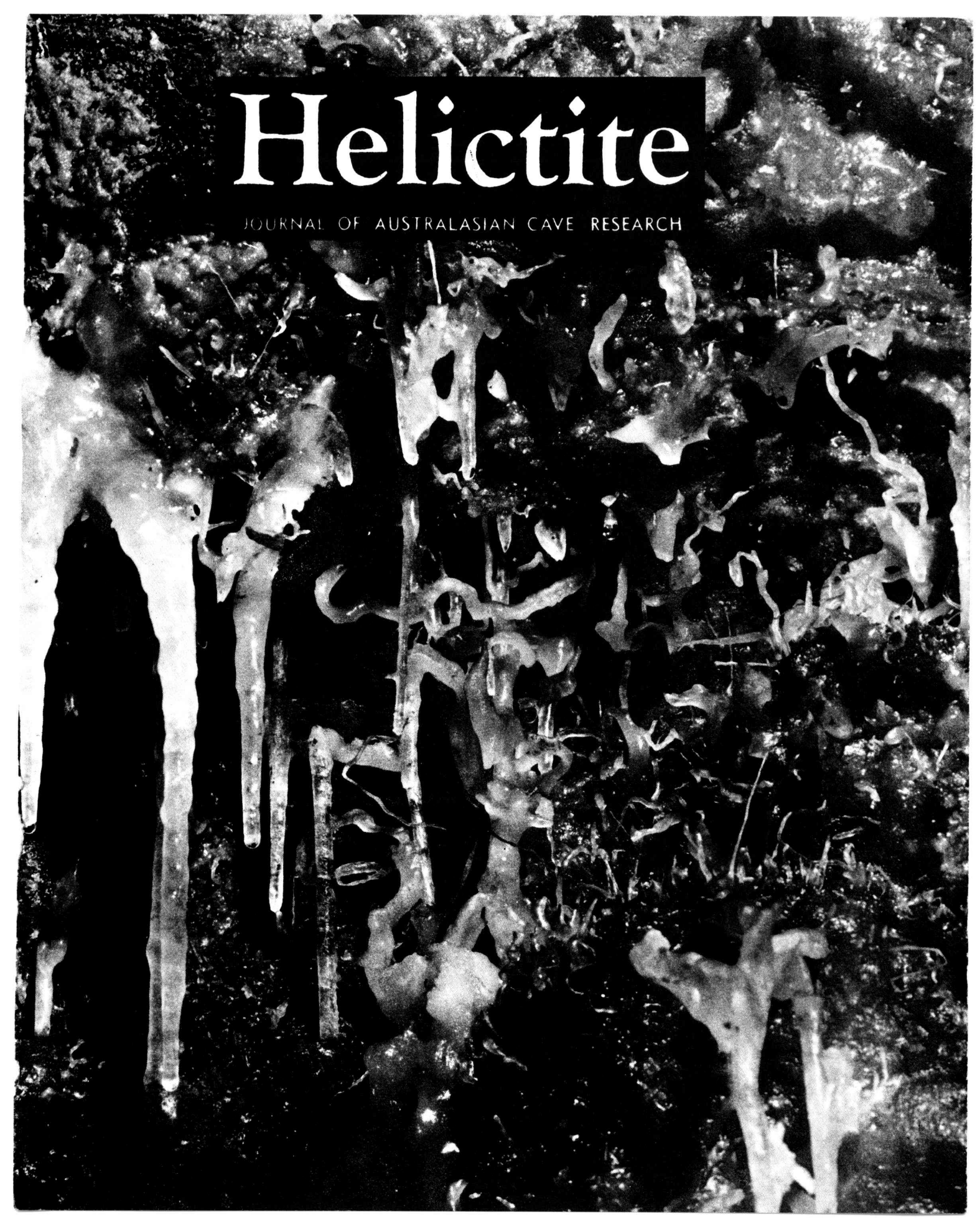
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GEOMORPHOLOGY OF PUNCHBOWL AND SIGNATURE CAVES, WEE JASPER, NEW SOUTH WALES

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Introduction

Because of the ease of its exploration, the Punchbowl-Signature system (Map reference 677587, Army 1/50,000 Sheet 8627-IV, Goodradigbee) is the most frequently visited of the Wee Jasper caves though it contains even less calcite decoration of beauty and interest than does Dip Cave. On the other hand, the system is of considerable scientific interest, both biological and geomorphological. Biologically the interest centres on the long-term investigations of the colony of Bentwing Bats (Miniopterus schreibersii blepotis), initiated by G. Dunnet, sustained and enlarged by D. Purchase. On the geomorphological side, though it is now a dry inactive system like Dip Cave, it possesses a morphology which reveals much of the history of its excavation by a former underground river and so contrasts with its neighbour in the same geological formation only a mile away where there are many difficulties in the way of interpretation of its evolution (Jennings, 1963a).

Exploration and Survey

Signature Cave, so-called because of the multiplicity of names and dates on its walls, has long been known. The dates go well back into the Nineteenth Century, though the cave is not one of those described in Bennett (1834).

Only the forward part of Punchbowl Cave was known when Canberra Speleological Society investigated it at the suggestion of the Yass geologist, A.J. Shearsby, since deceased. In 1936 a young woman had walked into the darkness at the rear of The Antechamber and fell to the bottom of Pitch Chamber without serious injury. A rescue party used long tree trunks to descend to get her out. This party did not go beyond Pitch Chamber; fragile false floors in the way of advance beyond The Snicket were intact when Canberra Speleological Society penetrated here in 1956. The rest of Punchbowl Cave was discovered on this occasion and a second trip shortly afterwards, with the exception of the small section between Loxin Chamber and Pitch Chamber. There was obviously a connection since sounds passed between the two chambers easily, but it wasn't till some months later when the University of New South Wales Speleological Society brought along some loxins to make the ascent of the steep flowstone at the far end of Loxin

Chamber easier that the link was made and Shawl Corridor was discovered also.

During 1957-8 a good deal of effort, stimulated by Edith Smith, went into digging a short tunnel through the rockfall between the eastern end of Pitch Chamber and the Lower Level of Signature Cave. Henceforth the ladder pitch into Pitch Chamber could be avoided. This new ease of access has facilitated scientific work but it is to be hoped it will not lead to spoliation of the cave as well through lack of care on the part of cavers and others. About this time, also, J. Webb used a great deal of gelignite trying to blast a way from the high side of Far Chamber upwards to the small caves at the bottom of the doline alongside The Punchbowl, which lies above. He was unsuccessful, merely enlarging Jimmy's Hole. Beyond Far Chamber, Edith Smith again insisted on digging and in this way broke into a pleasant small room, known now as Edie's Grotto.

With various helpers, Edith Smith carried on survey from time to time and produced a traverse and an outline plan of Punchbowl Cave between 1958 and 1961. In 1962, the writer, helped particularly by Andrew Spate, completed the detail of Punchbowl Cave and surveyed Signature. There was a change of method from one cave to the other, miner's dial replacing prismatic compass and Abney level.

In plan, the cave is so much "on top of itself" that even a simplification is hard to follow, particularly in The Mezzanine area. Therefore the course adopted has been to present a simplified plan (Sheet 1) to act as an index, followed by two more detailed plans of the lower parts (Sheet 2A-B) and of the higher parts (Sheet 3A-B) respectively. Where certain areas are common to both, e.g. Pitch Chamber and Far Chamber, only detail appropriate to each sheet is included. Sheet 1 also carries a simplified longitudinal section* of the whole cave, which acts as an index to Sheets 4-7. Each of the latter includes a part of the longitudinal section in greater detail, accompanied by the related cross-sections*.

Geological and Topographical Context (See inset locality map, Sheet 2A)

The entrances to the two caves lie close together on the eastern side of Punchbowl Hill, which occupies the western end of the outcrop of Wee Jasper Limestone extending up the valley of Wee Jasper Creek. This outcrop lies in the southern limb of a syncline into which the whole Lower Middle Devonian sequence including the limestone is folded. Grey to black in colour and generally massive, the limestone in and around these caves is more generally fossiliferous than at Dip Cave. Fossil Wall Chamber is by no means the only part of the system where fossils abound in the cave surfaces.

Fourteen determinations of strike, well distributed through the caves both horizontally and vertically, range between 112° and 127° with a median

* In references later, abbreviations will be used; Lsct = longitudinal section, Xsct = cross-section.

grid bearing of 122°. At all these points the beds were either disposed vertically or dipping extremely steeply northwards, i.e. into the syncline. In the lower part of Pitch Chamber near to Loxin Chamber there is a mass of rock where strike (55°) and dip (70° SE) were both anomalous. Though of sedimentary or penecontemporaneous, rather than tectonic, nature, this discrepant mass still needs adequate explanation.

Punchbowl Hill constitutes part of a subsidiary surface divide in the Wee Jasper Creek valley. An intermittent creek rising at 667572 descends the lower slopes of Wee Jasper Mountain in a steep gully cut in Wyora Porphyry. This tributary creek debouches into the broad major valley of Wee Jasper Creek just above Punchbowl Hill and flows over a coarse gravel fan which overlies the northwestern margin of the Wee Jasper Limestone, before it drops over bedrock (Hatchery Creek Conglomerate) into the narrow, inner valley of Wee Jasper Creek.

Clearance and grazing have led to arroyo cutting in the gravels and limestone has consequently been exposed in the fresh channel at a number of points. After heavy rains this tributary creek flows in flood to join Wee Jasper Creek at the surface but gradually as discharge declines, a higher proportion is imbibed by the limestone until it sinks successively at these points where limestone shows up in its bed. During these rainy periods, Dogleg Cave on the other side of the hill fills up and overflows at 679588 to run down to join Wee Jasper Creek near the Tumut and Micalong Creek road junction.

Thus Punchbowl Hill is not the divide it appears to be superficially. It is almost certain that some of the water sinking above Punchbowl Hill feeds the Dogleg Cave river even though a fluorescein test was inconclusive. The dye had not passed through after a 36 hour weekend watch but this is quite likely to have been too short a time for the small flow entering the limestone at that time to get through.

Since Dogleg Cave was first explored in 1957, there have only been two short periods when it has proved possible to pass beyond Lake Chamber and the other associated watertraps so that a full survey has not yet been carried to the far end of this cave. However, a rough survey by Canberra Speleological Society takes Dogleg very close to these sinking points in the creek west of Punchbowl Hill and to the limit of limestone in this direction.

The Punchbowl-Signature system also reaches fairly close to the line of the creek further upstream. Moreover, three dolines extend the probable former extension of this system closer still. A rockwalled collapse doline inosculates with a bowl-shaped grassy doline, which occasioned the name of The Punchbowl. The collapse doline is floored by a talus slope, which survey shows to be continued underground into the Far Chamber of Punchbowl

Cave (Jennings, 1963b). South of the Punchbowl doline is a deep conical doline right on the boundary of the limestone. The inference that Punchbowl Cave was fed from the creek nearby when it lay at a higher level than at present is both obvious and inescapable.

Major Characteristics of the Cave Morphology

In sharp contrast with Dip Cave, this system fails to show strict and obvious structural control in its plan. There are, however, some lineaments which do so. The Fossil Wall in Fossil Wall Chamber is the undersurface of a highly fossiliferous bed (Xsct G). The northeast wall of Loxin Chamber (Xsct D8) and part of its southwest wall (Xsct D10) are also controlled by the bedding. In Signature Cave Upper Level there is more bedding plane wall (Xscts C5, C6). Strike control is also evident in the northernmost part of the Phreatic Area of Signature Cave and in two of the small passages branching from Fossil Wall Chamber. The high hall of Pitch Chamber (Xsct A10) seems to fall into the same category but as has been mentioned previously the strike is oblique to its lower walls.

The overall trend of the cave is west to east, making a definite angle with the normal strike. However, the various chambers and passages are made up to quite a significant extent of segments which are roughly aligned along the strike or along a bearing of 30°. So the bedding and a joint system have influenced the plan in some degree though not all lineaments follow these two directions and moreover curved elements are nearly as common as rectilinear ones. These curved elements disregarding structure are due to lateral swinging and excavation by strong river currents and many of them are accurately described as meander niches.

Still less than the plan do the sections of the cave reflect the influence of structure. The most striking features of both longitudinal and transverse sections are the more or less horizontal roofs, which completely truncate the bedding and are indeed unrelated to any structural planes. Only in Far Chamber is the roof not like this. From two parts of this roof there has been substantial rockfall, though only one large fallen block of this origin can still be seen in the chamber. Since Far Chamber lies close to the collapse doline intersecting The Punchbowl, roof fall is not surprising here.

Generally quite smooth, flat surfaces characterise the ceilings, e.g. in Mud Crack Chamber (Xscts K, K1, K2, K3, K4). Often fossils project in minute bas-relief from these surfaces indicating that chemical solution, rather than mechanical abrasion, has been responsible for them. Interrupting these flat expanses in some parts are smooth, rounded hollows, e.g. in Loxin Chamber (Lsct D, Xscts D8, D9, D10). Some of these are used by bats as roosts and are disfigured by the characteristic tarry stains of roosts. It is very unlikely that these hollows are due to the action of bats in scrabbling for position in the manner suggested by King-Webster and Kenny

(1958). The hard, tough limestone is not readily susceptible to mechanical action of such a type. Nor is their smooth surface compatible with chemical weathering from excreta and urine such as seems to have occurred in Dip Cave (Jennings, 1963a) and to have produced very rough surfaces there. The surfaces are also too smooth to be due to scratching. Moreover, some of these hollows occur where there are no indications of roosting either in the form of the tarry stains or of guano accumulation beneath. Instead the hollows are to be interpreted as solution bell-holes (Bretz, 1942; Hooper, 1958) and indicate that water filled the chambers to the roof to produce them though Bretz's other inferences may not be so acceptable.

