Proc. Univ. Bristol Spelaeol. Soc., 1980, 15 (3), 227-240

GEOMORPHOLOGY AND SEDIMENTS OF AILLWEE CAVE, CO, CLARE, IRELAND

by
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O.S. 1 : 10560, Clare 5, E. 68.3cm., N. 39.6cm.

ABSTRACT

Aillwee Cave, now over 1km in length, is the most extensive cave thus far discovered on the high Burren. The cave is developed along a clay wayboard in the middle Asbian limestones and consists of a phreatic roof tube with a deep vadose trench below. Extensive rock fall and subsequent fluvial deposition occurred late in the history of the cave and the system is now almost fossil.

INTRODUCTION

Aillwee Cave (formerly McGanns Cave) is located on the eastern side of the Ballyvaughan re-entrant valley at an altitude of 92m. a.s.l. Since it has become a show cave finding the entrance has ceased to be a difficulty. The original cave, 204m. in length, is fully described in Drew (1974).

During excavation in the entrance passage in 1976 St. Patrick's Series was opened up and in 1977 the breakthrough into the new cave was made. The boulder choke at the end of the old cave was sufficiently massive and unstable to have defied conventional digging techniques. However, the fact that the roof tube disappeared into the choke made it certain that open cave existed beyond and thus a large excavation involving two men working for several weeks was mounted and the choke passed. Since then only minor finds have been made including the diving of the second sump.

In 1973 scattered bones of various small mammals and a horse together with a bear tooth were discovered in Horse Haven. In 1976 bear bones were found at the same site and in 1979 the upper part of the skull of a large male bear (*Ursus arctos*) was found at the eastern end of Bear Haven—some distance from the remainder of the bones. These finds lend some support to the theory that the shallow pits in Bear Haven were excavated by bears.

The section of cave as far as The Highway is open to the public; access to the remainder of the cave is restricted. The total length of surveyed passage in the system is 1070m.

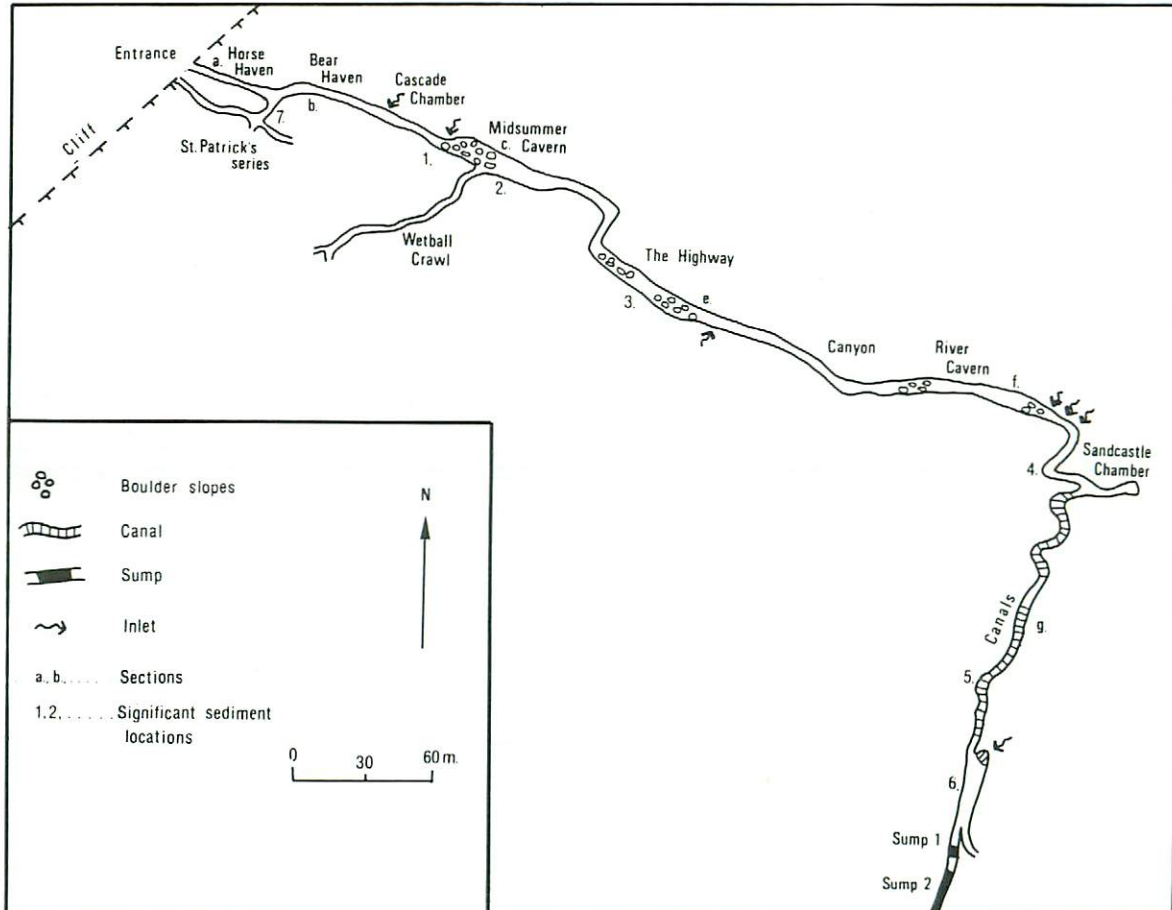

Figure 51: Plan survey of Aillwee Cave

CAVE DESCRIPTION

The enlarged entrance tunnel leads after 60m. to the slight enlargement known as Horse Haven (Figure 51). To the right is a low crawl into St. Patrick's Series, a passage parallel to the main route, terminating to the east in a mud choke and to the west in a second entrance (now blocked). The old cave consists of three linked chambers and beyond is the former boulder choke, now negotiated via an artificial tunnel.

