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AN UNCONFORMITY CAVE

Cloford Quarry, Eastern Mendip, Somerset (NGR ST 717444)

By

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ABSTRACT

At Cloford Quarry the unconformity between the Inferior Oolite above and the Carboniferous Limestone below is exposed. In this quarry is a cave that has been formed in close association with the plane that separates the two lithologies. Some of the passages are formed in both and some only in one. The roof of the cave is nowhere more than 3 m below the surface. All the passages owe their origin to solution by running water. Collapse has altered some. A developmental sequence is postulated and the effects of joint control are stressed.

INTRODUCTION

The cave entrance is located on a ledge above the northern face of Cloford Quarry, owned by Amey Quarries Ltd, and at an altitude of approximately 160 m above Ordnance datum. The entrance was first noticed in the spring of 1970 during quarrying operations concerned with the removal of the overburden of Jurassic Limestone, which overlies the Carboniferous Limestone, the stone worked by the quarry. It was first explored by members of the Wessex Cave Club in late 1970. Our attention was drawn to the cave by Dr. W. I. Stanton and the survey and observations upon which this account is based were undertaken during September and October 1971.

GEOLOGY AND TOPOGRAPHIC SETTING

The interest of this cave is that it is developed in close association with the unconformity separating the Carboniferous Limestone from the Jurassic Inferior Oolite. The regional geology is described by Kellaway and Welch (1948) and the most detailed account of the Carboniferous Limestone of this area of eastern Mendip is by Welch (1933). The revised Frome Geology Map (sheet no. 281) at a scale of 1 : 63,360 shows that the Carboniferous Limestone forming the quarry is likely to belong to the Clifton Down Group and that the regional dip is about 20° to the southeast. Detailed accounts of the Inferior Oolite for the local area are lacking but it is Upper Inferior Oolite of Middle Jurassic age.

The unconformity between the Upper Inferior Oolite and the Carboniferous Limestone in eastern Mendip is well marked. In some instances the borings of marine organisms can be found preserved in the top few centimetres of the Carboniferous Limestone. These borings were made into the marine platform associated with the Upper Inferior Oolite transgression and are infilled with oolitic materials. Such borings can be found in the top of the quarry face near the cave entrance and in exposures of the unconformity within the cave, notably in Unconformity Chamber. Infilled fissures are also sometimes found associated with the unconformity; a review of the variety of forms of such fissures was presented by Robinson (1957). One such feature was observed in the eastern wall of Unconformity Chamber and would appear to be of the type described by Robinson (p. 267) as a "Neptunian sagged-cover dyke". The fissure observed was some 50cm in width and was composed of angular fragments of Carboniferous Limestone set in fine-grained calcareous matrix which was in part oolitic.

In post-Inferior Oolite time only minor tectonic activity has occurred on Mendip. On the local scale however, the plane of the unconformity can be regarded as essentially horizontal. It is perhaps worth noting that the height difference between the plane of unconformity at Cloford Quarry and at Vallis Vale is about 80 m in a horizontal distance of some 6 km. This would give a generalized apparent regional tilt of slightly less than one degree.

Lithologically both the Carboniferous Limestone and the Inferior Oolite are limestones and whilst no detailed analyses have been undertaken for samples collected from the cave the calcium carbonate content of both rock types is thought to be in excess of 90 per cent. However it is difficult to conceive of two more markedly different forms of limestone lithology particularly in respect of hydrological properties. The Carboniferous Limestone has an extremely low primary porosity and a particularly marked secondary permeability. The Inferior Oolite has a high primary porosity due to its composition which consists, in large part, of small spherical ooliths with a discontinuous calcareous cement between the individual oolitic grains. The rock is normally considered to have a high primary permeability with secondary permeability developed along solutionally eroded joint planes. An account of these terms is given in Smith (1971) and a summary of the results of differing workers who have determined porosity and permeability figures for differing limestone lithologies is available in Atkinson (1971). Additionally Schaffer (1932) gives porosity figures for the oolitic limestones of the Isle of Portland.

The location of Cloford Quarry Cave affords the opportunity to observe the effects of cave genesis in two very different limestone lithologies within the same cave.

