draining the Riaño valley to a vauclusian rising in the Llueva valley. How and where the Matienzo water joined this cave in its early stages is uncertain, but eventually the present route in from Carcaveuso was established. Another feature at this stage was the loss of much of the Uzueka catchment. Incision of the Riaño valley took more water away to the west and even captured and reversed the drainage of Cueva de Riaño which was possibly once a tributary to Uzueka; the result of all this is the modern underfit stream in Uzueka. The present drainage now avoids the Llueva valley and emerges at the Secadura rising. This third sub-ridge connection is relatively unknown; the modern drainage is only known from the dye-trace and the Cellarón cave (cover ph) contains only a massive chamber which may represent part of the high level fossil route downstream of Llueva. The Cellaron chamber does not preclude the possibility of an ancient resurgence in the Llueva valley before diversion to Secadura, but equally the Llueva valley could just have cut down to the fossil levels of an older Matienzo to Secadura route.

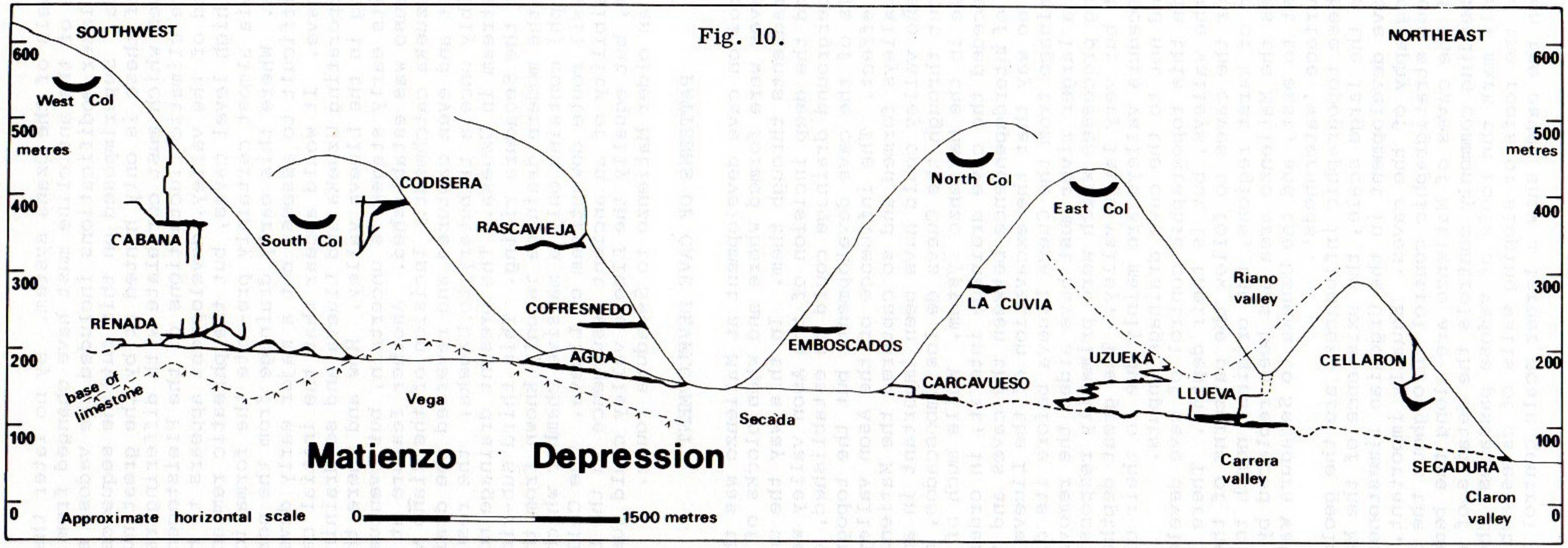
PATTERNS OF CAVE DEVELOPMENT

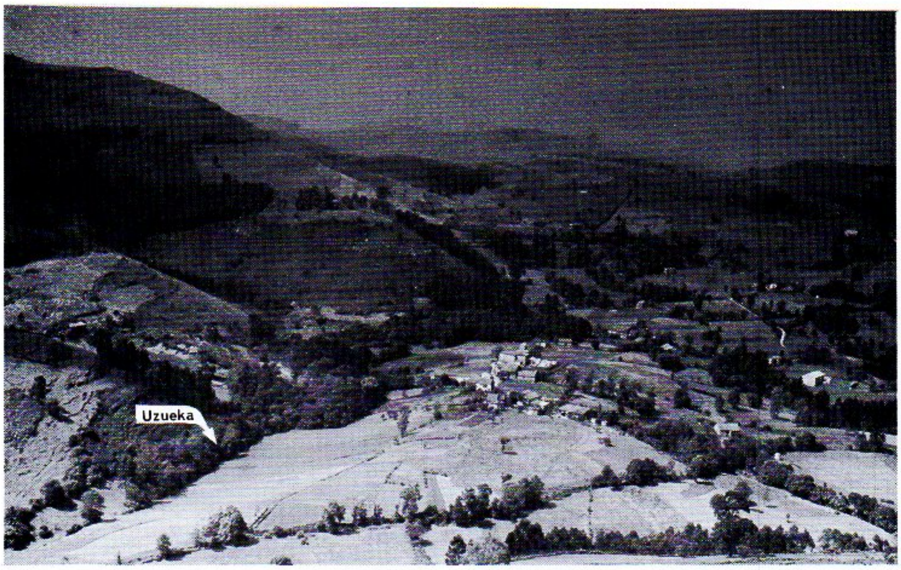
The earliest control on cave development at Matienzo was the surface topography in that caves were formed where and when blocks of limestone gained adequate hydraulic gradients through them. In this way the uncapping of the Matienzo anticline and the deep incision of the Ason valley were of prime importance. Once underground drainage could be established, geological factors influenced the details of the cave development, but the topography continued to have a major overall effect. The influence of the Ason valley diminished as the Llueva and Secadura valleys formed and so captured the Matienzo drainage. It is possible that the Riaño valley could have been important in an intermediate phase, taking water out through the Cueva de los Emboscados, but the valley now has only an input role in the Matienzo