Beyond, the cave opens out into the large Midsummer Cavern which contains a cluster of formations, otherwise very rare in the system. At the southwestern end of the chamber and near roof level is the entrance to Wetball Crawl, an unpleasant 100m. wriggle to a mud blockage where the passage bifurcates. From Midsummer Cavern to the end of the cave passage dimensions are determined by the extent to which the clay and boulders on the floor have been excavated by seepage waters. At first the route is a meandering tube, 2m. in diameter, until after 60m. the floor descends via boulder slopes at the beginning of The Highway. This is an almost straight section of passage, 150m. long, 16m. high and 9m. wide. At the far end a climb up leads to a 5m. pitch which may be by-passed through boulders to the left. A high, narrow rift, The Canyon, follows and then a climb up to the beginning of River Cavern. A medium sized stream emerges at roof level at the eastern end of this chamber and flows west for 30m. to sink through the boulder floor. The origin and destination of this stream are unknown.

Beyond River Cavern the passage reverts to a circular, 2m. diameter form until Sandcastle Chamber is reached. Ahead is a narrow vadose tunnel leading to the foot of an awkward 3m. pitch with a blockage at the top. A climb into the roof of Sandcastle Chamber enters an ascending rift, blocked by boulders after 25m. The main route on is a low crawl in water to the right through the canals. This 200m. long section has a minimum airspace of 20cm. under normal conditions but following heavy rain the entire passage sumps for several days. Canal Passage emerges into a lofty chamber oriented north-south with a 3m. deep pool at its northern end. At its southern end the passage forks; to the left is a descending sandy dig, whilst to the right the passage drops over sand banks to Sump 1. The sump is 3m. long and constricted and beyond is 30m. of low, wet crawl to the second sump. This has been dived for 60m. to a depth of 4.5m. in a cramped passage with no very obvious way on. (Farr, 1978).

GEOLOGY

The cave is developed in the uppermost part of the marked massive band in the middle of the Asbian (D1) formation. Above is the terraced sequence of the upper Asbian with well-developed bedding partings. The massive band is c.30m. in thickness with no true bedding planes, although the east-west jointing system is well-developed. (C. McDermott personal communication). The cave entrance is located 2m. above a