Stretching nearly horizontally through the system at different levels, these flat solutional roofs are often combined with curved incuts at the tops of the side walls, which are even smoother surfaced than the roofs. Where the roofs are narrow, the whole upper part of the cross-section is suggestive of a former elliptical form, the form characteristic of "conduits à eau forcée", passages fashioned by underground streams under hydrostatic pressure and completely filling them. Typical is the cross-section A21 at the eastern end of The Ballroom. However, incision into the bottom of the ellipse was followed by an emplacement of earthy guano fill. The lack of an exposed bedrock floor is characteristic of the whole system. Only in the Low Level of Punchbowl are there indications that a rock floor is only thinly covered with fill, here of loose sand and fine gravel. Here cross-section B3 has rock for much of its floor; there is much asymmetry of form, with a slip-off slope on the concave bank facing the typical outwardly curved incut of the convex bank. This cross-sectional form is an obvious product of meandering. Absence of current markings ("scallopings") may be associated with the presence of much grit and sand in the underground stream, resulting in pronounced abrasion.

The wider, flat-roofed cross-sections must also be inferred to be the result of pronounced meandering of the underground stream when the level of its outflow to the surface was fixed for a period of time. When these very wide roofs were formed, the passages would be shallow in proportion though the original, flat, elliptical form has since been largely lost. The flat roofs thus register phases of vertical stillstand in the development of the cave and this kind of excavation is the result of the "epi-phreatic" type of cave dynamics in Glennie's terminology (Glennie, 1958).

In contrast with these portions of the system are the tall, narrow passages. Though some of these are straight and suggestive of structural control, e.g. in Signature Upper Level (Sheet 3A), they are generally winding in plan and usually show the effects of meandering in cross-section also. Cross-sections E8 to E18 provide a good example. In E9 and E10 the passage was shifting to the right as it cut down, whereas E14, E15 and E17 show lateral erosion to the left accompanying vertical incision. The other cross-sections in this series, more symmetrical vertically, are located at or near points

of inflection between successive meanders. These various characteristics are typical of vadose stream passages and relate to phases of rapid degradation in the cave history.

These passages are in some cases "canyons" in the normal speleological sense, i.e. they are cut into the floors of chambers or wider passages, e.g. Xsct E4. Others are "roof canyons" projecting upwards from the flat roofs of chambers, e.g. in Signature Upper Level (Xscts C5, C5A, C5B). At Control Hole, such a passage cuts right through from an upper to a lower, wide, flat-roofed level, in fact from The Mezzanine to The Ballroom (Xsct A22). There is the further possibility of more or less complete independence of such levels, e.g. Shawl Corridor (Lsct J, Xscts J2, J3, J4). This reaches a maximum depth of 30 feet and in J4 lateral erosion in opposite senses at successive levels in the one cross-section is evident.

The two extremes of cross-sectional form have been discussed above; transitional types occur but they are much less common. In part of Pitch Chamber (Xsct A12) the flat roof steps down twice abruptly to the north as the stream migrated in that direction but with two phases of shallow incision. In Strawberry Shortcut, incision was too rapid for flat roof segments but lateral migration was quite pronounced; consequently the roof descends in a series of attractive arcs (Lsct S, Xsct F1). Roof meander cusps in Signature Lower Level relate to a short phase of shallow incision during the last phase of active cave formation.

True phreatic features are of restricted extent in the system. There is a very large roof pendant in Fossil Wall Chamber and a set of well developed, small ones in the Low Level close to The Snicket (Lsct B). Branching from Signature Low Level there is a sector so characterised by appropriate features that it has always been called Phreatic Area. The passages form a network, roof pendants are common and there are blades (Bretz, 1942). Former red clay fill remnants are found everywhere in this part of the cave.

Cave Deposits

Bedrock in the floor of the cave is a rarity. The large bat population ensures that guano occupies much of the floors. Beneath the most favoured roost in Far Chamber, there is a blunt pile four feet high in the form of a stalagmite. Even though the roost is in a dry part of the roof, this form must be due to the association of carbonate precipitation with the guano accumulation. A little to the east of this guano stalagmite in Far Chamber, drip pits form regularly in the guano and on their sides are little "demoiselles" or "earth Pyramids" capped by small particles of rock or other more resistant material.

Flowstone is the commonest of the other materials forming the floors, though it also is usually rotten and dirty from guano and its decomposition

products. Only rarely are the rimstone dams and basins unspoilt, e.g. in Edie's Grotto and in Strawberry Shortcut, both low parts. There is virtually no active development of flowstone floors today. The same inactivity is nearly as true of flowstone on the walls and of dripstone decoration. In Signature Low Level there are some fairly persistent drips; the following determinations were made of one of these.

Date	T°F	pH	$CaCO_3$ mg/l	$MgCO_3$ mg/l	Free CO_2 mg/l	State
?/12/'58	67.5	7.4	232	6	N.D.	Saturated
29/ 3/'59	54	7.5	242	0	13.6	Saturated
15/11/'59	57	7.8	327	55	N.D.	Supersaturated

The last value for calcium carbonate is the highest I have determined from a drip in Australia; nevertheless the stubby stalagmite receiving it does not appear to be growing very actively. In general, dripstone is dry or fouled and corroded by bat droppings. Of the eccentric decorations found here and there, perhaps the most interesting are the small heligmites in Strawberry Shortcut. The best decoration in the whole cave system was to be found in the dry pool deposits of Crystal Pool (Sheet 3B, Lsct S on Sheet 7) but this suffered so much damage at the hands of cavers that it was thought justified to rescue some specimens for Canberra museums.

Fallen blocks are rare throughout the cave in consonance with the prevalence of undisturbed solution roofs. The Tunnel linking the two caves runs through a mass of fallen rock and clay partly recemented by secondary calcite deposition. But the main evidence of collapse is found in the talus slopes of Far Chamber (Xsct A26), where rock and clay has entered in great quantities on the southern side from the rock-walled collapse doline next to The Punchbowl. The talus slope of that doline is continued in the same plane and at the same angle in the cave. The toe of this thick talus is found in Mud Crack Chamber (Xsct K). The talus is found also in the short passage near Edie's Grotto extending beyond Far Chamber (Xsct A26), where it has a fresher appearance suggestive of more recent movement but this may simply be due to the absence of guano here.

Reddish-brown silty clay floors some of the lowest parts of the system - in the Low Level (Lsct B), in the Lateral Extension from The Ballroom (Xsct H2) and most prominently of all in Mud Crack Chamber (Xscts K, K1, K2) where polygonal desiccation cracks are well developed. Similar material in the solution tube descending from the side of this chamber (Xsct K1) was the matrix from which T. Nicholas extracted a diprotodontid vertebra; this is the basis of the name given to the tube, Diprotodon Pit.

Coarser sediments - sands and fine gravel - floor the forward part of the Low Level (Xscts B1, B2, B3). When first explored, there was a well defined stream channel in this sediment as if this was the place where the last current flowed in the cave.

Most interest of all attaches to small bodies of sediment, found in meander niches occurring at virtually all levels in the caves. Often these survive beneath a protective flowstone carapace. The sediments range from silty clay to angular fine gravel and often exhibit graded bedding. On the southern side of The Ballroom near its eastern end is a deposit of this type which shows three cycles of change of sediment from coarse to fine upwards. The coarse sediment is derived from the porphyry and has been brought in from the creek above the limestone outcrop. These patches of sediment plastered against the sidewalls do not imply a cave fill up to their level right across the cave; they are for the most part slip-off slope deposits.

Evolution of the Cave System

Punchbowl and Signature Caves register in their morphology an alternation of phases of predominantly horizontal development, represented by the flat solution roofs, with phases of predominantly vertical development, expressed in the canyons in roofs and floors. The former phases will be termed "halts" and the latter "incisions"; they are shown schematically in the accompanying figure.

Halt 1

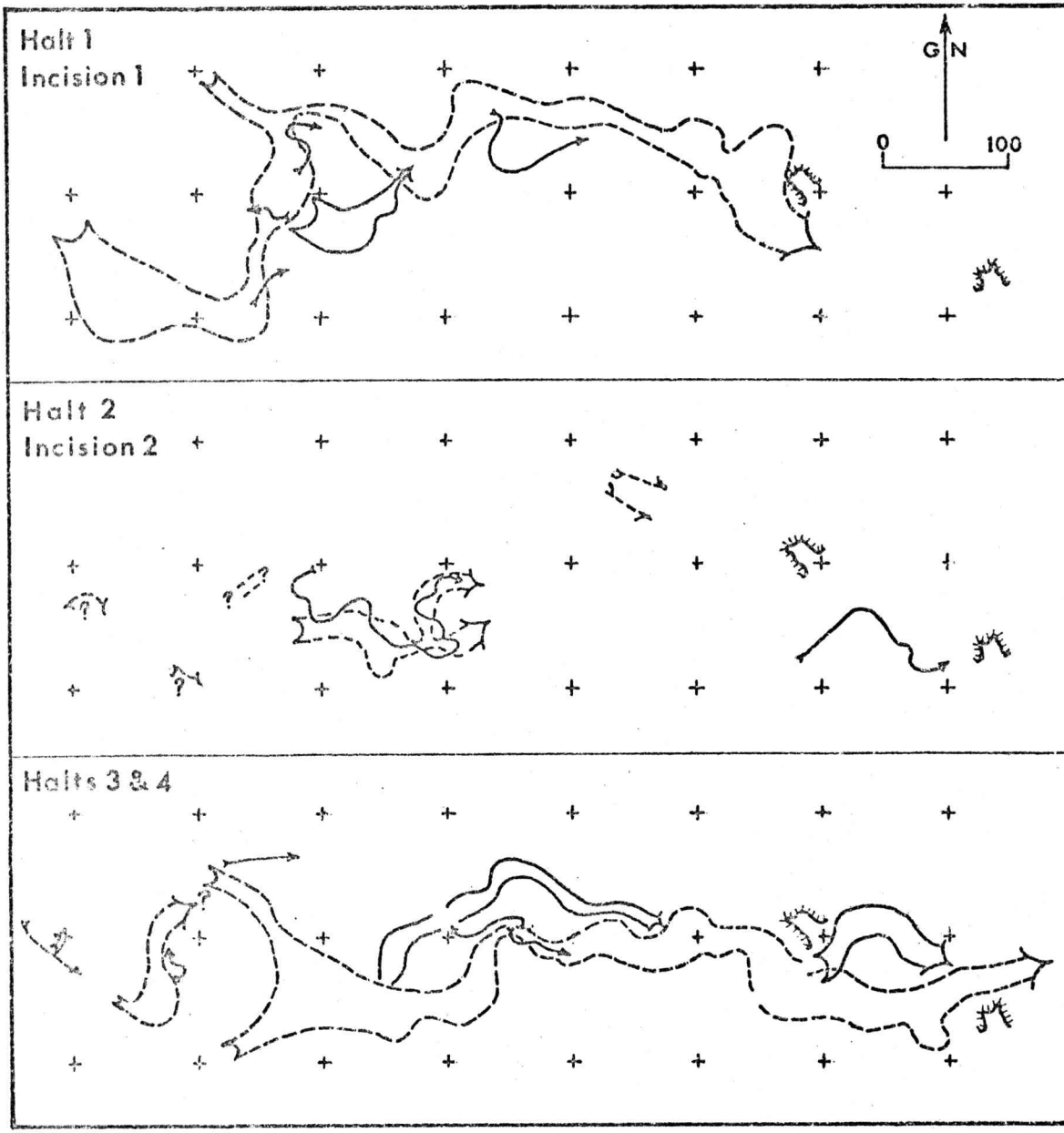
The first phase of development still recorded in the cave morphology, Halt 1, must have been preceded by at least minor enlargement of joints and bedding planes through groundwater solution, i.e. by a phreatic phase in the narrow sense.

The first phase is best traced from front to rear of the cave. The Antechamber of Punchbowl Cave has a broad, flat roof (Xscts D1, D2), which is continued right across the top of Pitch Chamber. Meandering at this level appears in the plan but it is even better expressed in the meander niche, 5-10 feet high, at roof level on the northern side of Pitch Chamber (Lsct D, Xsct A10).

This Top Level of Punchbowl runs on as a narrow passage into Loxin Chamber, though it is almost blocked by massive stalagmitic deposits at the western end of Pitch Chamber. It broadens once more in Loxin Chamber (Xscts D8-D11), where a flat roof with bellholes is only interrupted by the fine stalactites aligned along the strike in the western part of this chamber.

The slightly lower roof line shown in Lsct D between Loxin Chamber and the eastern Slippery Dip is somewhat misleading as the traverse line lies north of the main passage which is blocked by flowstone build-up and pillar formation near Xsct D13.

To the rear of the western Slippery Dip there is a junction in Top Level, a branch coming in along the strike from the WNW to join the main passage



EVOLUTIONARY SCHEME FOR PUNCHBOWL & SIGNATURE CAVES

coming from the fairly large unnamed room near the Window and the Balcony. From The Balcony, the flat roof runs straight through into the eastern end of Far Chamber, where it is interrupted for the first time along its whole length from Punchbowl Entrance (Lsct D).

In the middle part of Far Chamber, an extent of fairly flat roof (Xscts K, A25) seems to be its continuation though separated from it by a higher, irregular ceiling, partly due to roof fall and partly to solutional aven development. Behind this middle section, the farthest part of the cave at this high level lies over and beyond the Bridge. Here again the roof is high and irregular, probably due to roof fall. The walls around are so thickly decorated that any inflow passage is obscured.

In Far Chamber the flat roof of Halt 1 descends rather steeply from about -5 feet below datum to -20 feet; thence it rises to -12 feet in The Antechamber. Neither Punchbowl Entrance nor the small Daylight Hole south of it seem to have been the cave exit at Halt 1 since this would involve a steeply rising final passage. Such a final rise does not occur in Dogleg Cave, which there is every reason to regard as the present-day equivalent active system. A former outlet at The Antechamber roof level east of Daylight Hole may have been choked by calcite. Nor must we presume that there has been no retreat of the eastern slope of Punchbowl Hill since this early phase in the cave history; some part of this Top Level may have been lost completely. Coarsely crystalline secondary calcite occurs on this surface slope and it is more likely to be spelean than subaerial in its formation, being subsequently exposed by erosion of the slope.

Incision 1

Shallow, narrow channels on the south side of The Antechamber and on the outer curve of the meander niche on the north side of Pitch Chamber point to the beginnings of the process of incision from Top Level. The flattener, which extends eastwards from the former of these channels, represents a minor halt at -30 feet.