The cave is also unusual in that it is at an extremely shallow depth. The thickness of the Inferior Oolite overlying the unconformity is considered to be less than 3 m and, allowing for the development of certain of the cave passages into the oolite itself, the roof in parts must be only about a metre below ground level. So much so that plant roots are present in the main chamber. It is difficult to give precise figures for the thickness of rock over the cave roof as much of the overburden, stripped off in the course of quarrying operations, has been dumped on the land underlain by the cave. Parts of the cave however are formed beneath a field under arable cultivation and which has a local relief of perhaps 40 cm. The cave reaches almost as far as the main Wells to Shepton Mallet road, A361. The form of the cave itself does not appear to be affected by its shallowness except for the location of the plant roots where the rubbly nature of the infill suggests that the roof had penetrated into the deeper parts of the C-horizon of the soil.

A REVIEW OF OOLITIC CAVES

The literature on oolitic caves is limited. This is in part due to the relatively small number of such caves but it also reflects the fact that oolitic caves do not have the same caving potential as caves in Carboniferous Limestone. Cave descriptions are available for three regions of oolitic limestone: The Caves of the Isle of Portland (Ford and Hooper, 1964), various reports of the Cotswold oolite caves (Standing, I.J.S., 1964, Standing, P. A., 1964 and Davis, 1971) and lastly an account of a number of caves in Upper Ryedale in Yorkshire (Fitton and Mitchell, 1950). From these descriptions it is clear that the caves in all three regions are developed in lithologies which can be described as oolitic.

The salient feature shared by all these reports is that the various authors, in many cases independently, have remarked upon the fact that the caves they were describing were *not* formed by water action although such action may have slightly modified the original form. All the accounts draw attention to the joint control found in oolitic caves and which in many cases is responsible for the extensive vertical development.

The above descriptions of oolitic limestone caves differ from the Cloford Quarry Cave in one important particular, namely that the caves are not developed in close association with a major lithological break of the kind associated with the Carboniferous Limestone/Inferior Oolite unconformity. One other small cave in the Mendip region is similar to Cloford Quarry Cave, namely the Vallis Quarry Cave (Barrington and Stanton, p. 116, 1970). This cave has a length of about 30 m but in part the roof is developed on the plane of the unconformity.

Parts of Cloford Quarry Cave are developed in Oolitic Limestone but, as will be apparent from the cave description, its overall form is undoubtedly due to water action. The dominant control on the development of the cave is the juxtaposition of the two differing limestone lithologies at the plane of the unconformity. It is first and foremost an unconformity cave but also of interest is the occurrence of *water-formed* passages in oolitic limestone. Descriptions of unconformity caves are even less common than those of oolitic caves and Ford (1971) remarks