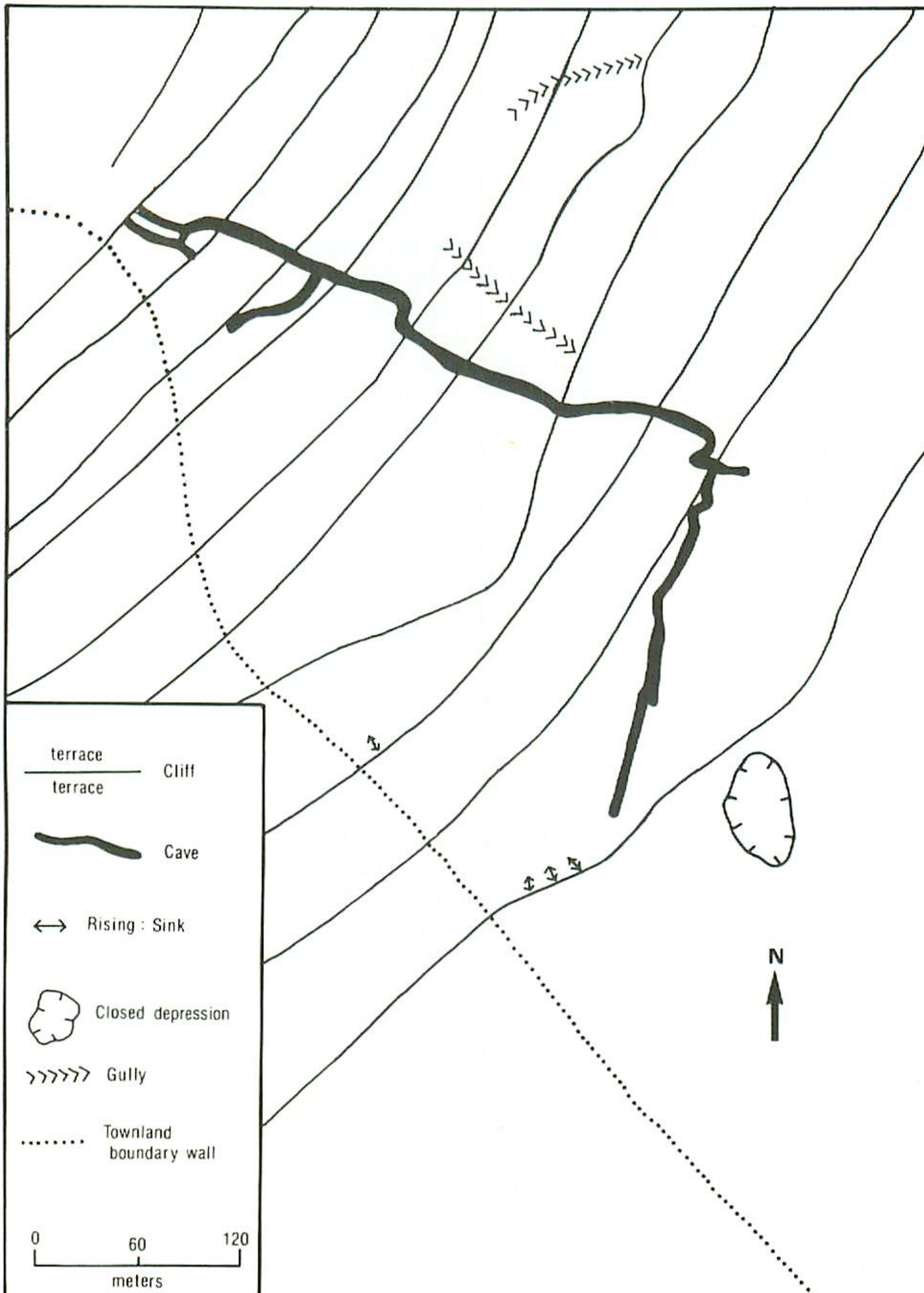

Figure 52: Aillwee Cave in relation to surface features

Plate 8 The cliff face immediately northeast of the cave entrance showing the clay wayboard overlain by the calcite layer.

Plate 9 Canal Passage showing the limit of the original rhythmite fill. Note that the fill reached the roof in places.

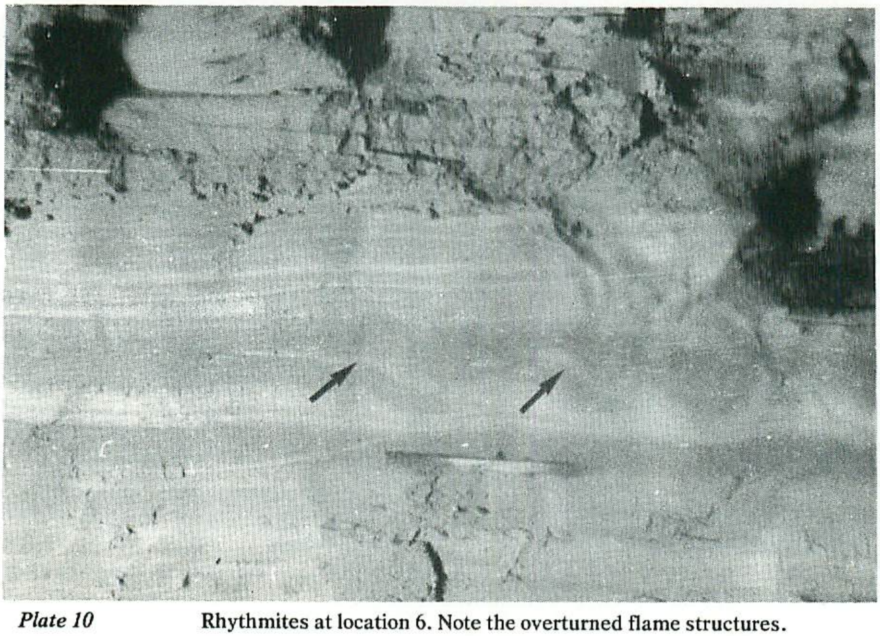

Plate 10 Rhythmites at location 6. Note the overturned flame structures.

very pronounced clay wayboard, 0.5m. thick which marks the top of the massive unit (Plate 8). the wayboard, on bentonitic clay, is probably a reworked volcanic tuff and is overlain by a 0.2m. thick layer of macro-crystalline calcite. Above the calcite the limestone is very thinly bedded for 2m. and contains abundant productid fossils. The higher beds are 1-1.5m. thick and it is in the lowest bed of this sequence that the roof tube of the cave is developed (Figure 53). Although the wayboard is not apparent in the cave it was almost certainly the prime determinant of the horizontal position of the cave. The calcite layer is visible at many places in the system.

The cave is oriented along the strike (i.e. west-east), of the strata as far as Sandcastle Chamber beyond, the passage to the end of the cave runs down-dip (south). Throughout its length the roof tube is developed in the beds immediately overlying the *Productus*-rich zone. The wayboard seems to function as a considerable barrier to the downwards percolation of water—a series of springs emerge above the wayboard along the whole length of the terrace to the east and west of the cave, whilst underground all tributary passages and water inlets occur at this stratigraphic level, as does the terminal sump.

The cave entrance is located just above the level to which glacial drift is banked against the hillside. This drift includes decayed granite erratics and is therefore presumably a reworked deposit from the penultimate glaciation of the Burren.