More substantial cutting down resulted in Shawl Corridor, which swings south from the roof of Loxin Chamber and is blocked by flowstone where it veers back towards Pitch Chamber. Its maximum depth is 30 feet and its roof descends eastwards. Its continuation forward is almost surely to be seen in recesses in the walls of Pitch Chamber at -60 feet, which will be mentioned later.

In probable chronological order of development the next canyon is the short, meandering passage ending underneath the western Slippery Dip (Lsct N, Xscts N1-N5, Sheet 3A). It is blocked by flowstone at its downstream end and its continuation is unknown, though it presumably fed into the western end of Loxin Chamber.

The whole of the northern bight of the cave through Slippery Dips was next put out of action by the formation of The Window-Strawberry Shortcut section, which led more directly from The Balcony to Loxin Chamber. As mentioned above, lateral erosion went on at much the same rate as incision here so typical canyon form was not attained. The present way out of Strawberry Shortcut into Loxin Chamber, though cut through rock and representing a previous level of flow, lies some ten feet above the ultimate outlet into that chamber, now choked with flowstone (Lsct F, Sheet 3B; Xsct F4, Sheet 3A). At this stage the outflow from Loxin Chamber may have been by way of the inclined flattener running SE from the southern side of this chamber (Sheet 3B).

From the vicinity of The Balcony and The Window water also descended to lower levels by the Laundry Chute, a steeply inclined solution tube. This must have functioned subsequently to The Window-Strawberry Shortcut route but prior to the incision rearward of The Balcony, which left that feature elegantly hanging. The main channel immediately below The Balcony leading to The Mezzanine was later superseded by the shortcut from the eastern end of Far Chamber down to Control Hole directly (Lsct S, Sheet 7).

Each of these elements in the cave morphology functioned in turn as the effects of the vertical displacement of the surface outlet of the system worked headwards within it. Minor quantities of seepage water from above and of occasional river flood flow would utilise canyons forward of the most upstream one at a given time; normal and low flow of the river would use the latter route only.

Halt 2

Horizontal cave development took pride of place once again at about -60 feet. This is chiefly represented in The Mezzanine (Lsct E, Xscts E2-E7, A22). This remains a shallow part of the cave system even though little bedrock is seen in its floor. The stream was deflected into it first from part way along Strawberry Shortcut, then from a point upstream of The Balcony and finally from the eastern end of Far Chamber. At the bottom of Laundry Chute, the Crystal Pool also belongs to this halt but its former connections at this level, e.g. with The Mezzanine, have not yet been determined.

In Far Chamber there is an alluvium-filled incut in the north wall at the bottom of the climb to the high eastern end of this chamber. Also grooves, partly filled with sediment, run round the area beneath The Bridge at the same level of -60 feet. Both these features are relict from this second halt, though without doubt practically the whole area of Far Chamber formed an active part of the cave at this level as at Top Level.

The forward half of the cave has so far yielded little evidence of Halt 2. In Pitch Chamber there is an alluvium-filled incut at -60 feet on the south wall and opposite it a meander niche in the north wall, which has not

yet been examined. The flat ceiling at the top of the roof canyon in Signature Upper Level (Xscts C5, C5a, C5b) lies at -63 feet and relates also to this halt. The possibility that more cave at this level will be discovered in the front half of the system seems good.

Close to Signature Entrance, cross-section C3 has a flat roof at -66 feet. If this entrance were formerly the exit of the cave system at Mezzanine Level, there must have been a rising final passage. Collapse to give the present entrance, together with choking of the true former outlet seems more likely and again the possibility of some retreat of the hillslope outside must be reckoned with.

Incision 2

Following the development of The Mezzanine, a fresh phase of incision left its trace in canyons in the floors of that level and in roof canyons belonging to the chambers of the level beneath. The most upstream part is found in the roof canyon in The Ballroom near the way to Fossil Wall Chamber. This runs into Control Hole, where it becomes a floor canyon of The Mezzanine level for a short distance before reverting to roof canyon in The Ballroom again. Choked with flowstone and other fill, it resumes as a shallow canyon in The Mezzanine above (Xscts E3-E5). Finally it forms the excellent winding passage of E8-E16 which deflected the flow northward.

A big gap follows but without doubt the roof canyon of Signature Upper Level is its congener. The western end of this canyon where it is choked with dripstone is a point well worthy of exploratory attack.

Halt 3

This level is the only one represented over the whole length of the known cave and for the most part it lies south of Top Level as does Halt 2. Passages and chambers at -80 to -90 feet belong to Halt 3.

The low passage beyond Far Chamber (Lsct A) begins the Main Level of Punchbowl Cave but it is immediately lost beneath the great talus slope of that chamber. Forward of this, it is continued in the broad expanse of The Ballroom, the flat roof of which is interrupted by the winding canyon just discussed. Mud Crack Chamber is also part of Halt 3 development (Xsct K, K1), though there is no certain indication as to whether it was tributary to a main channel through the then floor of Far Chamber or whether it represents a substitute for the latter as collapse into Far Chamber forced the flow northwards. On the latter view a former connection between Mud Crack Chamber and Fossil Wall Chamber has been blocked by flowstone. This is the interpretation illustrated in the schematic diagram of the cave evolution. The roof of Fossil Wall Chamber shows that this part of the cave was eventually tributary to The Ballroom section of the Main Level via the present

passage between the two (Xsct G). At a previous stage the link lay through the flattener reaching scuth-eastwards from Fossil Wall Chamber at roof level and which joined up with the roof canyon of The Ballroom, now separated from it by flowstone.

The various flatteners at roof level protruding east from The Ballroom suggest a former extension in that direction but they are all choked with calcite now. The present continuation is through the constricted passage which includes The Snicket and leads into the long, low part of Pitch Chamber. A branch came in from the hall of Pitch Chamber which is excavated down to these levels.

The Main Level in Pitch Chamber (Lsct A) is only divided from its continuation, Signature Upper Level, by a narrow barrier of calcite (Lsct C). At its other end Signature Upper Level reaches beyond Signature Entrance before it is blocked off by flowstone again (Xscts C1, C2). Only a hundred feet away horizontally and at the appropriate level of -90 feet is the small Anemone Cave, which leads out to the surface not very many feet above the bottom of a dry valley leading down to the active outflow of Dogleg Cave. Anemone Cave must have been the former outlet of Halt 3.

Halt 4

The lowest level of horizontal development in the system has roofs ranging between -90 and -110 feet from the rearward to the forward parts. Since the difference in altitude of Halts 3 and 4 is small, the incision from one to the other finds little separate expression.

With its roof below the floor of the adjacent Mud Crack Chamber, Edie's Grotto is the westernmost and highest element of Halt 4 at -90 feet. Diprotodon Pit projecting downward from Mud Crack Chamber belongs to this phase whilst leading eastwards from the foot of Fossil Wall is a narrow passage with a roof at about -105 feet and choked off distally (Scts G3, G3a, G3b, Sheet 7).

The Lateral Extension from The Ballroom has its roof around -103 feet (Xscts H, H1-H3) and is separated by the narrowest of barriers from Punchbowl Low Level. From this point of proximity, Low Level (Lsct B) runs forward as a meandering, low elliptical passage at -100 to-105 feet into Pitch Chamber (Xscts B1-B4).

Immediately east of The Snicket, a hole in the floor of the Main Level leads down to Low Level. From this point a small upper passage (Lsct B, Xsct B9) follows below Main Level through to the floor of the westernmost extremity of Pitch Chamber. This must have formed before the Lateral Extension from The Ballroom deflected flow into Low Level farther upstream. The lowest part of Low Level (Xscts B7-8) is marked by an excellent devel-

opment of roof pendants. This indicates a locus of standing water in the last phase of the cave evolution.

Cross-sections A11 and A12 show that the Low Level stream crossed Pitch Chamber, the river shifting northwards as it dropped from Halt 3 to Halt 4 level. Collapse in the vicinity of The Tunnel and subsequent flowstone construction have obscured the former way through to Signature Lower Level. The flattener at -95 feet of cross-sections A8 and A9 belongs to an early phase of this connection.

At the western end of Signature Lower Level there are two flatteners (Scts A4, A5); the upper one at -97 feet relates to the A8-A9 flattener, the lower one at -110 feet to a slightly later phase. The main roof of Signature Lower Level is at -105 feet, though a small stretch of roof canyon (Xsct A3) rises higher than this and relates to the incision between Upper and Lower Levels. Within the Lower Level, fine roof meander cusps are associated with the double character of this part of Signature and the bases of the cusps form part of the flat roof at -110 feet. At the junction of Upper and Lower Levels, the latter is heading southeastwards but large flowstone accumulations now block the way. The former continuation and outlet in this direction are unknown.

The Phreatic Area (Xscts M, M1-M5) is an offshoot to the north from Signature Lower Level. Its characteristics suggest standing water rather than definite currents. This part lies nearer to Dogleg Cave than any other section of this system, though it may lie as much as 20 feet higher. Any very open connection would surely have led to modification of the Phreatic Area by through-current activity, instead of the latter retaining its aspect of a cul-de-sac. The Phreatic Area suggests a final phase of solution by standing water after the Punchbowl-Signature system ceased to provide the main passage of creek water through Punchbowl Hill. Its role had by then been taken over by Dogleg Cave.

Conclusion

Thus the Punchbowl-Signature system reveals the effects of four periods of epi-phreatic flow, intermittent in action with varying weather and seasonal conditions, and of three intervening phases of vertical incision and vadose, free-surface streams. The vertical intervals of incision were successively less in depth; 45-50 feet separate Top and Mezzanine Levels, 20-25 feet make the interval between Mezzanine and Punchbowl Main-Signature Upper Levels, only 10-20 feet lie between Punchbowl Main-Upper Signature and Punchbowl Low-Signature Lower Levels.

The phases of stillstand and epi-phreatic flow produced wide-low, flat-roofed passages or elliptical ones. These are best preserved in the lowest level (Halt 4) but some remnants survive from all levels though much less than the flat roofs on their own. Canyons of the vadose phases are well

represented from the first and second periods of pronounced downcutting, but the small vertical interval of the final period of incision did not result in much characteristic passage of this nature. Deposits of various kinds frequently block the canyons.

The larger chambers and rooms of the system are found where there was little lateral shift of the underground river between one level and the next. Loxin Chamber functioned from Halt 1 through almost all of the substantial downcutting to the second standstill. Far Chamber remained at least partly in action from Top Level to Main Level. The third and fourth halts are both represented in Fossil Wall Chamber but as the incision between these two was small, this chamber hasn't the height of the previous two. Pitch Chamber is the loftiest of them all since it seems to have remained an active part of the system at all levels, though it may not have provided the main channel throughout the second halt and the second incision.

The profile of Dogleg Cave is governed by the altitude of its outlet at the contact of Wee Jasper Limestone with the Hatchery Creek Conglomerate series. From this it can be inferred that the various levels of the Punchbowl-Signature system were similarly governed by former altitudes of the outflow of its underground river onto the surface of the impervious rocks to the north. Halts in the downward erosion of Wee Jasper Creek thus controlled the evolution of the cave system. It is likely therefore that some of the cave levels are related to the valley bench remnants, 200-250 feet above the R. Goodradigbee, noted by Edgell (1949) but no close correlation seems possible. In contrast the most important phase of excavation of Dip Cave a mile away seems to have preceded the development of this bench and to be phreatic in character, though enlarged by cave breakdown later (Jennings, 1963a). It is a salutary warning against hasty generalisation from one cave to others even in a limited area.