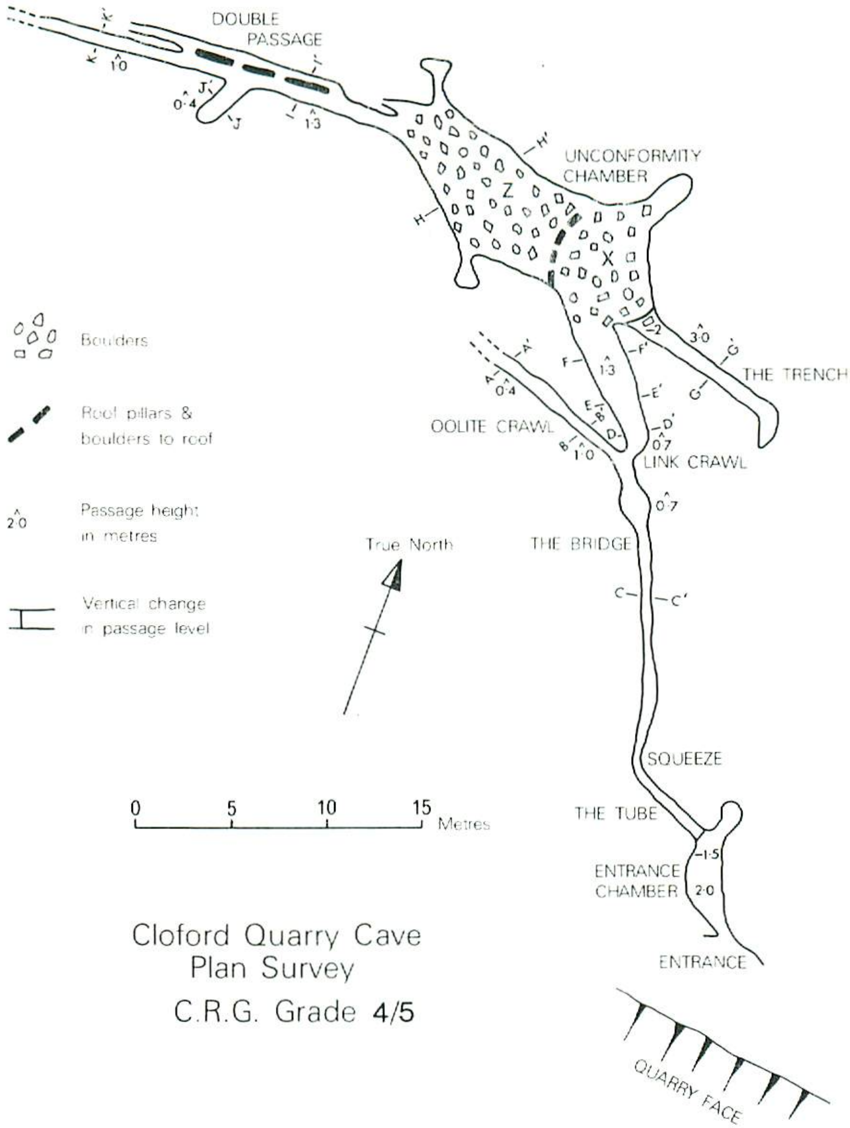


Fig. 24.

that '. . . no unconformity guided cave within the limestones of Britain has yet been reported'. Cloford Quarry Cave would appear to be one instance in which an unconformity is the all important control.

CAVE DESCRIPTION

A plan survey of the system is given in figure 24; passage cross sections for locations marked on figure 24 are illustrated in figure 25. The cave entrance is locate some 1 m above the level of the unconformity and close to the quarry face. A descending crawl through boulders gives access to the Entrance Chamber. Here the unconformity lies some 1.5 m above the floor though its exact position is hidden by calcite deposits. A short crawl at floor level leads off from the northern end to terminate in a blind circular chamber. This side passage is developed entirely in Carboniferous Limestone, although the chamber roof is at the level of the unconformity.

From the NW corner a constricted crawlway, The Tube, leads off at roof level (Pl. 7). This tube is initially almost circular in cross-section and appears to be developed entirely in oolite; a fill of silty-clay common throughout the cave, however, obscures the bedrock floor. Beyond a squeeze the passage takes on a more keyhole-shaped cross-section (C-C′) until The Bridge is reached. Here a narrow rock bridge of Carboniferous Limestone separates two small pits (1 m deep) in the passage floor.

Some 3 m beyond The Bridge the passage forks. To the right is a flat out crawl, Link Crawl. To the left is Oolite Crawl, which may be followed for 10 m almost due west until the fill approaches the roof and prevents further progress. Near Link Crawl the cross-section of Oolite Crawl is similar to that of The Tube (B-B′) but toward the explored limit it widens and becomes rectangular in form (A-A′).