GEOMORPHOLOGY and HYDROLOGY

Cave Morphology

Figure 53 illustrates passage cross-sectional form at selected sites. Section number refers to those shown on the survey (Figure 51).

Perhaps the most significant passage component in the cave is the roof tube (half tube) which runs the full length of the cave from the entrance to the sump. In the entrance series it is 1m. in diameter, increasing to 2.5m. diameter from Midsummer Cavern onwards. Although it is oriented first along the east-west and then along the north-south joint system, in detail the tube seems largely independent of structural control, in places meandering tightly as between Midsummer Cavern and The Highway and east of River Cavern. Smaller roof tubes join at the same level from Wetball Crawl, from the inlet at Sandcastle Chamber and from the entrance passage itself. The *Productus* beds below the tube were probably the zone of cave initiation as in the areas where collapse has not occurred they display an extensive network of anastomosing channels. The roof tube may represent selective enlargement of these anastomoses. Although it was originally thought that the cave was a fossil resurgence the evidence from scalloping in the roof tube together with the fact that the tube increases in diameter progressively into the cave suggest that the water flow that initiated the cave was into the hill.

The form of the passage below the roof tube has been obscured by collapse of the thinly bedded strata and by lateral spalling of the closely jointed strata of the massive unit, particularly in the east-west trending section of the cave which parallels the dominant joint system. With the exception of the section between the entrance and Horse Haven, bedrock is never seen at floor level. Borings at several sites inside the cave show that the passage must be at least 20m. in height. The unmodified remnants of the cave (roof tube and anastomosing channels) appear wholly phreatic in origin, but at The Canyon the low-level passage is a narrow (1.5m. wide) trench with walls of bedrock and the roof tube offset to the south. This may indicate that the passage form was a deep vadose trench now obscured by collapse and sedimentation. Of some interest is the fact that the entrance passage is a simple roof tube with no development below. The main cave swings to the southwest at Horse Haven to intersect the cliff-face immediately west of the tourist entrance.

Hydrology

Although the cave is now fossil in terms of the water that initiated cave development, the passages have been invaded by numerous smaller inlet streams. Major inlets occur in Cascade Chamber, The Highway, River Cavern and just before the sumps. The water entering River Chamber is sufficient in discharge and consistency to suggest a discrete surface source. However, repeated attempts at water tracing all known sources of water on the hill above, including the major stream at Mill Sink, have proved fruitless. The modern hydrology of Aillwee Hill appears to consist of shallow groundwater flow along the bedding, perched by the numerous shale bands and it is difficult to understand how large quantities of water percolate the 100-150m. vertically in order to enter Aillwee Cave. Following heavy rainfall a large stream emerges from the sumps and from the deep pool at the end of the canals and flows through to River Cavern. Under these conditions the volume of water makes the passage between the River Cavern and Sandcastle Chamber virtually impassable. The catchment area required to generate such a flow must be in the order of several square kilometres.

SEDIMENTS

Description

Clastic sediments cover the complete floor of the cave. They are best preserved at location 6 (Figure 51) and in the canals where subsequent erosion has been minimal, in contrast to The Highway where most of the fill overlying the boulder floor has been eroded. A total of four main non-genetic classes of sediments are recognised.

1. *Rhythmites*. These consist of thinly bedded (0.1-2.0cm.), rhythmically laminated units of clay or silt and fine to medium sand arranged in couplets. a range in lamina thickness may occur with exceptional individual thicknesses of up to 13.2cm. of fine sand in the section at location 6 (Figure 54a). Clay laminae thicknesses also vary laterally in the