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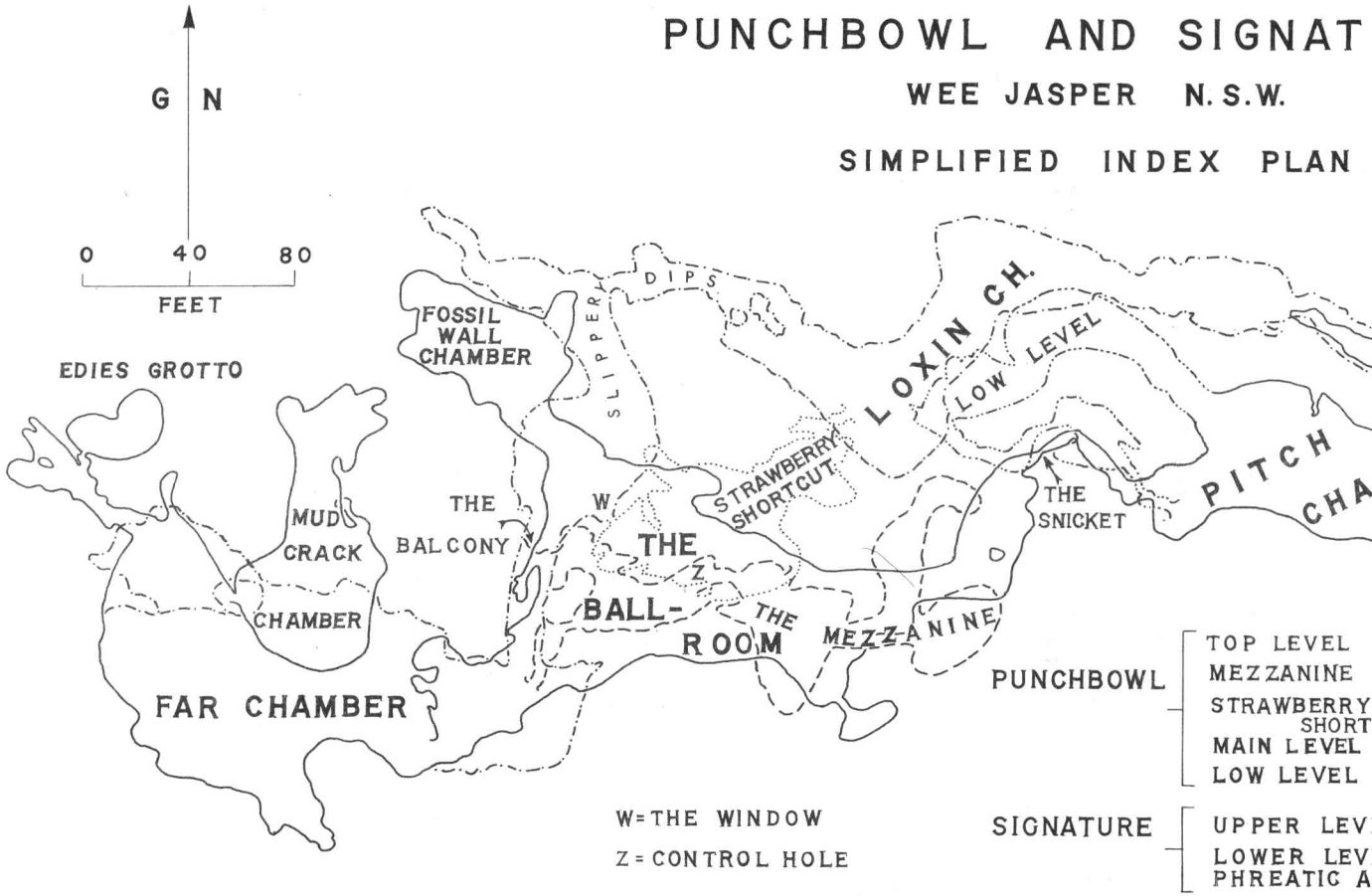
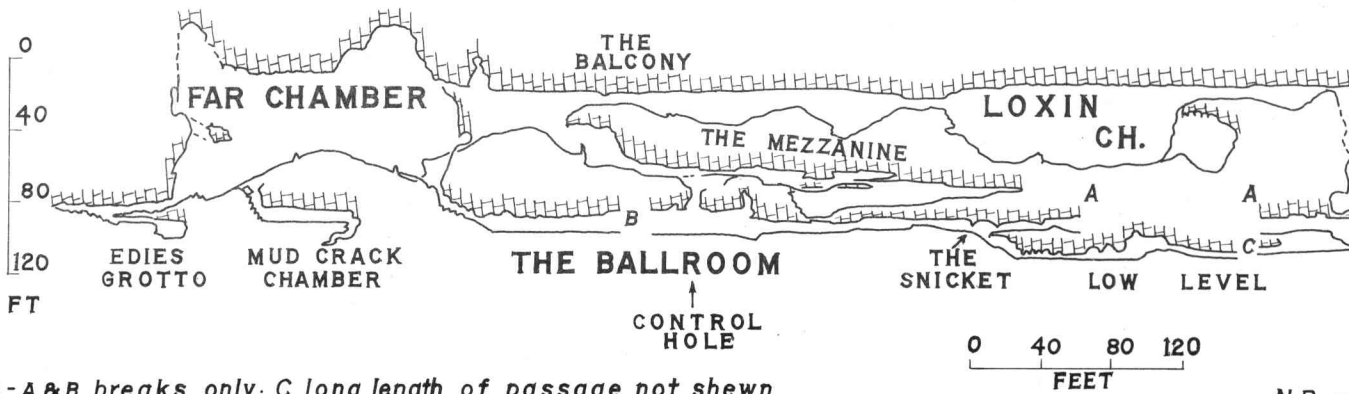
PUNCHBOWL AND SIGNAT

WEE JASPER N.S.W.

SIMPLIFIED INDEX PLAN



LONGITUDINAL SECTION



A-A&B breaks only: C long length of passage not shewn

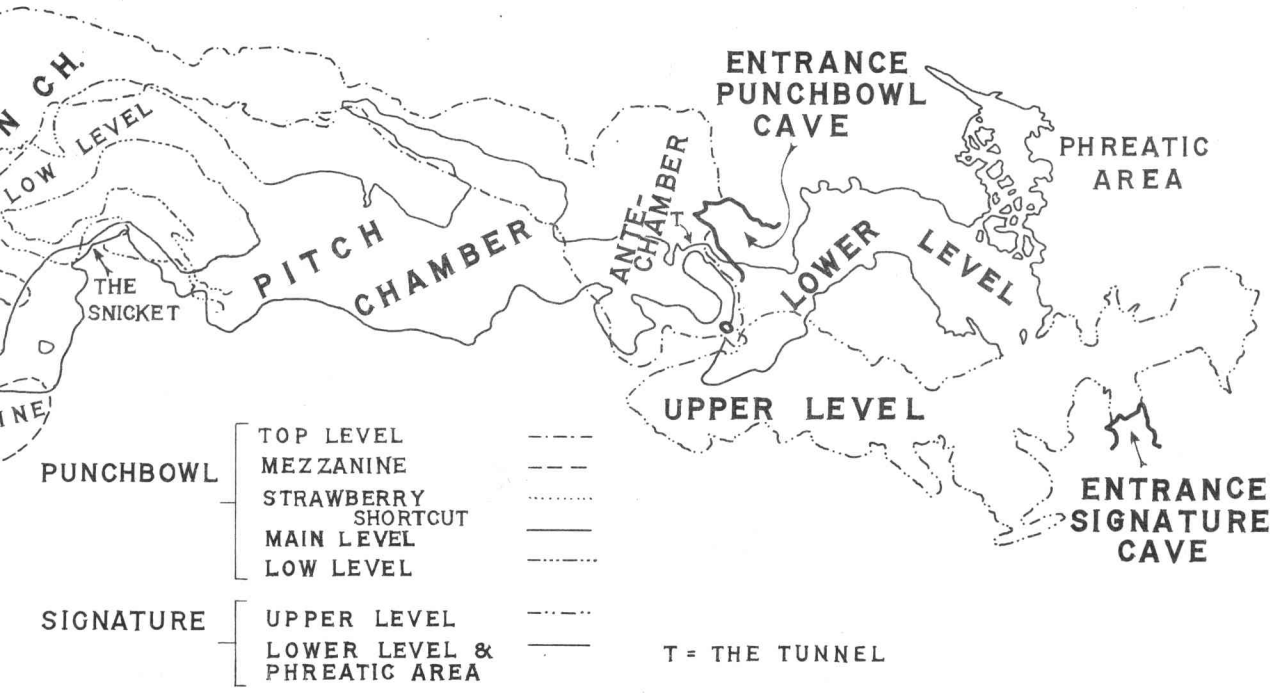
N.B. sc

L AND SIGNATURE CAVES

E JASPER N.S.W.

For survey details see sheet 2A

IFIED INDEX PLAN



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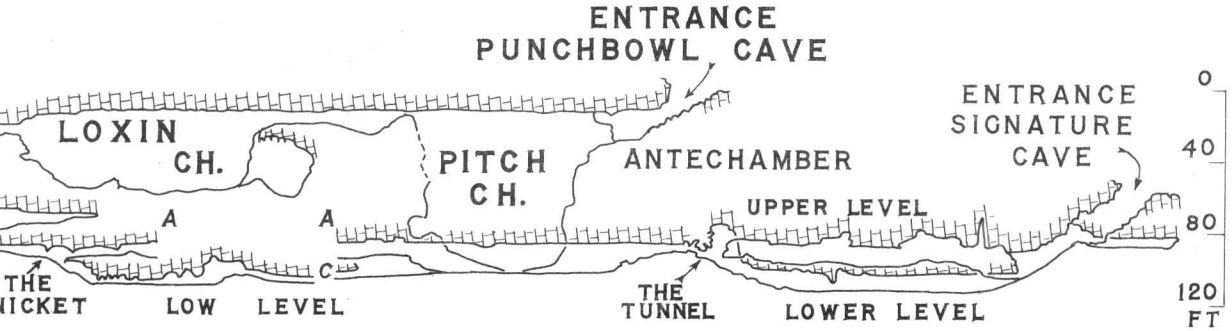
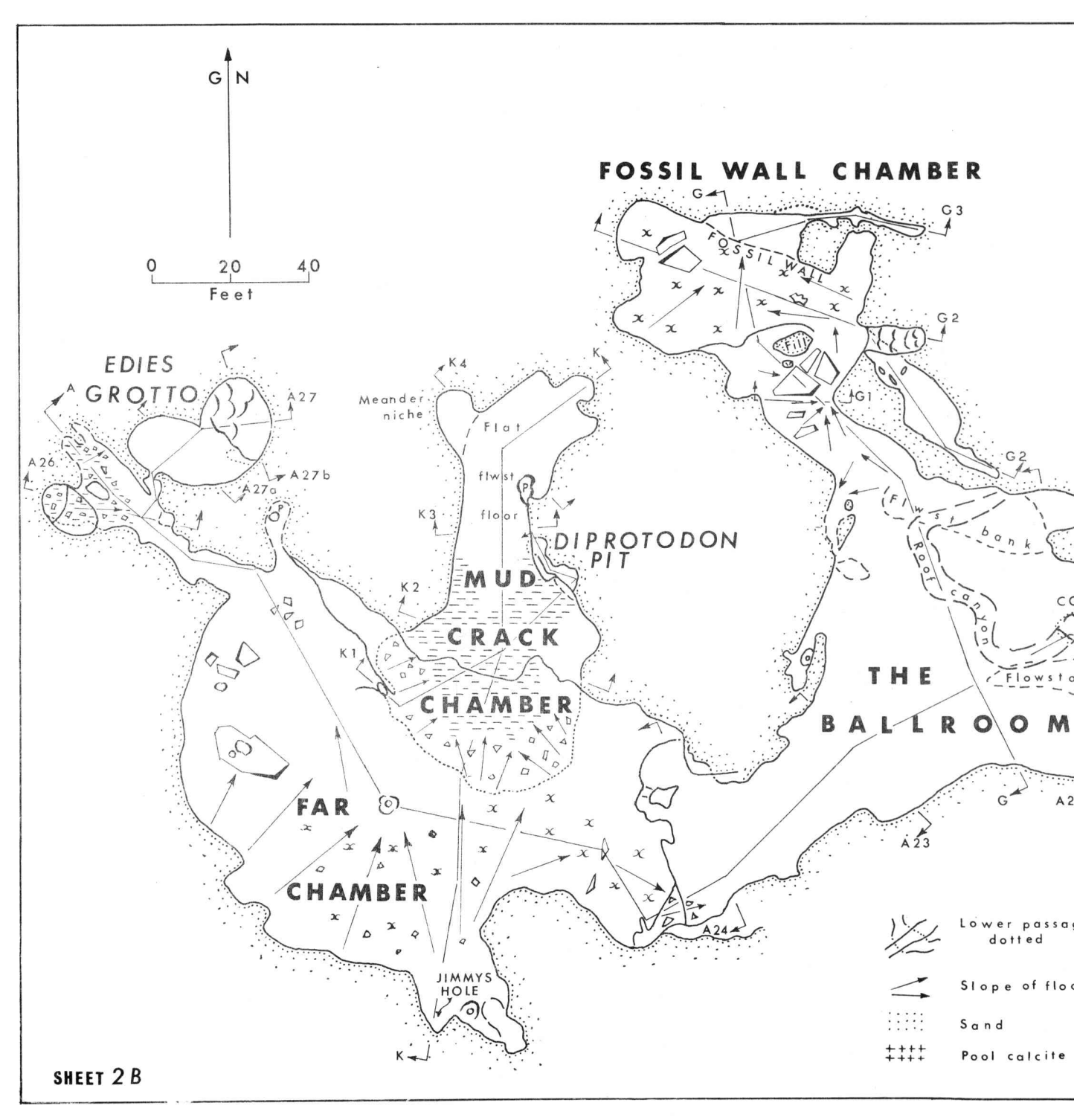