system. While much of the Llueva valley cutting must have preceded the cave drainage into it, in order to successfully capture it, a degree of interdependence between the caves and the valley cannot be denied. There is no way that the excavation of the Llueva valley can be attributed to the drainage from the Cueva Llueva before its diversion to the Secadura rising, but a larger river must have aided the removal of the products of the surface wasting processes which were primarily responsible for the erosion of this short but very large valley. The great depths and widths of both the Lleuva and Secadura valleys are mainly due to their closeness to their sea-level outlets, and not to the cave drainage inputs.

The prime factor in this topographic control of cave development is not the surface patterns of the valleys, but is their depths. There is consequently no necessary tendency for the caves to follow the patterns of the surface thalwegs. In a style diagnostic of karst regions, the original north to south, or south to north, drainage across the Matienzo area has been replaced by underground drainage which is west to east, and the Uzueka to Secadura water now manages to pass beneath three surface 'watersheds'.

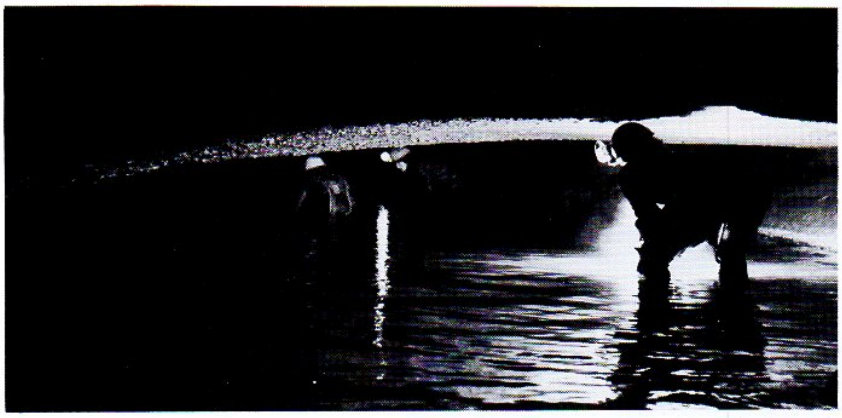
Superimposed on these topographic influences, are the geological controls of cave development. On the large scale, the existence of the Matienzo anticline and the favourable cave development in the Urgonian limestones, still leave their mark on the geography of the caves. Equally important, though on a smaller scale, is a conspicuous stratigraphic control throughout the limestone succession. The great majority of the caves of Matienzo are along the bedding of the limestones, and the bedding commonly controls the details of cave passage shape. Bedding planes commonly mark the roofs of vadose passages, the widest axes of phreatic passages and the roofs or sloping walls of caves subject to extensive collapse. In addition the caves show a larger scale control by the bedding.