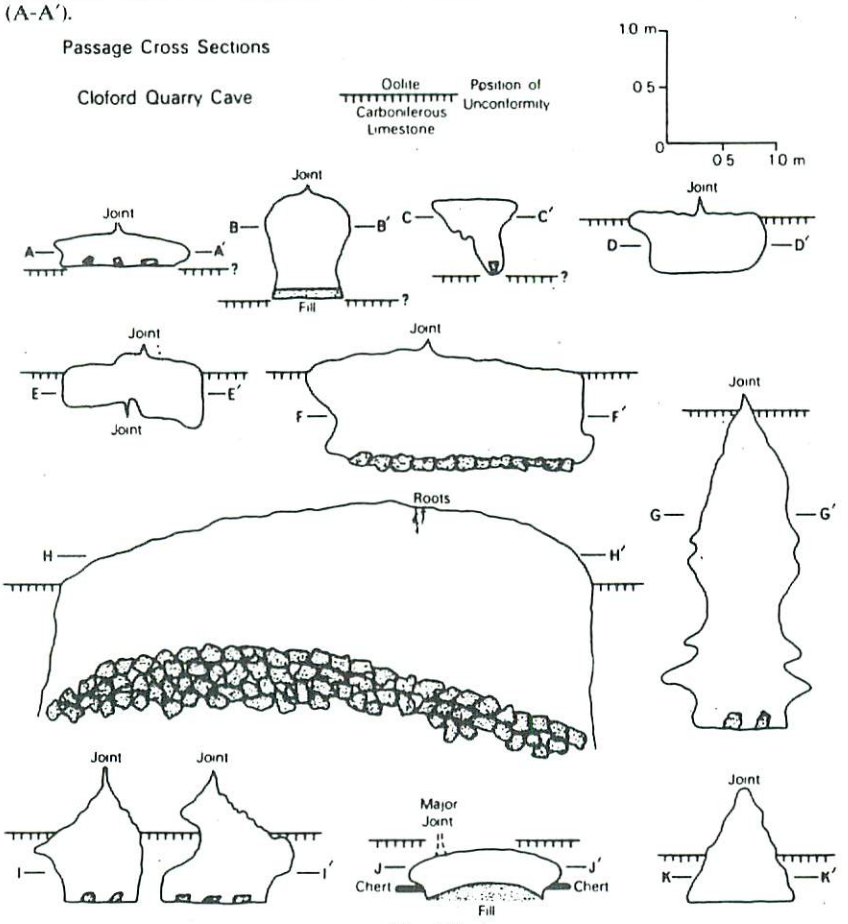


Fig. 25.

The whole of this passage is developed in oolitic limestone but again the floor is mantled with a clayey fill and oolite boulders. The walls are heavily fluted and pocketed and the flowstone, especially on the roof shows signs of re-solution.

Link Crawl is a low, wide passage initially developed entirely in the Carboniferous Limestone but after 2 m the passage gradually increases in height and breadth (D-D′; E-E′; F-F′) and the roof is composed of oolite, the nearly vertical walls of Carboniferous Limestone. The floor is covered with angular breakdown blocks up to 1 m in diameter. The oolite roof in this section shows extensive pocketing and poorly developed rock pendants. Plate 8 illustrates the cross section E-E′, photographed from Unconformity Chamber looking towards Link Crawl.

The passage terminates in Unconformity Chamber. Strictly speaking there are two chambers (X and Z on the survey) separated by rock pillars and large boulders. The floor of these chambers is a jumble of boulders with oolitic blocks on top, carboniferous blocks below. The breakdown is at least 2-3 m thick in the chambers. As in Link Crawl the walls of Carboniferous Limestone are almost vertical but particularly in chamber Z the roof is domed into the oolite. The boulder floor in chamber X is almost horizontal but in chamber Z the breakdown slopes steeply from north to south. That these chambers are very close to the land surface above is shown by the numerous roots in the roof of chamber Z and by the presence of fragmented rock and soil in the NW corner of the chamber. In the NE corner of chamber X micro-scallops (up to 1 cm diameter) were observed (Pl. 9). These scallops were developed on the roof of the chamber on the actual unconformity, in detail some of the scallops were observed on the highest parts of the Carboniferous Limestone but continue across onto the lowest beds of the Inferior Oolite. The surprising feature is that the form is comparable on both lithologies and the scallops shown on plate 9 are on both lithologies. This occurrence is the only clear example of scalloping noted in the cave. A cross section of chamber Z is given (H-H′).