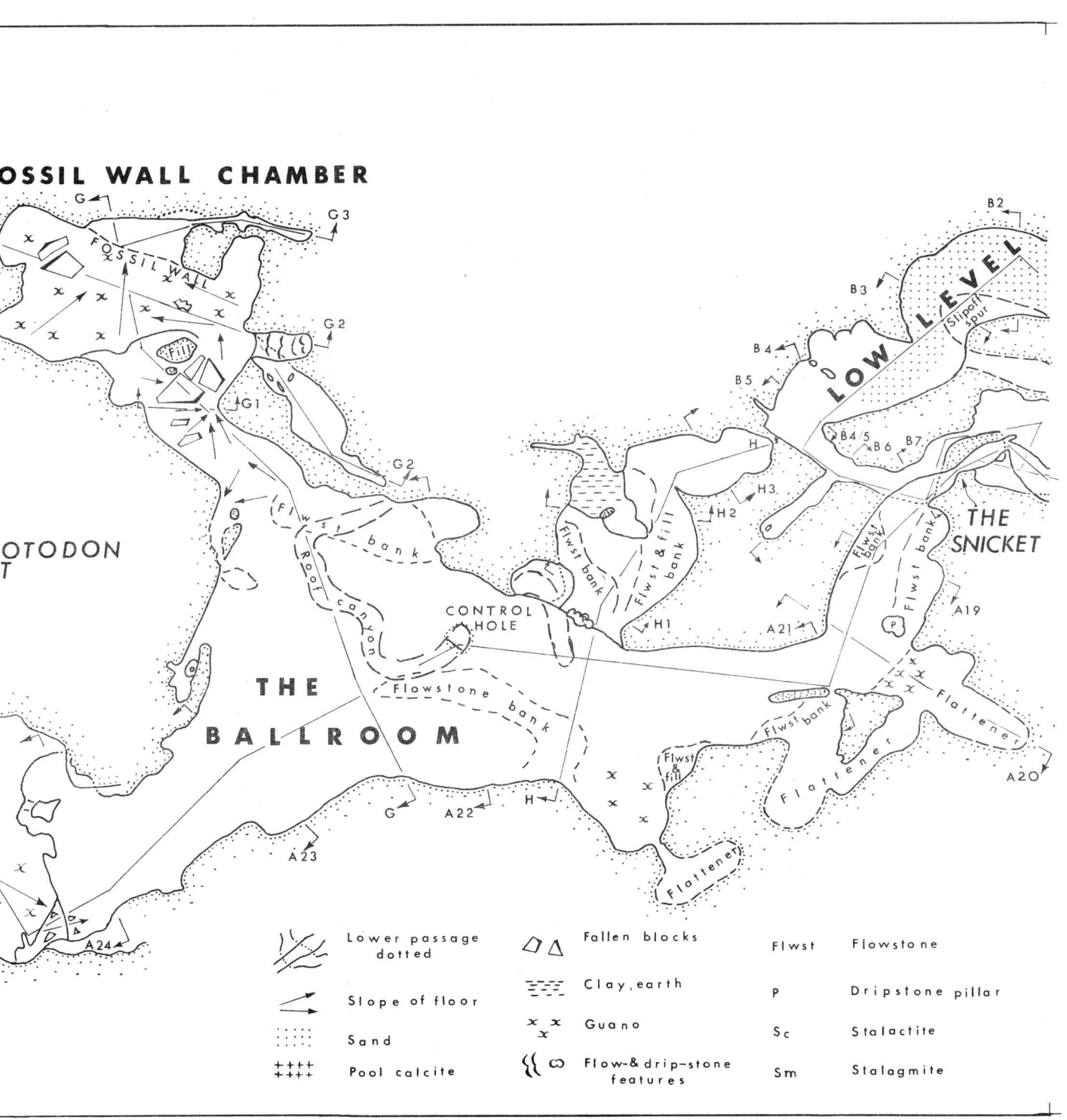
0 40 80 120
FEET

N.B. scale of section different from that of plan

SHEET 1

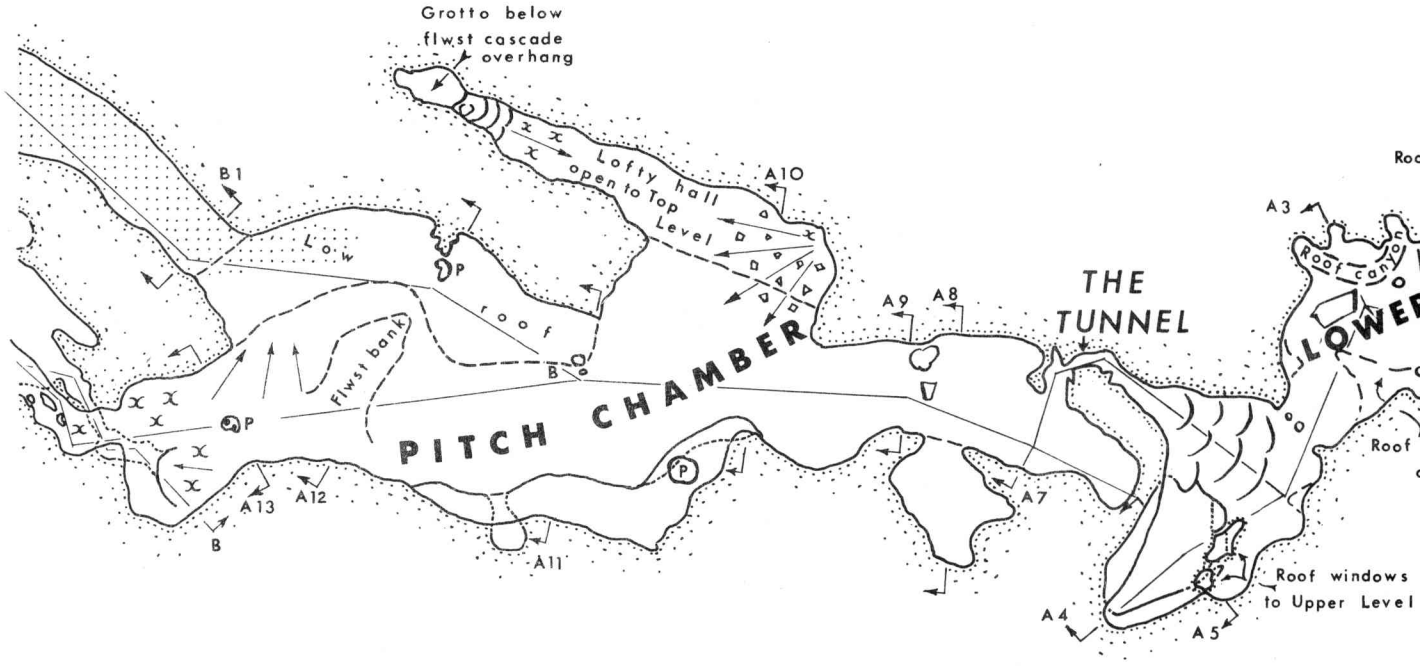

G N
0 20 40
Feet
FOSSIL WALL CHAMBER
G
G3
FOSSIL WALL
G2
Fill
G1
EDIES
A GROTTO
A27
A26
A27b
A27a
K4
K
Meander niche
Flat
flwst
floor
P
K3
DIPROTODON PIT
MUD
K2
CRACK
CHAMBER
K1
Flwst bank
Roof canyon
THE
BALLROOM
Flowsto
FAR
CHAMBER
A23
A24
JIMMYS HOLE
Lower passag
dotted
Slope of floo
Sand
Pool calcite

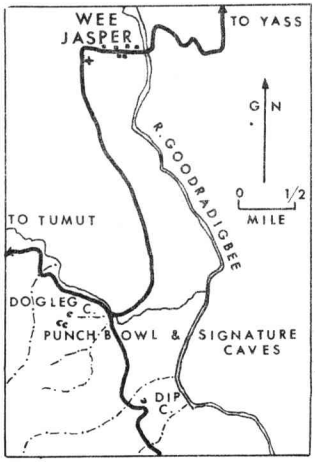
SHEET 2B


OSSIL WALL CHAMBER
FOSSIL WALL
Fill
G
G1
G2
G3
OTODON
T
Flwst bank
Roof canyon
CONTROL HOLE
THE BALLROOM
Flowstone bank
G
A22
H
A23
A24
LOW LEVEL
Slipoff spur
B2
B3
B4
B5
B4/5
B6
B7
H
H1
H2
H3
Flwst & fill bank
Flwst bank
THE SNICKET
A19
A21
A20
Flattener
Flwst & fill
P
Lower passage dotted
Slope of floor
Sand
Pool calcite
Fallen blocks
Clay, earth
Guano
Flow-& drip-stone features
Flwst Flowstone
P Dripstone pillar
Sc Stalactite
Sm Stalagmite

PUNCHBOWL & SIGNATURE CA

Plan of Main & Low Levels (Punchbowl)
Lower Level (Signature)





1. Survey by E. Smith, J. N. Jennings and other members of the Canberra Speleological Society at intervals in the years 1958 to 1962. Drawn by J. N. Jennings, 1962.

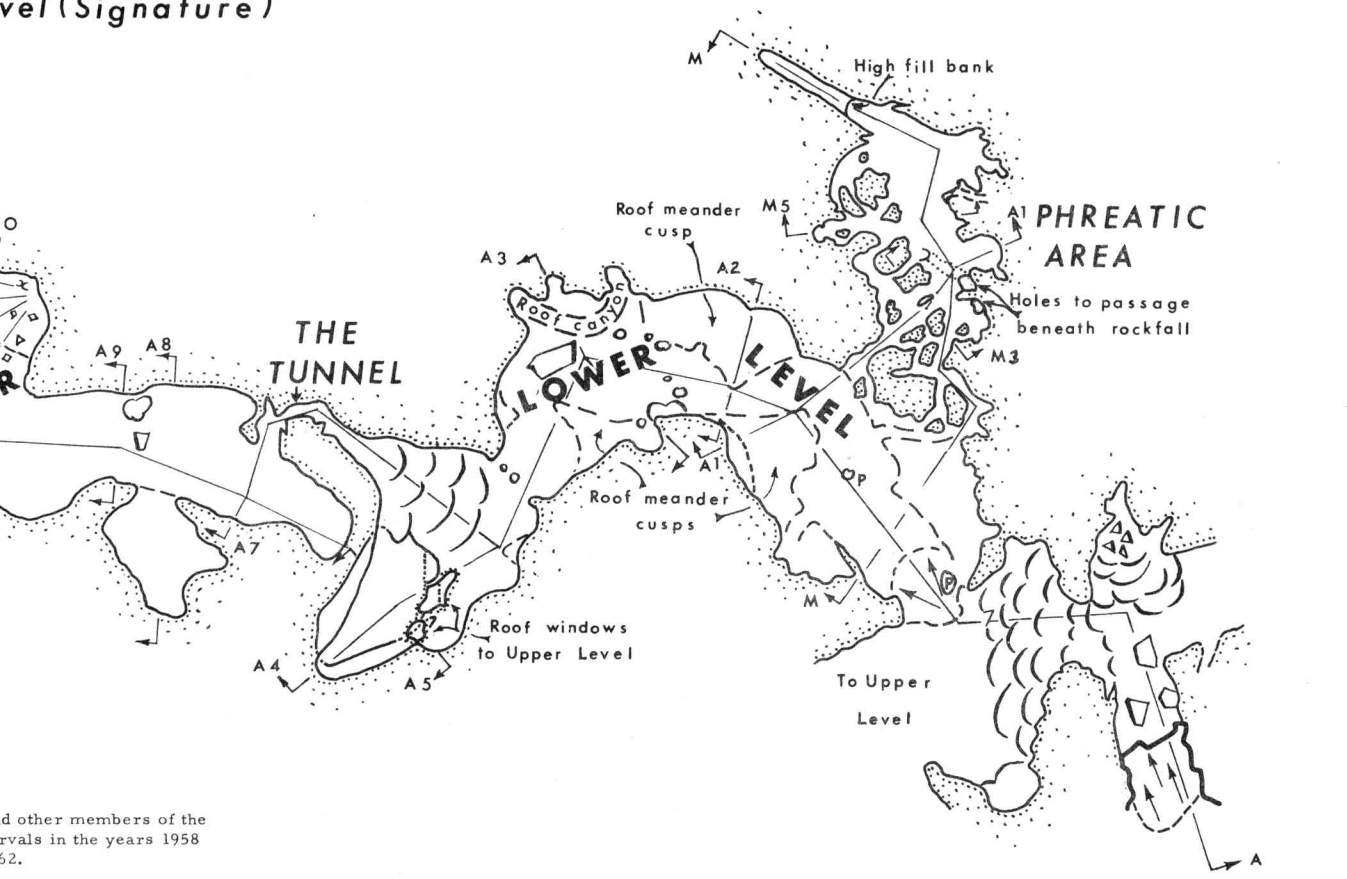
2. Punchbowl Cave by metallic tape, prismatic compass, Abney Level and hydrogen balloons (CRG Grade 5). Signature Cave by steel tape and miners dial (CRG Grade 6).

3. Heights are referred to datum on rock at right top of entrance to Punchbowl Cave. Altitude of datum is approximately 1480 ft. above sea level.

4. The various levels e. g. Upper and Lower Levels of Signature Cave refer to roof levels which, more consistently than the floors, preserve the record of successive phases of vertical stillstand and horizontal development of the cave system.

& SIGNATURE CAVES

ow Levels (Punchbowl)
vel (Signature)



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62.