Fig. 10.


SOUTHWEST
NORTHEAST
600
500
metres
400
300
200
100
0
West Col
CABANA
South Col
CODISERA
RASCAVIEJA
RENADA
COFRESNEDO
AGUA
base of limestone
Vega
Matienzo Depression
EMBOSCADOS
Secada
North Col
LA CUVIA
East Col
CARCAVUESO
UZUEKA
LLUEVA
Riano valley
CELLARON
Carrera valley
SECADURA
Claron valley
Approximate horizontal scale
0
1500 metres



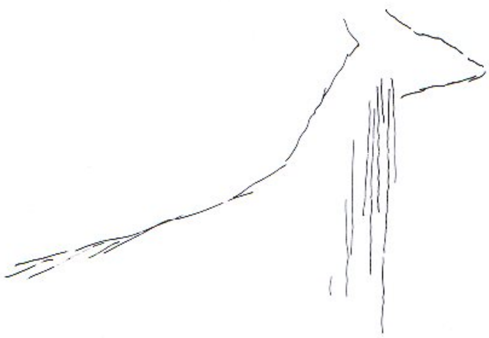
1. Looking west over Riano. The entrance to Cueva Uzueka is at the base of a sloping maize field (J.S. Corrin)



2. A typical view of the 1 kilometre long Gorilla Walk in Cueva Uzueka. (L.D.J. Mills)

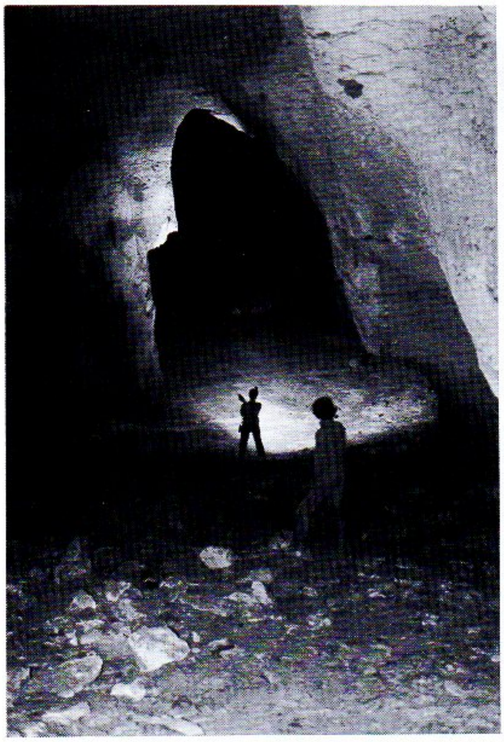
3. The Armageddon boulder choke, Cueva Uzueka. (J.S. Corrin)