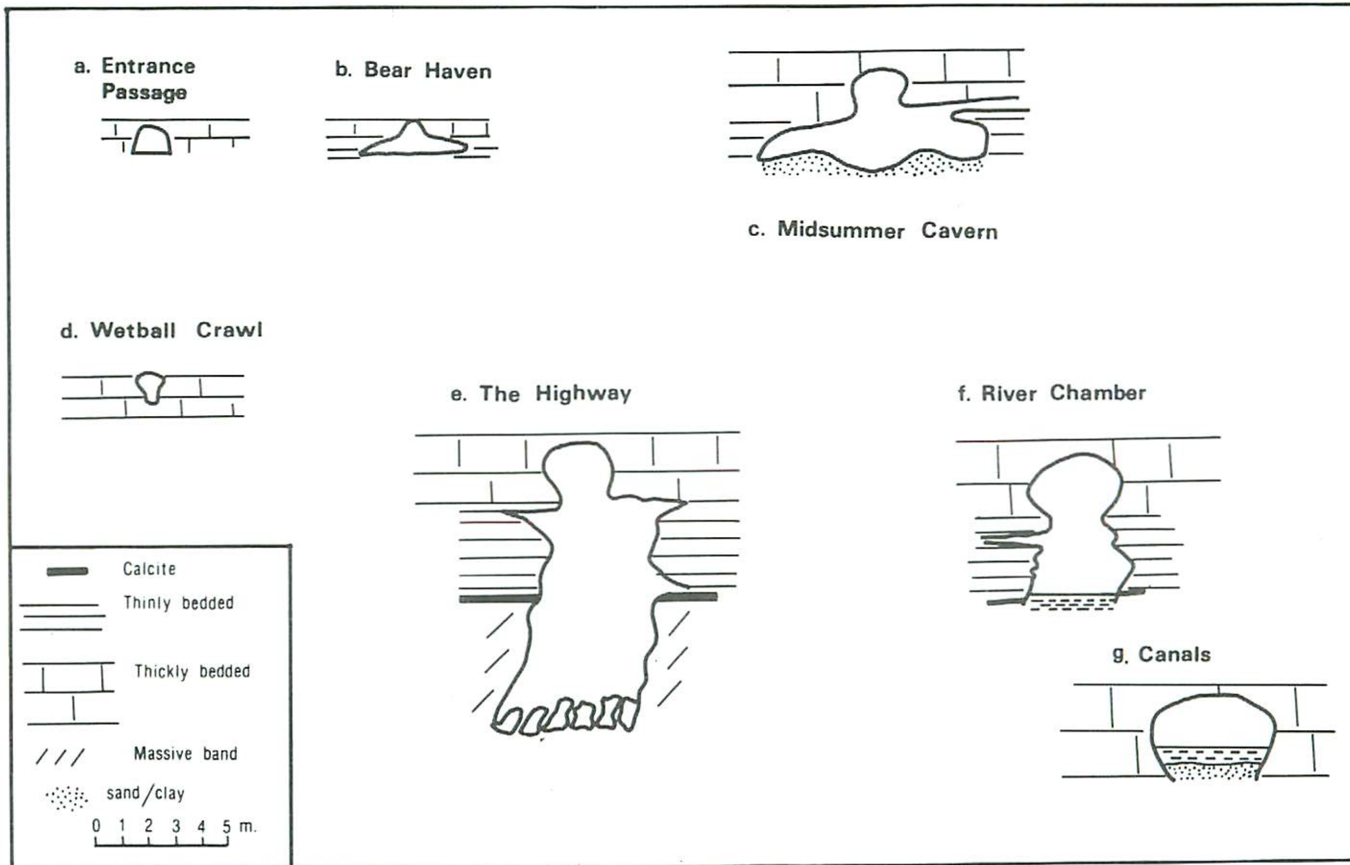

Figure 53: Passage cross-sections and cave lithology at selected sites (Figure 51) in Aillwee Cave. Sections are drawn looking inwards.

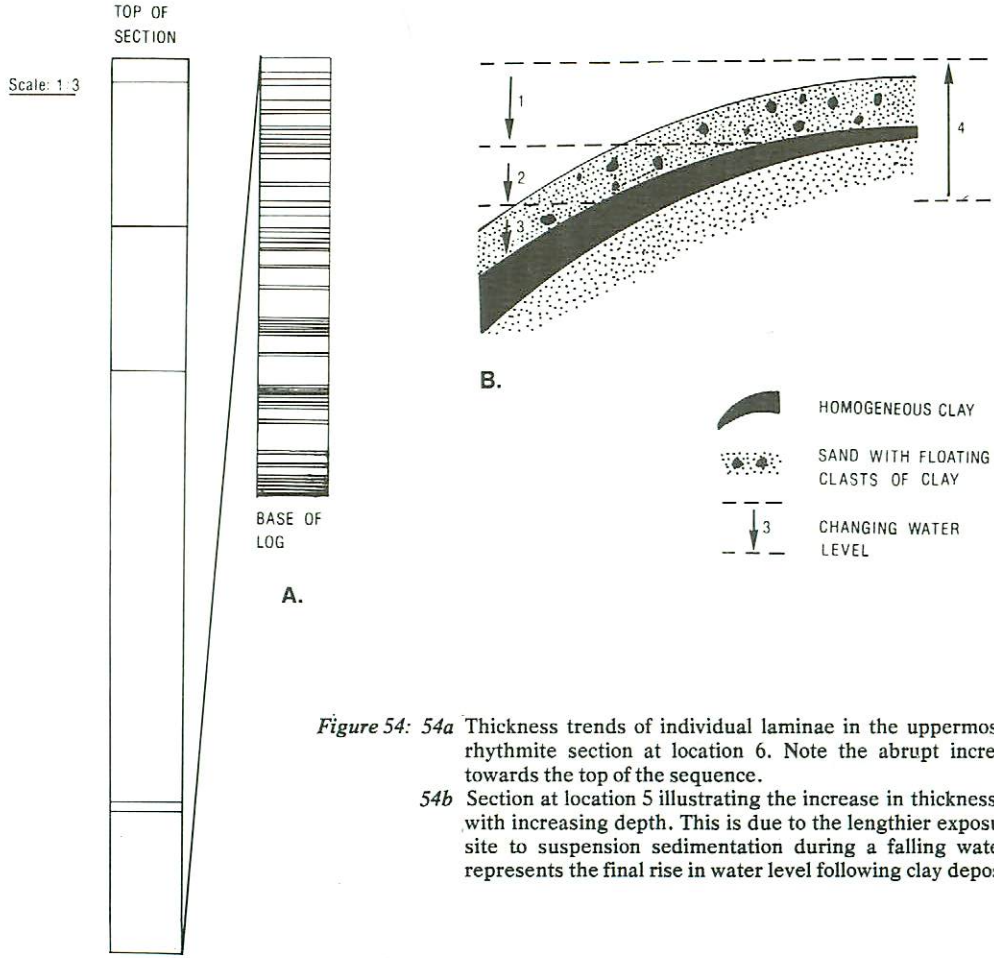

Figure 54: *54a* Thickness trends of individual laminae in the uppermost 13.7cm. of the rhythmite section at location 6. Note the abrupt increase in thickness towards the top of the sequence.