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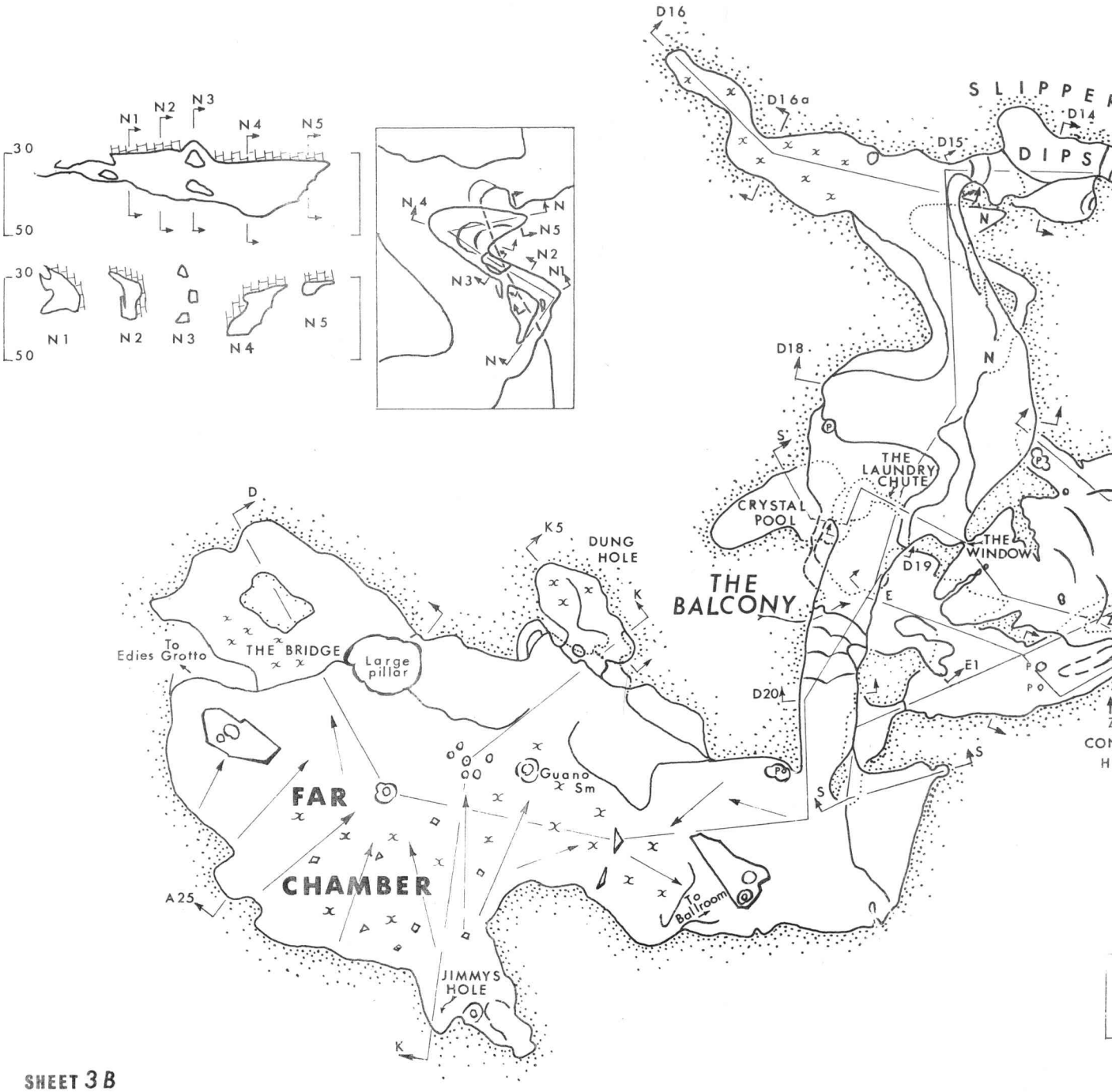
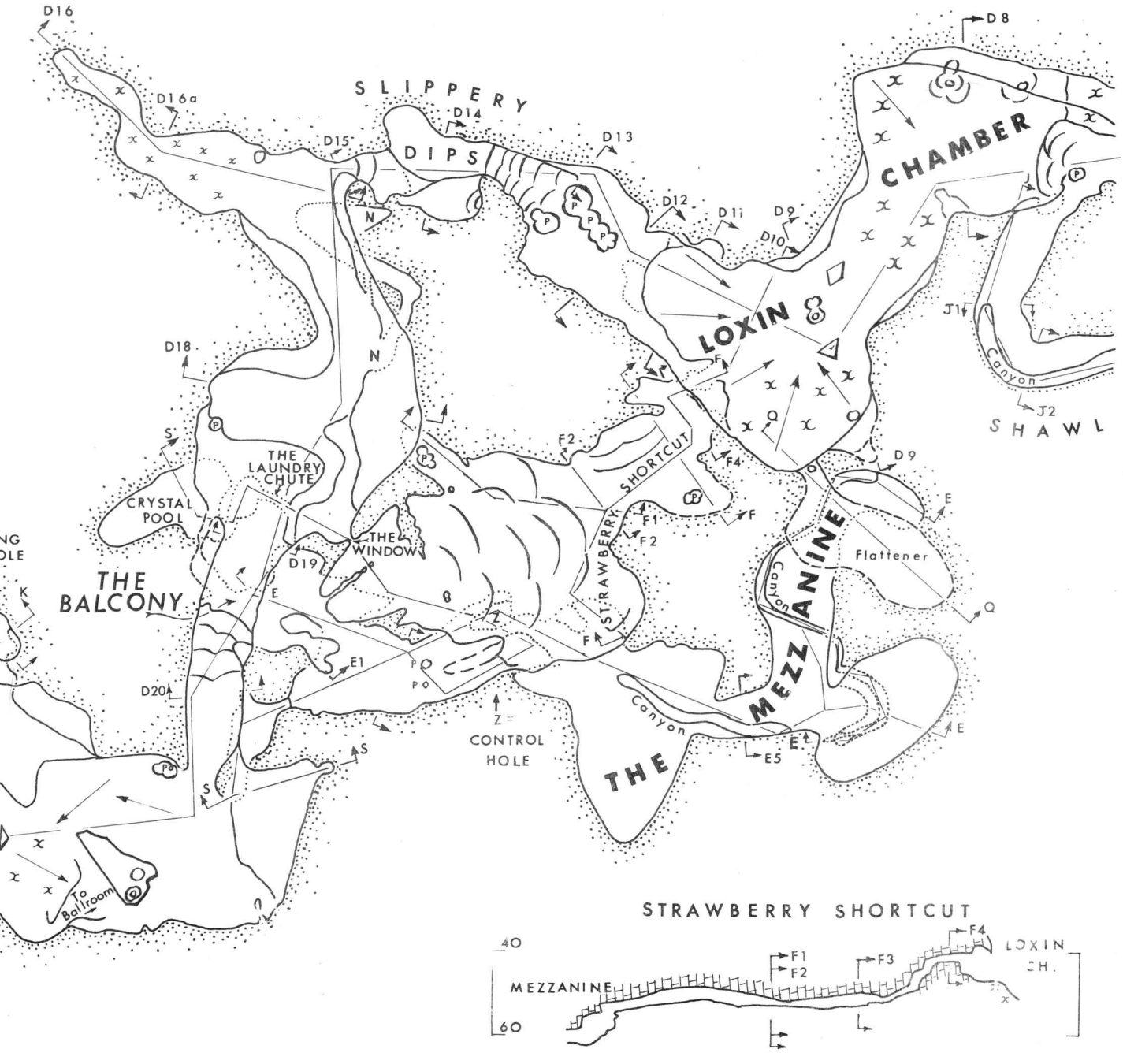

D16
D16a
SLIPPER
D14
D15
DIPS
N1
N2
N3
N4
N5
30
50
N
D18
THE LAUNDRY CHUTE
CRYSTAL POOL
THE WINDOW
D19
THE BALCONY
E
E1
D20
D
K5
DUNG HOLE
K
To Edies Grotto
THE BRIDGE
Large pillar
Guano Sm
FAR CHAMBER
A25
To Ballroom
JIMMYS HOLE
S
P
P3
Po

SHEET 3B


D16
D16a
SLIPPERY
DIPS
D14
D15
D13
D12
D11
D9
D10
D8
CHAMBER
LOXIN
J1
Canyon
J2
SHAWL
D18
N
S
THE LAUNDRY CHUTE
CRYSTAL POOL
THE WINDOW
D19
THE BALCONY
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E1
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P
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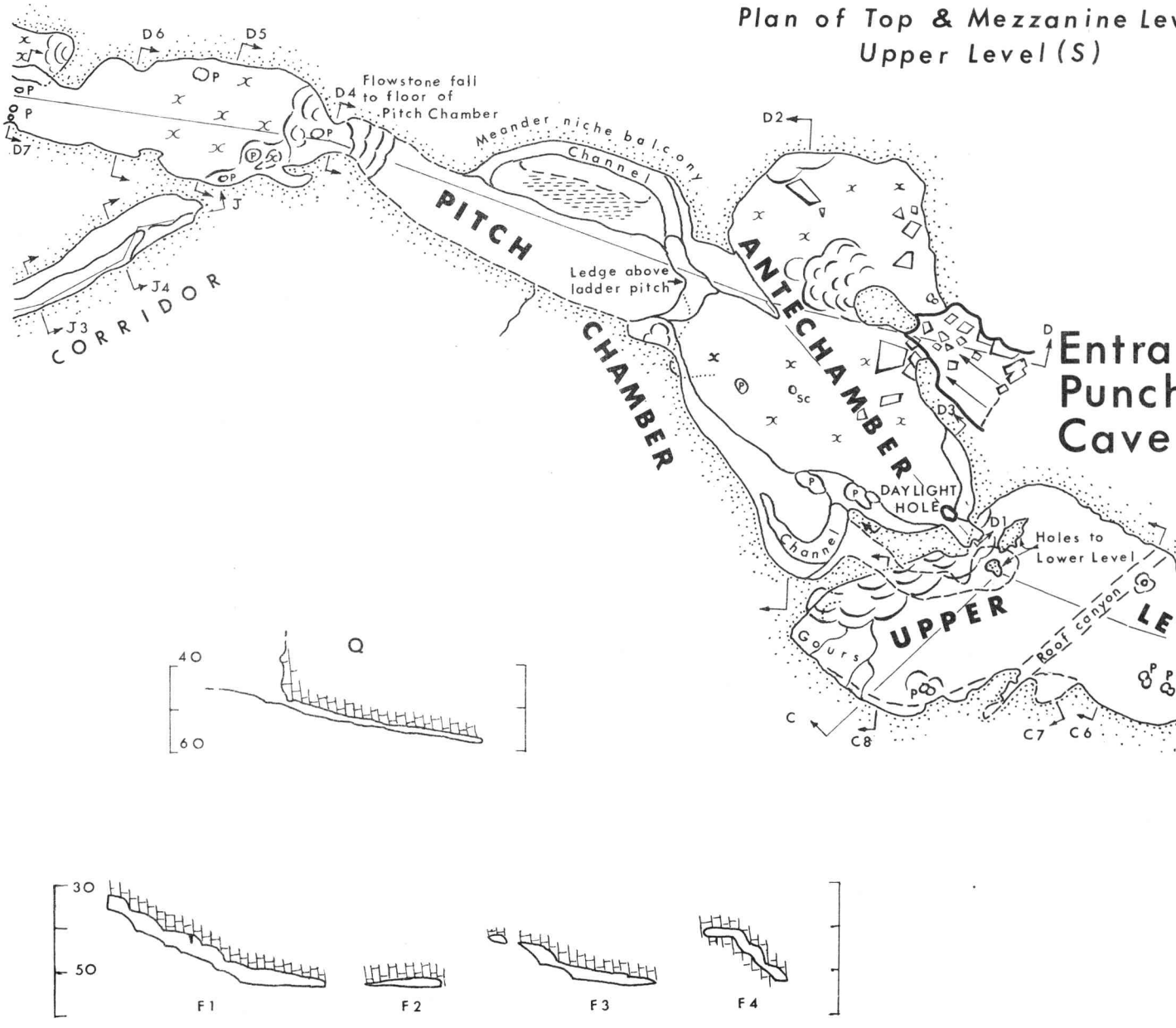
F2
STRAWBERRY SHORTCUT
F4
F1
F
D9
E
MEZZANINE
Canyon
Flattener
Q
Z = CONTROL HOLE
THE
Canyon
E5
To Ballroom
STRAWBERRY SHORTCUT
40
60
MEZZANINE
F1
F2
F3
F4
LOXIN CH.

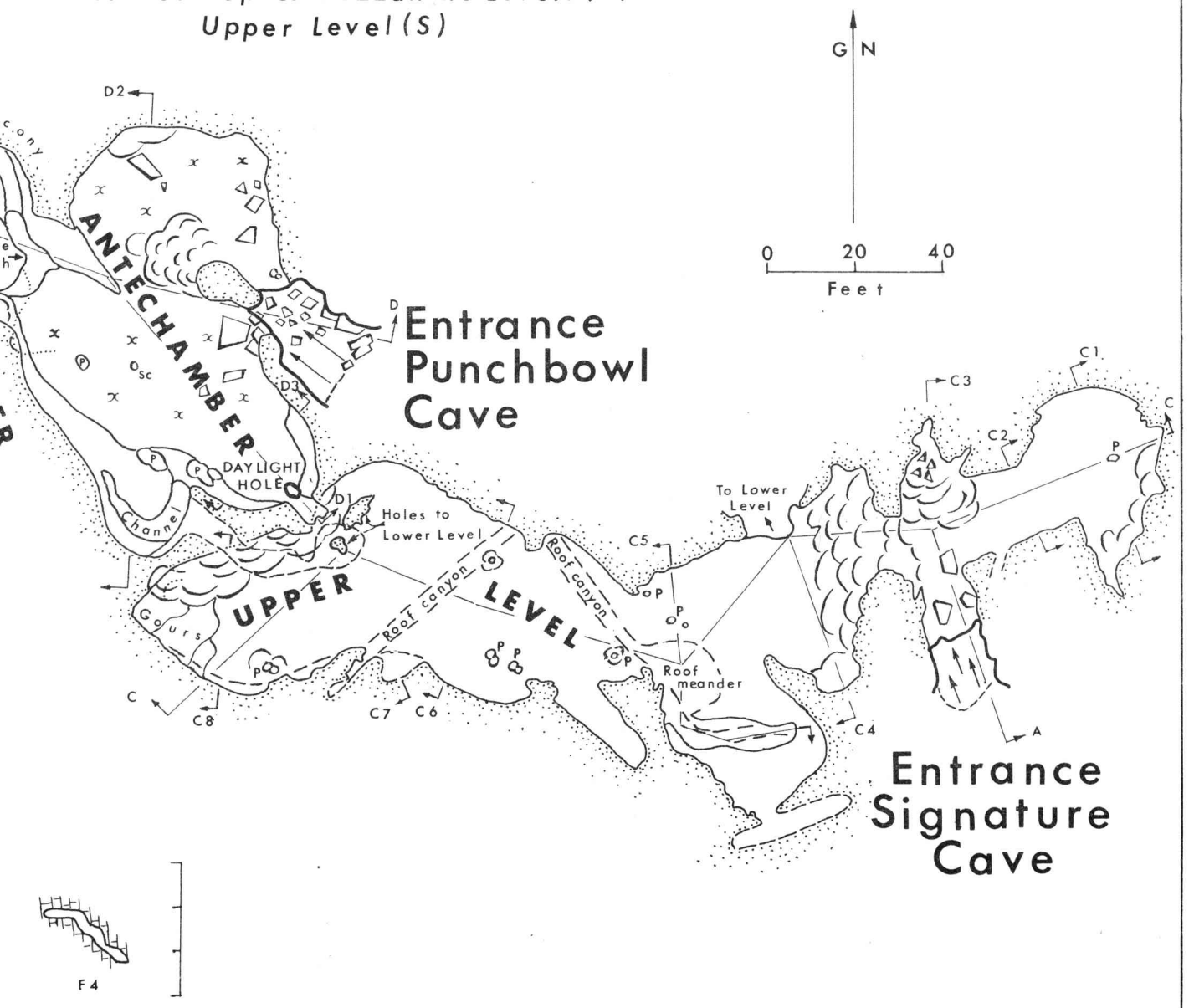
PUNCHBOWL & SIGN

Plan of Top & Mezzanine Lev
Upper Level (S)