1. The wide bedding which forms Paisley Passage in Cueva Uzueka. (J.S. Corrin)



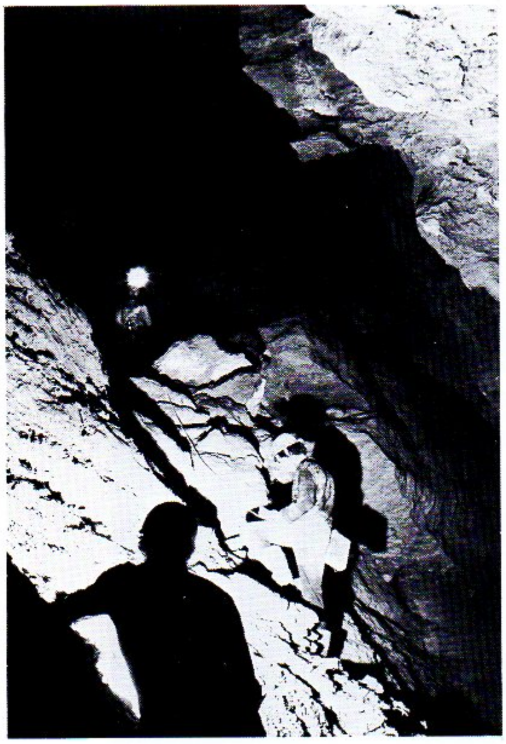
2. & 3.

Deer engravings from Panel 1,
Cueva de los Emboscados.
(P. Smith)

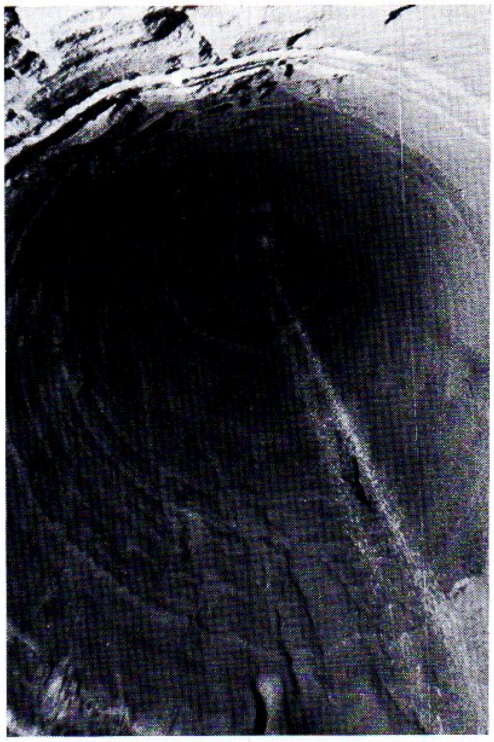


1. The phreatic remnant of Cueva de los Emboscados. (J.S. Corrin)

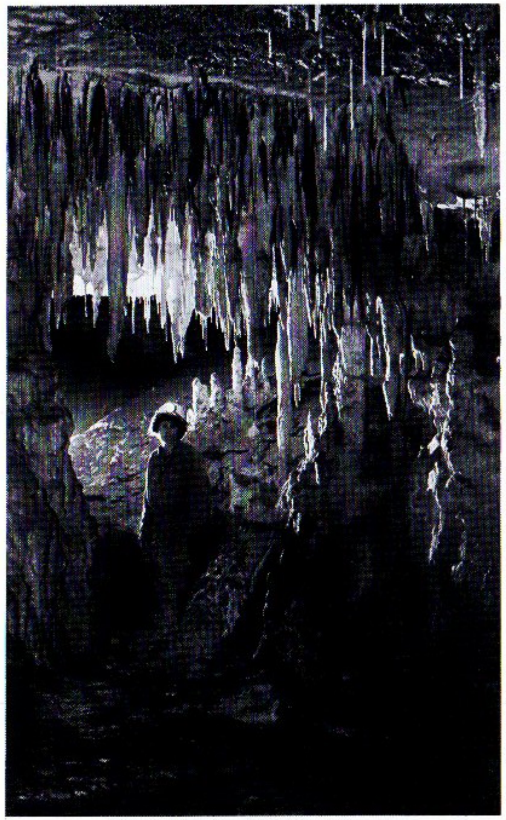
2. Bright red gour pools in Blood Alley, Cubio de la Renada. (L.D.J. Mills)