54b Section at location 5 illustrating the increase in thickness of a clay lamina with increasing depth. This is due to the lengthier exposure of the deeper site to suspension sedimentation during a falling water level. Level 4 represents the final rise in water level following clay deposition.

rhythmites in the canal passages (Figure 54b). The rhythmites are present both in the narrow tube passages commencing inwards from the boulder choke at location 2 and in the larger caverns including that at location 6 and in The Highway. In The Highway, erosional remnants of the rhythmites are preserved overlying a boulder fill (location 3, Figure 51). A clay coating on the cavern walls up to a maximum height of 6m. above the boulder floor indicates the level of a previous fill. Further evidence of this fill is indicated by a coating of clay on the upper surface of individual boulders. Erosion of previous fills is also evident in the canal series where water occasionally flows in the eroded channels. Rhythmites have previously filled the canals to the roof in places (Plate 9).

Sedimentary structures exposed in the 3m. section at location 6 include: isolated ripple formsets and overturned flame structures (Plate 10) in the fine sand units; minor (2cm. diameter maximum) scours; intra-stratal crumplings and syndepositonal faults of the normal and reverse types with graben type patterns. Massive dislocation of bed dips are also present with secondary dip angles up to 20°. Occasional boulders are also exposed within the rhythmite sequence at this location.

2. *Diamictons*. This term is used to describe non-sorted to poorly sorted clastic sediment consisting of sand and larger particles in a muddy matrix (Flint 1960). These sediments are poorly sorted in contrast to the fluvial gravels and sands described below. Except at location 7 (Figure 55) the diamictons always occupy the top of the clastic succession. A diamicton unit extends from the main entrance to location 1 where it was separated from the rhythmites at location 2 by a boulder choke.

3. *Fluvial gravels and sand*. These sediments occur both in the St. Patrick's series in a fossil sequence and as sediments presently being deposited on the passage floor between River Cavern and location 6. These sediments are relatively well rounded compared to the clasts within the diamictons. No erratic (non-limestone) material was noted. Large accumulations of well sorted coarse sand occur in Sandcastle Chamber on the outside of a passage bend. Fossil sand accumulations are also exposed at location 7 (Figure 55) and contain cross-stratification which indicates successive flows in opposing directions.

4. *Boulder fill.* This is present throughout the cave except between the main entrance and Horse Haven where the floor is bedrock. The boulders are angular and irregular and were clearly not transported by water. At location 4 the boulders tend to dip consistently towards one wall. Generally, however, the boulders assume a random orientation and fill the cave to different levels depending upon the effect of local dissolution and partial removal.

A facies model of the principal sediment types in the main passage is presented in Figure 56 and represents the general stratigraphy. The exact relationship between the rhythmites and diamictons in locations 1 and 2 is not fully apparent.