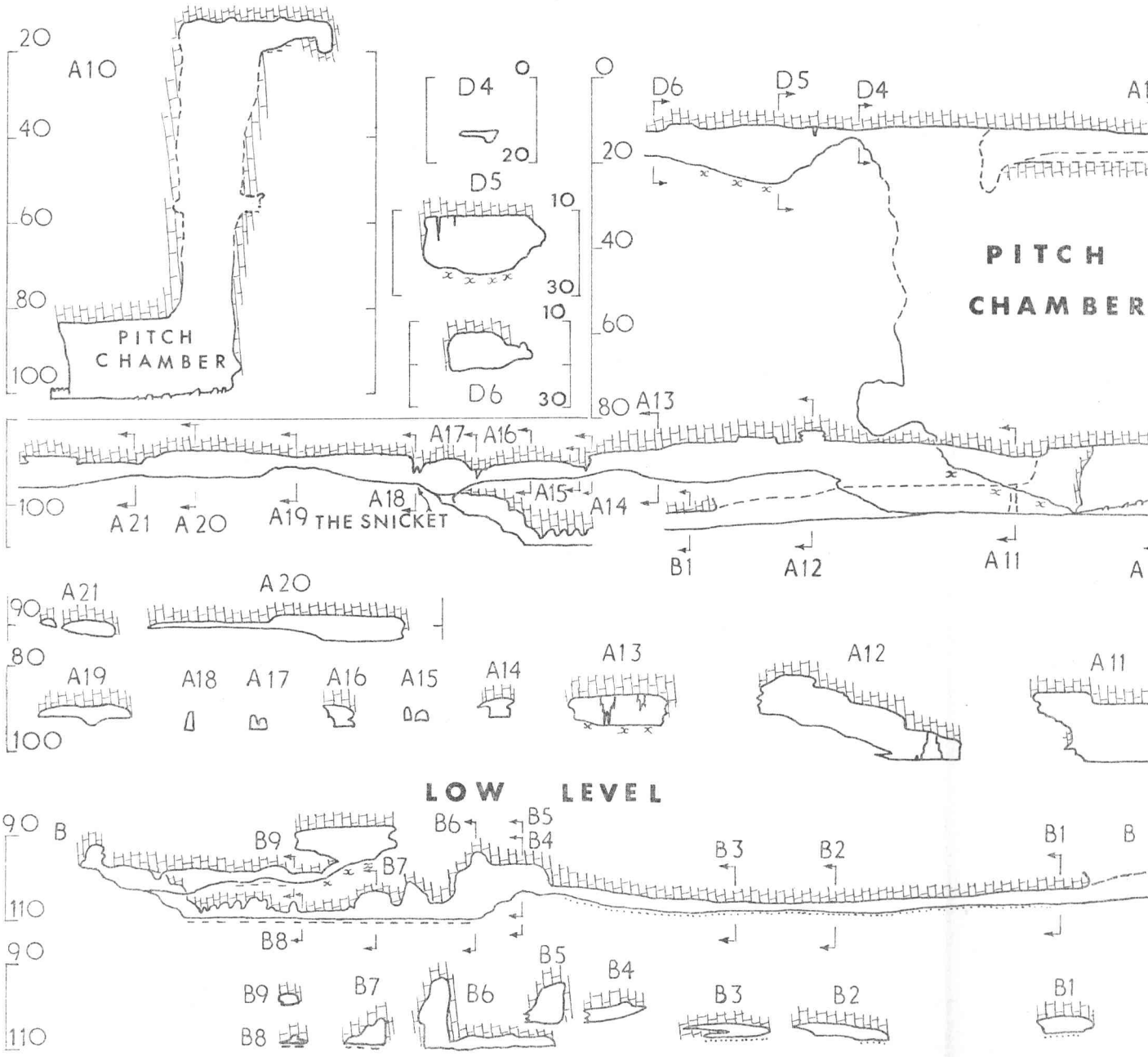


CHBOWL & SIGNATURE CAVES

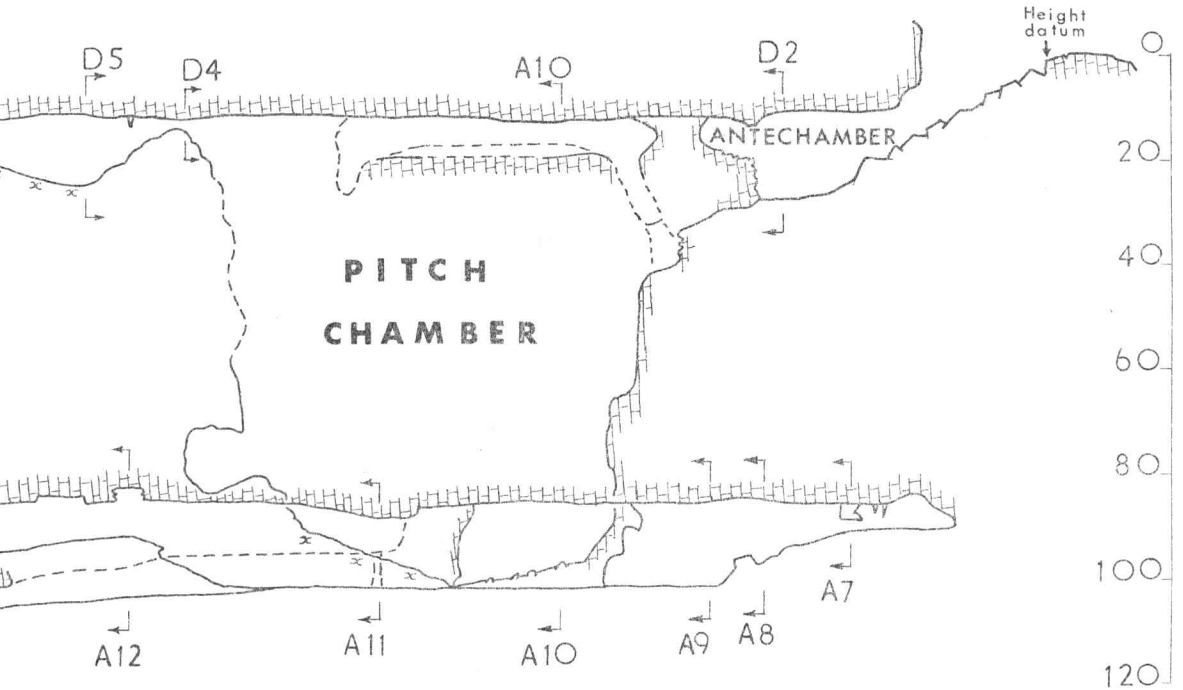
Plan of Top & Mezzanine Levels (P)
Upper Level (S)



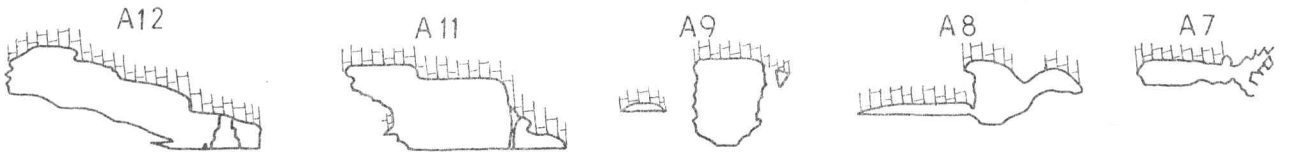
SHEET 3A

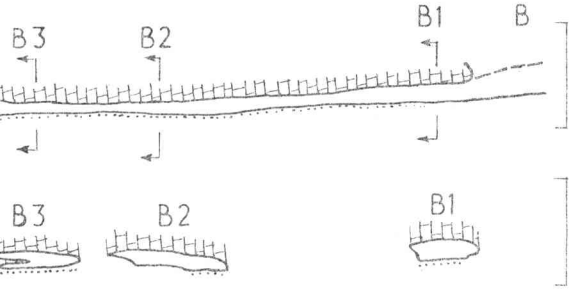


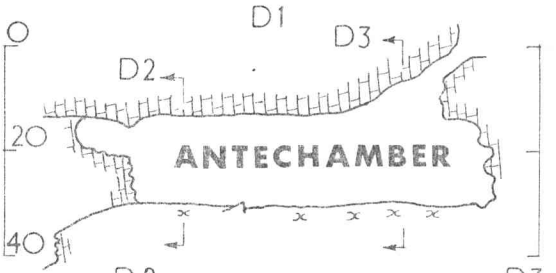
PITCH CHAMBER AND LOW LEVEL

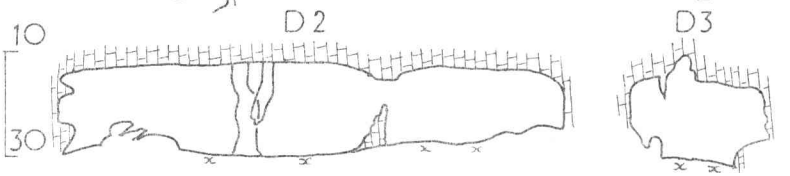


Sheets 4-7 comprise longitudinal and cross sections of the system.