3. Surveying in Gran Risco, Ozana. (L.D.J. Mills)

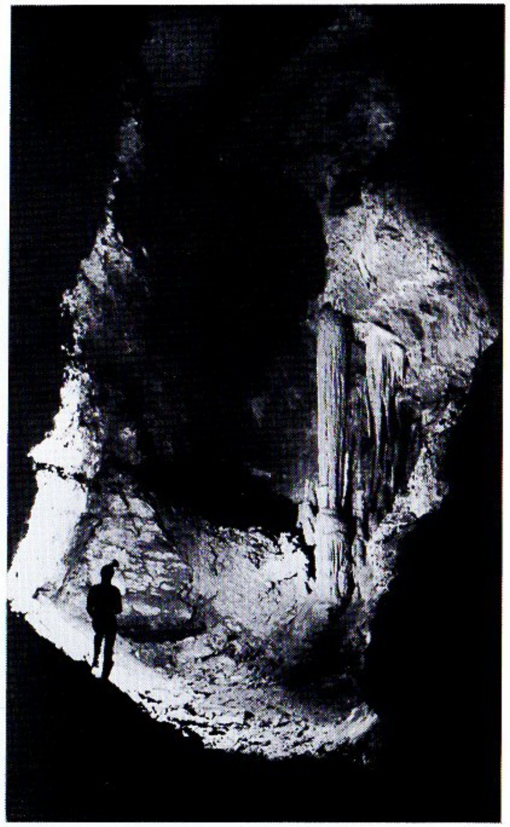


4. The circular, 101 metre high Astradome in Cueva Uzueka. Circles near the top are multiple images of a helium balloon. (J.S. Corrin)



1. Formations in Fuente de la Cuvia, Riano (J.S. Corrin)

2. Formations in Cueva de Solviejo, Secadura (J.S. Corrin)



3. ... In Stuffed Monk Gallery, Cubio de la Renada. (L.D.J. Mills)

The Ozana and Uzueka caves, for example, maintain remarkably constant stratigraphic levels in their inclined courses in the dipping limestones, and many segments of horizontal passage, for example in Cabaña and Reñada, are orientated on the strike of the bedding. The control therefore seems to be due to both thin shale partings in the bedding planes and also preferred solution of some limestone beds.

In addition, strong control is exercised by both the thin sandstone beds and the horizons of Orbitolina marl. The latter is a thinly bedded impure limestone crowded with the foram fossils which give it its name, and it guides a number of caves. Its main underground exposures are in the Uzueka cave where it lies just above a sandstone and the relative importance of the two horizons is confused. The thin sandstone beds are important stratigraphic controls which influence many lengths of passage notably in the Ozana, Uzueka and Llueva caves. Being resistant to erosion they commonly form the floors of the passages, both phreatic and vadose development being perched on them and the cave streams breaking through the sandstones on faults or major joints. In Llueva the main phreatic cave developed below the sandstone and roof collapse has worked upwards leaving the sandstone as a strong roof in the main passage.

The persistent stratigraphic controls in the Matienzo caves mean that the major folds achieve their own significance, with synclines tending to gather any vadose drainage. The Four Valleys System is located in the northern syncline with water collecting from both limbs and then draining east roughly along the axis. However, this is not a classically simple case of synclinal vadose control, for nearly all the known cave passages have clearly phreatic origins. There is no clear reason why a syncline should collect phreatic drainage, though the transfer to the modern vadose phase subsequent to a rejuvenation at the resurgence would have been aided by the synclinal form. Synclinal controls of the phreatic caves could have existed if the caves were merely flooded conduits within an essentially vadose zone - prior to their enlargement when true vadose conditions could progressively take over. But the large cross sectional passage sizes, notably in the Uzueka and Llueva caves, would have required inconceivably enormous flows to maintain totally flooded conduits over the gradient present. There are no signs of local constrictions in the passages which could have developed a staircase-like series of perched phreatic zones down the dip of the limestones. Instead, the location of the Four Valleys System in the syncline appears to be a fortuitous result of the incision of the Llueva and Secadura valleys so close to the fold axis.