Discussion of sediments

The rhythmites resemble varves, however, no type of seasonal cycle

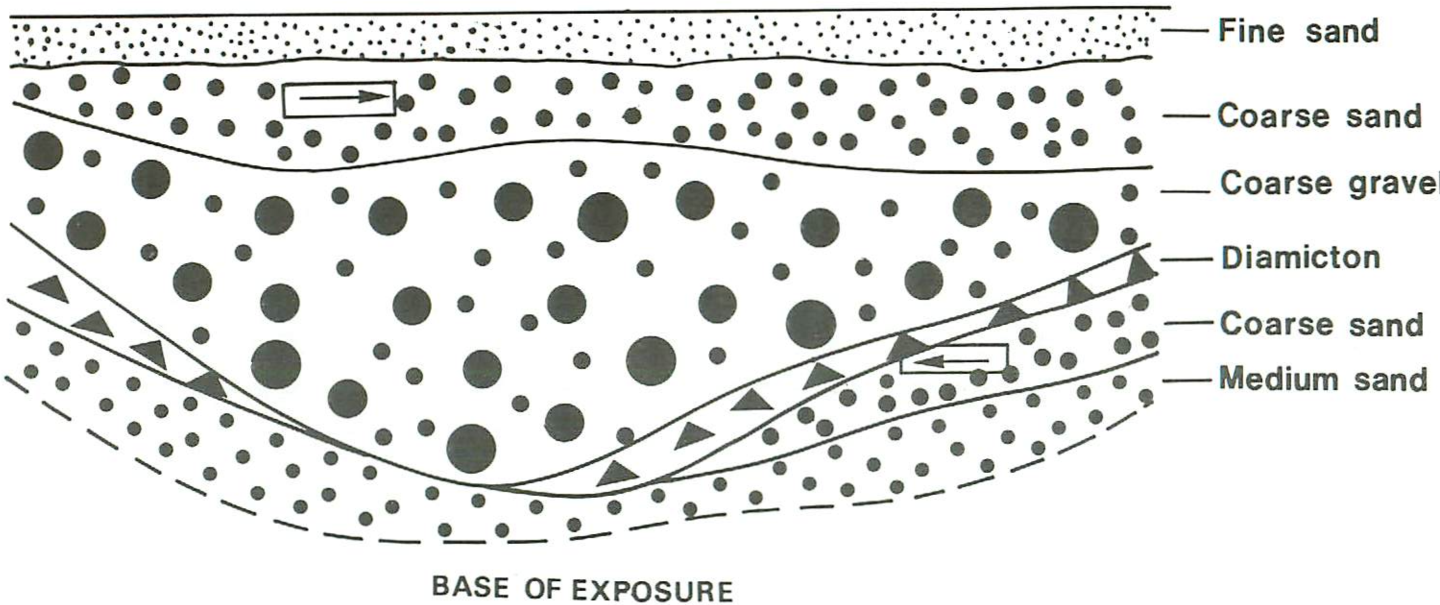

Figure 55: Section at location 7 containing fluvial sands and gravels and a partly eroded diamicton unit. Note the successive and opposing current directions.

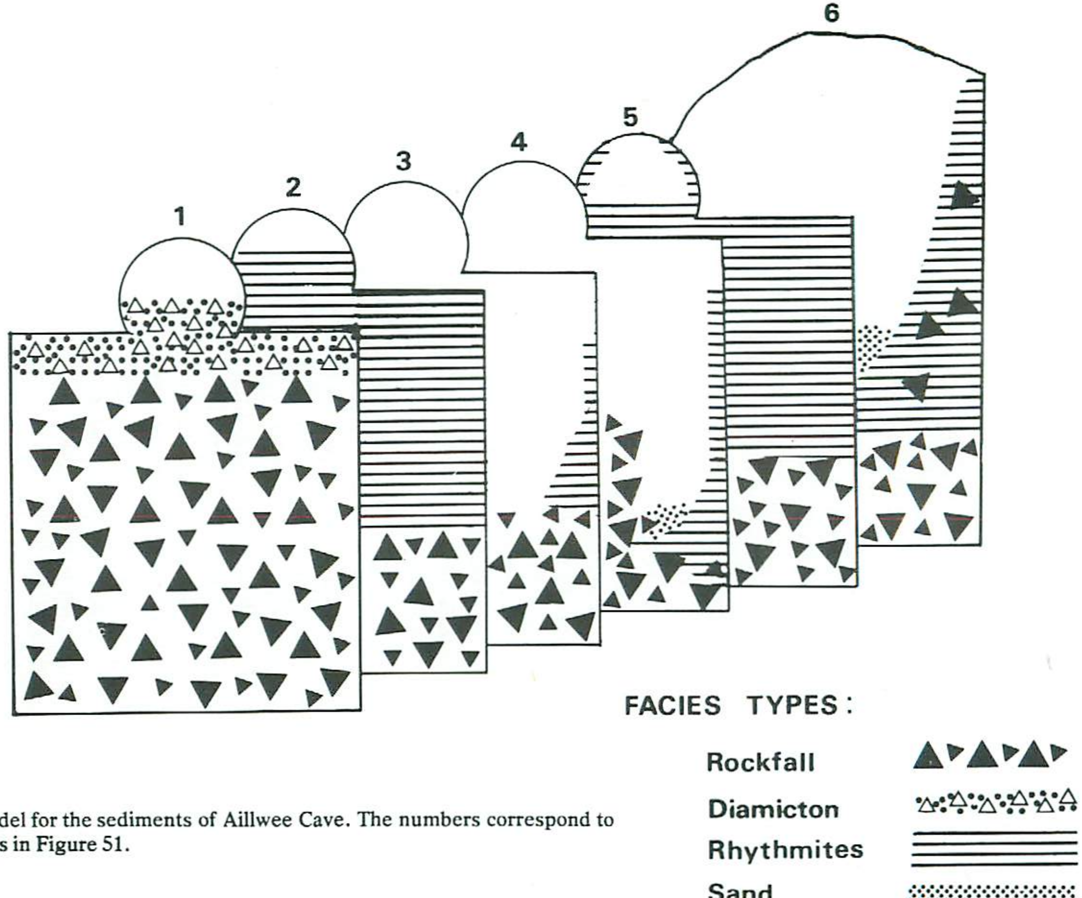

Figure 56: A facies model for the sediments of Aillwee Cave. The numbers correspond to the locations in Figure 51.

in sedimentation was recognised. The probability that the rhythmites are non-annual and that they are therefore non-varved comes from the presence of overturned flame structures which indicate rapid deposition Cohen 1979, see Plate 10). Current activity is also indicated by floating mud balls within sand units, erosional scours and isolated ripple form-sets. Assuming that the coarser units are non-season, then clay laminae must represent residual sedimentation from stagnant water between each flow event and are correspondingly non-seasonal. The thickness of suspension derived silt and clay laminae was determined by the frequency of the interrupting flow events and also in some cases by the relationship between the height of a depositional site and falling water level (Figure 54b).