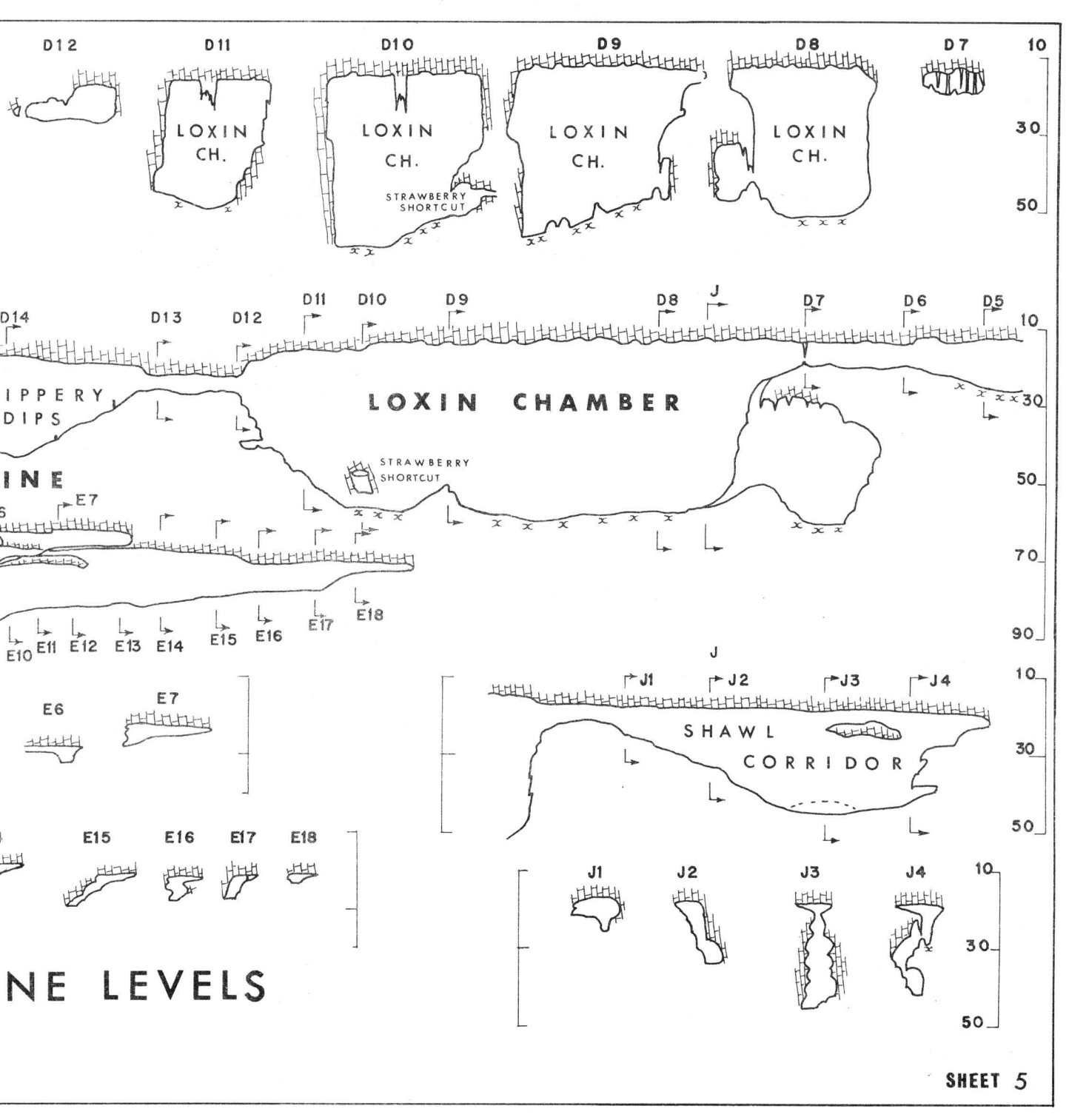






LOW LEVEL

TOP & MEZZANINE LEVELS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LOXIN CH.
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LOXIN CH.
STRAWBERRY SHORTCUT
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LOXIN CHAMBER
STRAWBERRY SHORTCUT
E7
E10
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E14
E15
E16
E17
E18
J
J1
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CORRIDOR
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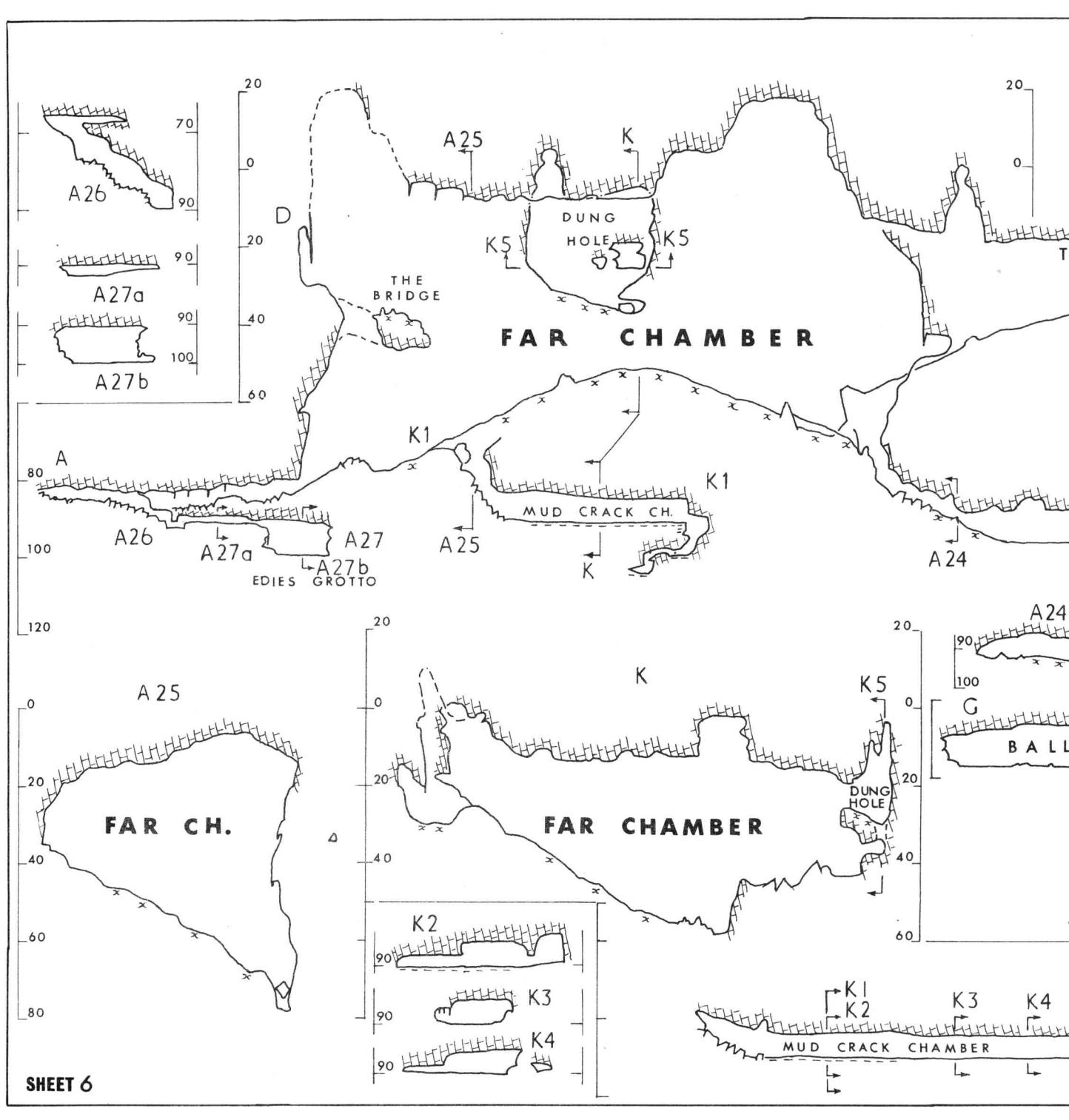
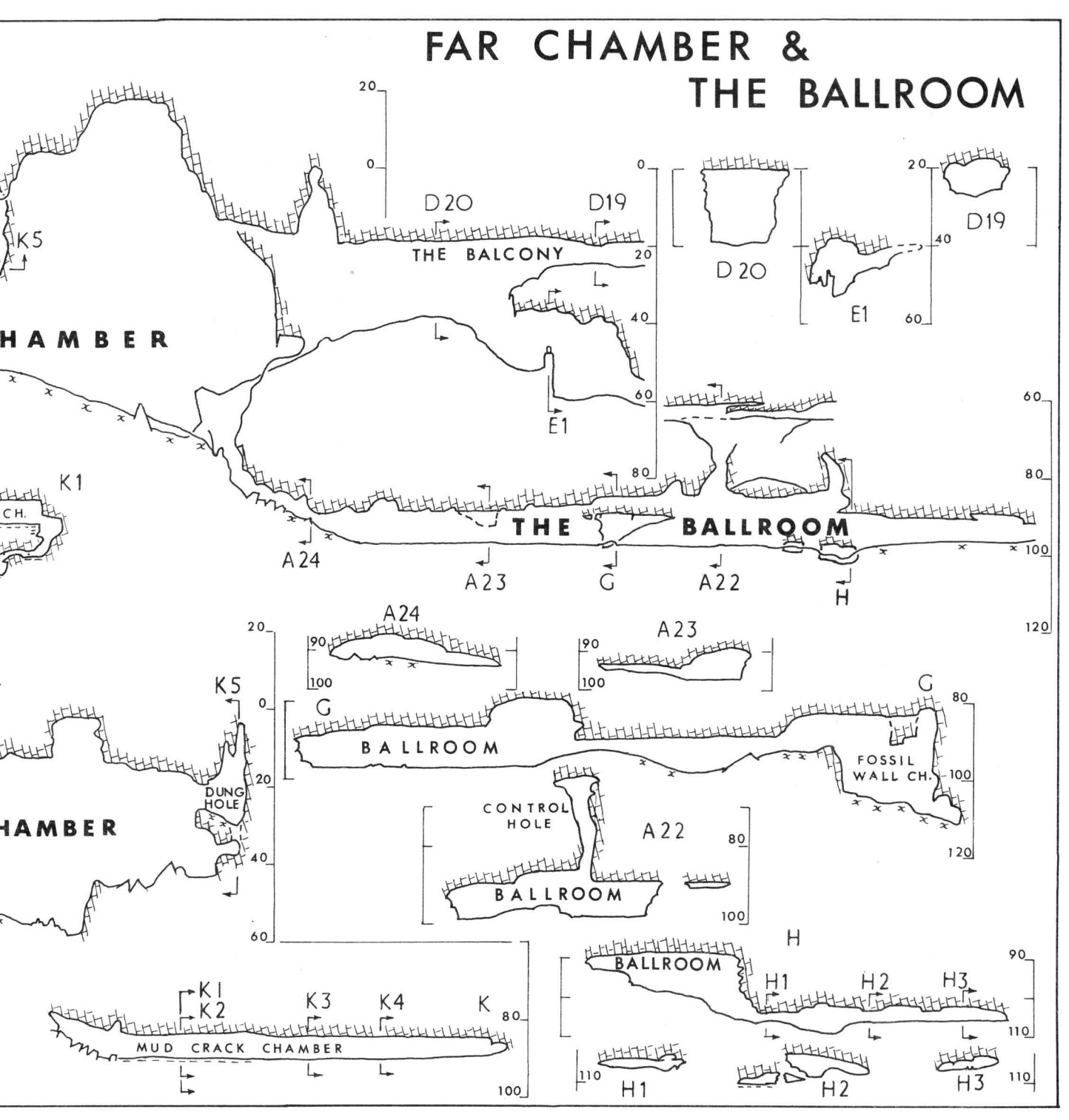
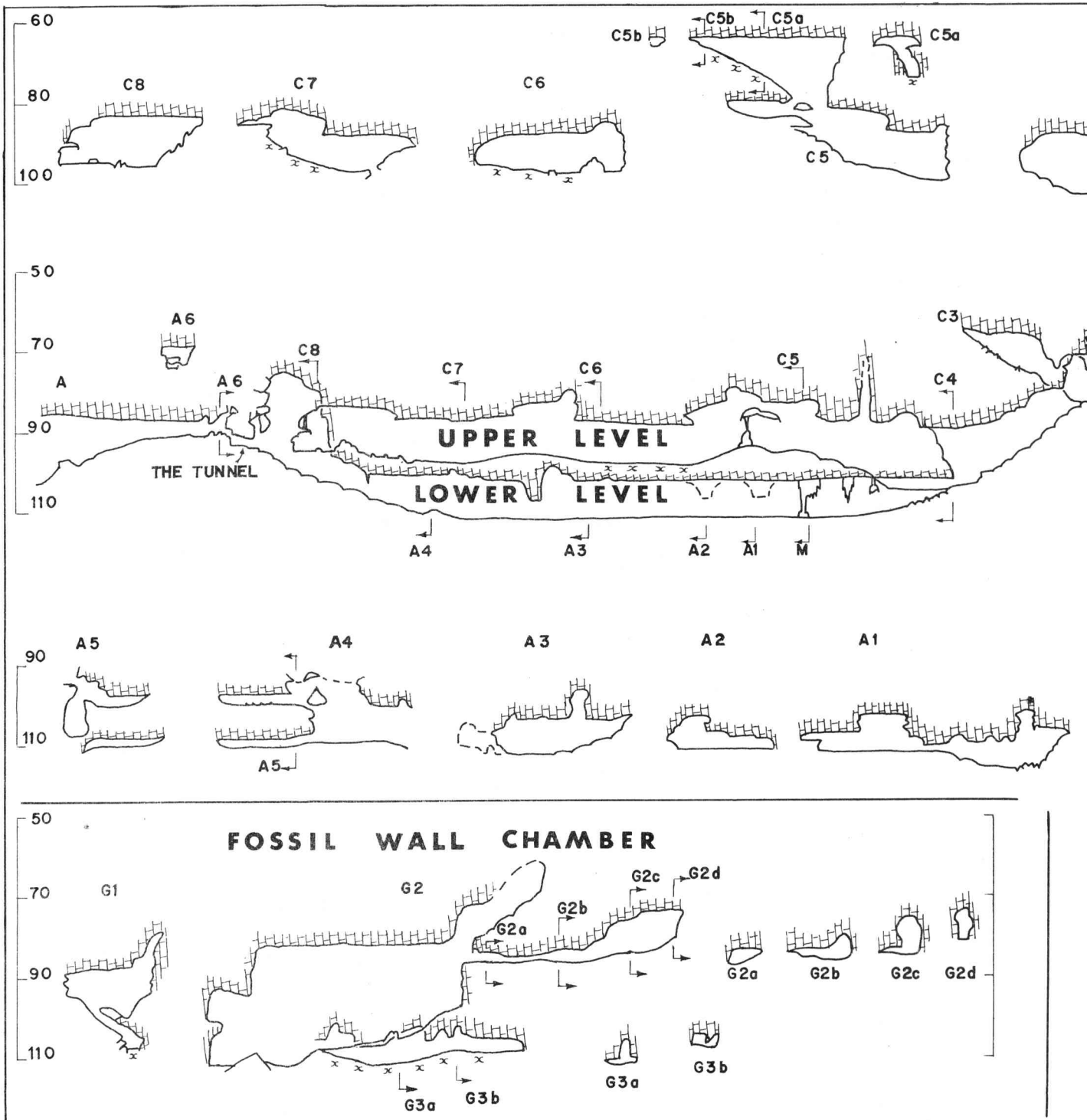
NE LEVELS
SHEET 5


A26
A27a
A27b
A25
K
DUNG HOLE
K5
THE BRIDGE
FAR CHAMBER
K1
MUD CRACK CH.
A24
A27
EDIES GROTTO
FAR CH.
K2
K3
K4
MUD CRACK CHAMBER
BALL

SHEET 6

FAR CHAMBER & THE BALLROOM

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C8
C7
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A6
C8
C7
C6
C5
C4
C3
UPPER LEVEL
THE TUNNEL
LOWER LEVEL
A4
A3
A2
A1
M
90
110
A5
A4
A3
A2
A1
A5
50
70
90
110
FOSSIL WALL CHAMBER
G1
G2
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G3b
G3a
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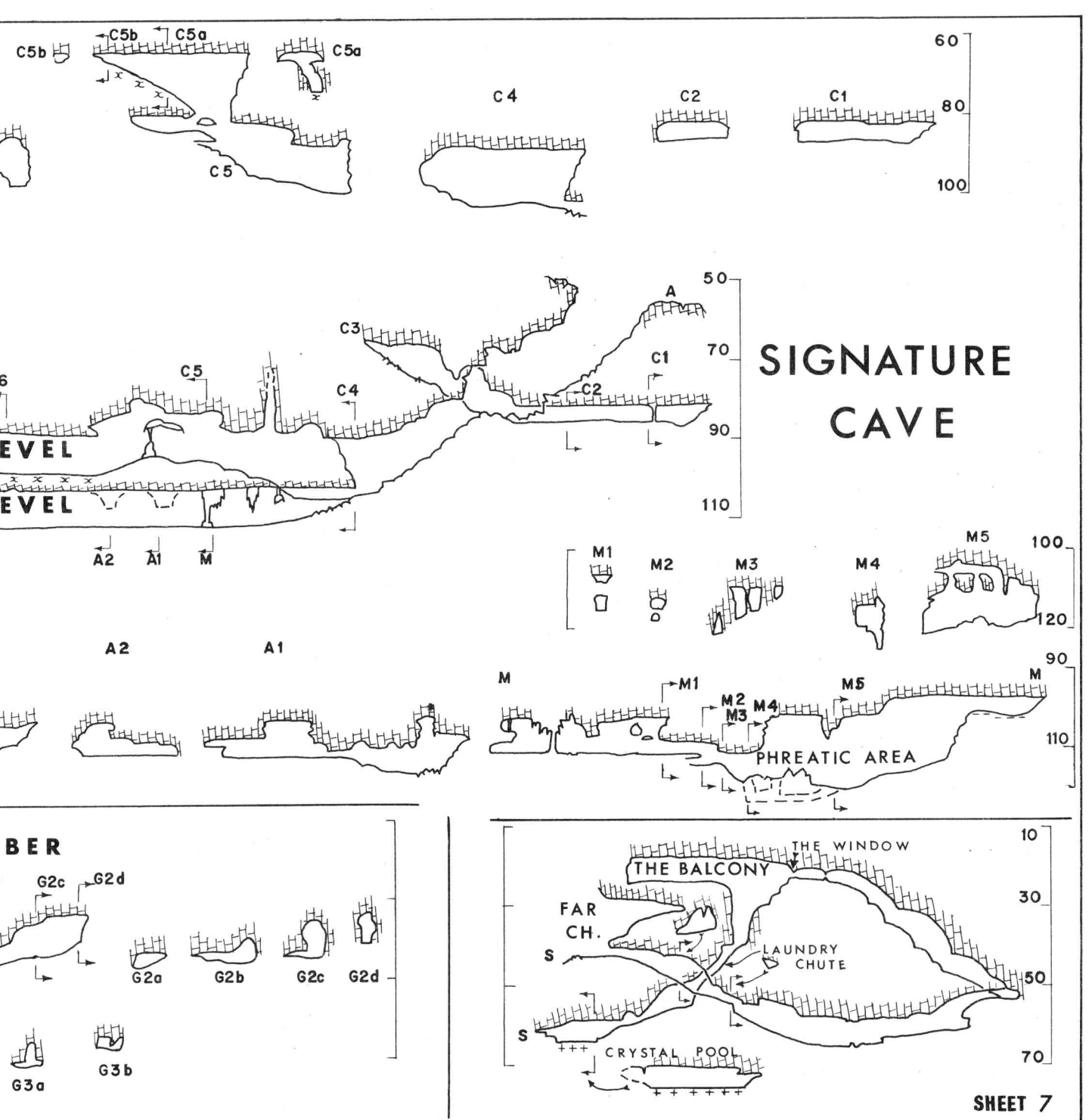
C5b
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M1
M2
M3
M4
M5
M
90
110
PHREATIC AREA
BER
G2c
G2d
G2a
G2b
G2c
G2d
G3a
G3b
THE WINDOW
THE BALCONY
FAR
CH.
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S
LAUNDRY
CHUTE
CRYSTAL POOL
10
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SHEET 7