Faults and joints have had a considerable influence on plan forms of the caves, as is well revealed by the cave surveys; perhaps the zig-zag maze in the Uzueka entrance series shows the best. However, the control is only secondary to the stratigraphic control; passages are aligned along fracture/bedding intersections but usually break from joint to joint while still remaining at the one bedding level. The situation is different in much of the Renada cave where the drainage is against the dip and the cave has developed in a more complex maze using both bedding and the faults and joints; many of the major fractures have been picked out into enormous solutional rifts. Faulting in the Ozana cave has mainly had the effect of inducing collapse, to the extent that most of the fault/passage intersections are now lost in impenetrable boulder piles. Even though they clearly represent a weakness in the limestone there has been no preferential cave development along them; in fact the opposite is true, as nearly all the passages are in the bedding between the faults.

It is an almost perpetual debate, in cave regions, how much a base level or a water table has controlled cave development. The same question must be raised at Matienzo, and unfortunately the answer is still not clear, (Fig. 10). The evidence for such a control is always in the form of "levels of development". In the Matienzo valley, many of the caves are close to the present valley floors, but then the Codisera, Cuatribu, Rascavieja and Cabaña caves, together with some lesser ones are all at altitudes around 400m. Does this represent an old level of the valley floor which was constant for a period of time and at which cave development stabilised? Beyond the general coincidence of levels, there seems little real evidence for this. The only accurate way of recognising the altitude of an old water level (whatever that may be related to) is by locating a cave passage which changes from vadose to phreatic along its length. Codisera includes a section of massive vadose canyon (with phreatic features high in its roof) which appears to continue as the entirely phreatic passage in Cueva del Coveron, and the morphological change is at a level of around 320 m in the short inaccessible section. In a single passage this could represent only a local water level of no regional significance and anyway it is related to drainage to the Ason and not the Matienzo basin.

It therefore sheds no light on the significance of the development within Matienzo at around 400 m. All the fossil caves at around this level are phreatic, and there is no indication of how their level related to any contemporary valley floor. In detail, all the cave passages show local control by geological features and consequently range over considerable variations in altitude. It is reasonable to suggest that they represent a single phase of development, formed long ago during a period of relative stability when the valley floor was somewhere above them and much higher than it is now. But they provide no precise data on the actual level of the contemporaneous valley floor. Any concepts of "levels of development" must only be applied in very broad terms.

It is instructive to examine how any "level of development" is manifesting itself in the currently active caves. The main river caves are all close to valley floor levels. They range in altitude across the area from about 250 m (in Ozana) to less than 100 m (in Llueva and Secadura). They are nearly all locally controlled by stratigraphy. While most are vadose and therefore above valley level, some, such as the downstream sumped sections in Reñada, are below valley level. The overall picture is therefore one of a zone of development with a restricted altitude range, close to the present valley floors. It is debatable, however, whether the valleys control the caves or the caves control the valleys. The main caves of Agua, Carcaveuso, Uzueka and Llueva are old phreatic systems which merely happen to carry the present drainage but were formed initially long ago when valley floors were higher than they are now. In the Vega valley surface erosion of the weak Wealden sediments is now controlled by the level of the Agua outlet. Rapid downcutting of the valley is now restricted to the low rate of solutional downcutting in the limestones within the Cueva del Agua, and the result is a planation of the valley floor. The same applies to the Carcaveuso outlet of the Secada valley, and in neither case has the valley level exercised any control over the cave level. The converse has occurred. Similar must apply to any coincidences of cave and valley levels in the past, except that the valley floors would have been limestone too and there would have been greater scope for deep phreatic drainage.

In conclusion, the Matienzo depression appears to represent a fine example of cave and karst development where the patterns of drainage and evolution have been subject to a variety of interacting geological and topographical controls.

ACKNOWLEDGEMENTS

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One author (L.D.J.M.) spent seven summer seasons at Matienzo, as the leader of the earlier expeditions, while the second author (A.C.W.) visited the area as a guest of the 1977 expedition.

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Note: The four English reports contain descriptions and surveys of many of the Matienzo caves, mostly in the 1975 report except for the caves noted above described in the other years reports. All the reports are available from L.D.J. Mills at the address below.

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