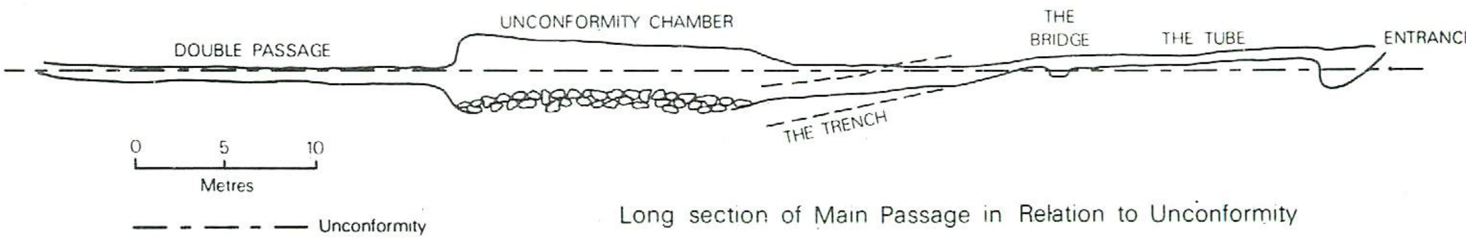
Three small passages entirely within the Carboniferous Limestone, lead off from Unconformity Chamber, to terminate in blind circular chambers after *c.* 3 m —these are similar features to the short crawl from the Entrance Chamber.

At the eastern end of the chambers a 2.5 m drop to the base of the breakdown leads to the foot of the Trench. This passage, 3 m high and 1 m wide, ascends steeply with a bedrock floor over its entire 10 m length, the roof rising but little whilst the floor rises in a series of steps. The passage is developed in Carboniferous Limestone though it is only possible to examine the roof at its upper end where oolite may be seen. The walls of the Trench exhibit a series of shelves which are especially pronounced near floor level (G-G′). At its upper limit the passage bends to the south and becomes too tight for progress.

The main route on from the chambers is via a low crawl at the base of the boulders at the western end. Initially this passage is similar in form to Oolite Passage but after a few metres it splits into two parallel passages separated by thin rock walls with occasional gaps. This passage, (Double Passage), continues in this fashion although the more northerly branch becomes too tight to follow after some 10 m. This passage, developed in both limestones (I-I′). The Carboniferous Limestone portion of the walls are generally very smooth with solutional pocketing whilst the upper oolitic section is heavily fretted. Plate 10 illustrates a portion of Double Passage.

The southerly passage becomes triangular in cross-section and gradually rises above the unconformity. At the explored limit the fill of silty-clay and rocks impedes further progress (K-K′). At 9 m beyond the chambers a small side passage leads off Double Passage to the south. A section of the passage is developed in Carboniferous Limestone is shown (J-J′). A chert band occurs in this passage. The fill is distinctively convex upwards—a feature common throughout the cave.

On the evidence of the visits made to the cave it appears to be hydrologically inactive at present. Only a few very slow drips were noted and intermittent pools occur in The Tube. There was no evidence to suggest recent concentrated flow in any of the passages.



Long section of Main Passage in Relation to Unconformity

Cloford Quarry Cave

Fig. 26.

GEMORPHOLOGY

The outstanding geomorphic feature of the cave system is its close relationship to the Carboniferous/Oolite unconformity. All the explored passages within the system lie within 2-3 m of this feature and the majority of the passages are developed within both rock types (Fig. 26).

A second significant characteristic of the cave passages is that with few exceptions they appear to be joint controlled: in some instances by coincident joints in both rocks and in others by joints in only one lithology. It is convenient to consider the passages according to their lithology.

(i) Passages developed completely in the oolite

These include The Tube (Pl. 7), Oolite Crawl and the western end of Double Passage. All of these passages have some degree of infilling and thus it is difficult to assess whether or not they are in fact totally developed in oolite. However, the floor of the entrance to the Tube appears to be at least 30 cm above the unconformity and we consider that all the passages mentioned are wholly developed in the oolite.

Joint control is very apparent in all these conduits which vary in cross-section from almost circular to triangular to a more elliptical form—the last form suggesting a degree of bedding control. The western limits of the Double Passage assume a rift-like form characteristic of oolite rift caves observed in other areas, but the remainder of the oolite passages are unarguably phreatic in form showing extensive pocketing and fretting of the roof and upper walls and the typical circular or ovoid cross-section. All the oolite passages appear to be developed in portions of the system most distant from the chambers.