Syndepositional deformation structures may represent minor contemporaneous erosion and undercutting whereas the massive disturbance structures represent undercutting and gravity sliding on a large scale during the fluvial erosion episode which followed the rhythmite deposition. The rhythmites are present only between the sump at location 6 and location 2 which is adjacent to the old boulder choke.

On the entrance side of the boulder choke (location 1) the diamicton unit is exposed. Three origins are considered for this deposit; glaciogenic (till), mass flow and sliding bed processes. The glaciogenic origin is disputed on the basis of passage size and unit thickness. The unit of diamicton as exposed in the half tube passage at location 1 is 1m. in thickness which represents half of the present passage height. The unit is unstratified and therefore must have been deposited during a single flow event. It does not seem possible that approximately 1m. of ice could have transported and deposited 1m. of sediment inside the cave. The second origin is deposition by mass flow of exterior sediment into the cave, either directly from an exterior ice margin as flow till or from the reworking of glacial sediments which probably extended up to and higher than the cave entrance. The difficulty here is to establish how a mass flow could extend for approximately 150m. into the cave over the extremely rough bed of boulders. The final option is deposition from a sliding bed transported under full pipe flow conditions as in subglacial esker sedimentation processes (Saunderson 1977). This would require high sediment discharge into the cave and a phreatic situation. A problem here is to account for the termination of the diamicton at the old boulder choke. If this mechanism is viable then it must be accepted that the boulder collapse only partly filled the passage beyond Cascade Chamber. The partial fill may have then retained most of the sliding bed on the entrance side and allowed the associated water to escape and pass over into the passage beyond. This hypothesis cannot be elaborated however until either the mass flow or sliding bed hypothesis is established from further evidence. The distinction between these two hypotheses is essential to the determination of the stratigraphic relationship between the diamicton and rhythmite sediments at locations 1 and 2 respectively. If a mass flow origin can be proved then it is possible that the rhythmites are contemporaneous with or predate or postdate the diamicton. This is because a complete blockage of the cave passage by the boulder fill could have occurred before a mass flow without impeding the process. In that case the cave could have been divided into two systems each with distinctly different processes. Alternatively, if the sliding bed hypothesis is viable then the rhythmites must postdate the diamicton as complete fill by the boulder choke must have occurred before rhythmite formation.

It is suggested that the rhythmites and diamictons are Pleistocene in age as dissolution of the underlying boulder fill (originally probably of fairly uniform depth) in Midsummer Cavern and in Cascades to a maximum of 8m. must have taken longer than the 15,000 year long post-glacial period. It is not clear however, which Pleistocene period they may be related to. The period of diamicton formation cannot be established until their precise mode of deposition is determined. It is tentatively suggested that a temperate glacial environment with ice directly outside the cave entrance would provide suitable conditions for diamicton formation. Ice may have supplied water saturated sediment to produce mass flows into the cave or supplied high meltwater sediment discharges to deposit diamictons from sliding beds under full pipeflow hydraulic conditions.

CONCLUSIONS

Aillwee Cave is the only major cave system, with the exception of Kilcorney Cave, so far discovered on the High (non-shale) Burren. Unlike the active caves of the western Burren, Aillwee Cave seems to have no relationship to shale cover, past or present, and is developed in limestones some 250m. below the uppermost beds. Again, unlike contemporary Burren caves, it shows extensive phreatic development under fast-moving water conditions. In this respect it is similar to many of the other fragmentary caves known from elsewhere on the High Burren and suggests that hydrological conditions were very different to those prevailing today when the High Burren caves developed.

Little may be said concerning the origin of the cave as the only evidence available relates to the final stages of fossilisation of the system. The initiation of the cave seems to have occurred as bedding plane anastomoses, followed by the development of the phreatic tube, and then by vadose downcutting to an unknown depth. It seems improbable that such flow conditions could exist given the cave's present day location relative to the Ballyvaughan valley, and thus this early development may pre-date the glacial deepening and widening of the Ballyvaughan re-entrant. When the cave became fossil, boulder collapse from the walls partially infilled the vadose trench and this was followed by a probably rapid infill of sediment under glacial melt conditions, leaving the passages filled almost to the roof. Since that time, small invading streamlets have removed a part of this fill in certain isolated zones.

ACKNOWLEDGEMENTS

The authors wish to thank the following for assistance with fieldwork in the cave: K. Ecock, P. Durrant, P. Coxon. Also T. Dunne for the photographs and C. McDermott for information on the local geology.

REFERENCES

COHEN, J. M. 1979 Aspects of Glacial Lake Sedimentation. *Unpublished Ph.D. thesis*, University of Dublin, Trinity College, 344pp.

DREW, D. P. 1974 McGann's Cave, Ballycahill, Co. Clare. *Proc. Univ. Bristol Spelaeol. Soc.*, **13** (3), 361-367.

FARR, M. J. 1978 *Cave Diving Group Newsletter*, No. 49, p. 32.

FLINT, R. F. 1960 Diamictite, a substitute term for symmictite. *Geol. Soc. Amer.*, Bull. 71, p. 1809.

SAUNDERSON, H. C. 1977 The sliding bed facies in esker sands and gravels: A criterion for full-pipe (tunnel) flow? *Sedimentology*, **24**, p. 623-638.