(ii) Passages in Carboniferous Limestone and Oolitic Limestone

The Entrance Chamber apart, these passages are located close to the breakdown chambers. In all cases where the floor could be observed both parts of the passage were joint controlled, although at E-E′ the joints were slightly offset giving the passage an asymmetric cross-section (Pl. 8). The form of these passages is not consistent (see sections), but in general the Carboniferous Limestone forms vertical or near vertical walls whilst the oolite is more fretted and rarely vertical. Plate 10 demonstrates these effects in the small passages of Double Passage.

(iii) Passages wholly in Carboniferous Limestone

With the exception of the short passage near the entrance, all these passages are located just off the breakdown chambers. Typically they are low, rectangular crawls, seldom more than 3 m in length and ending in small circular chambers commonly with the roof formed of oolite.

ORIGIN

A. Passage Form

It is considered that all passages in the system are a function of joint and unconformity control. Figure 27 suggests a possible mode of origin for the typical passage types within the cave.

Examples (1) and (2) illustrate development where the joint in the oolite is either poorly developed in the Carboniferous Limestone below or is non-existant. In this case the normal development is shown in (2) —the Carboniferous Limestone acting as an aquiclude and causing

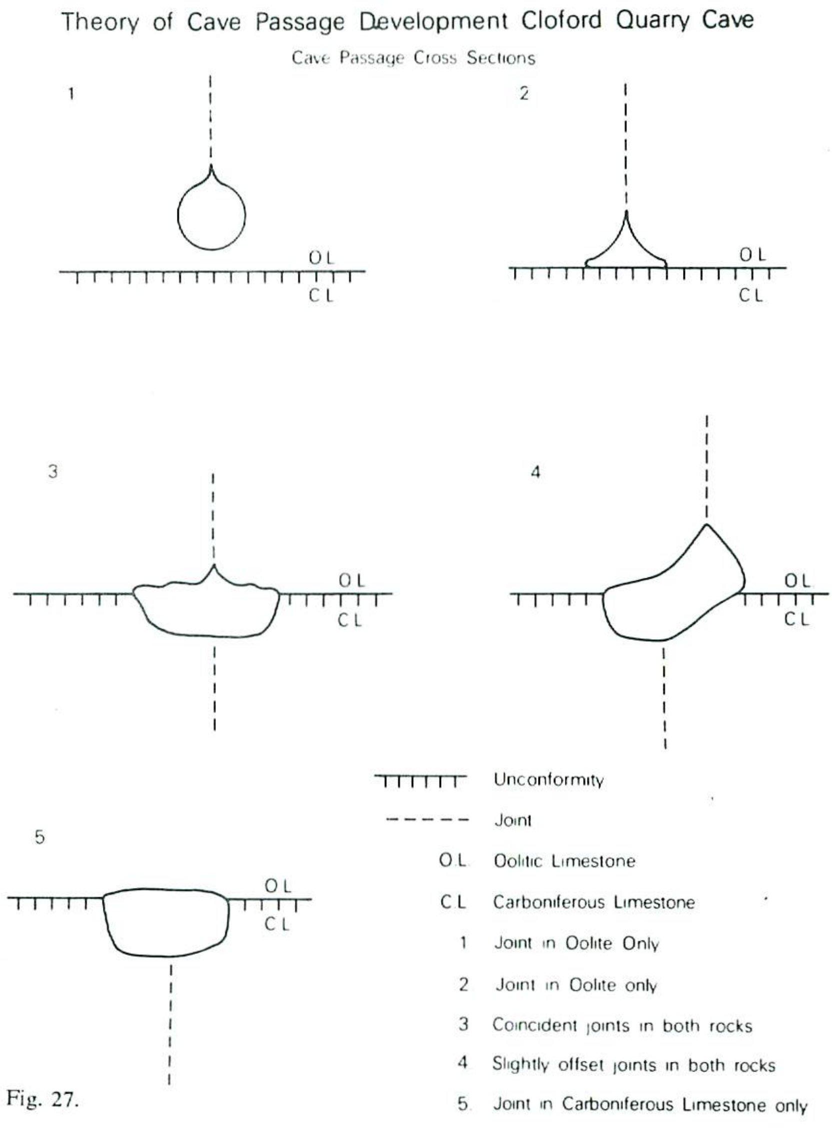


Fig. 27.

Hypothetical Development of Cloford Quarry Cave (Diagrammatic)

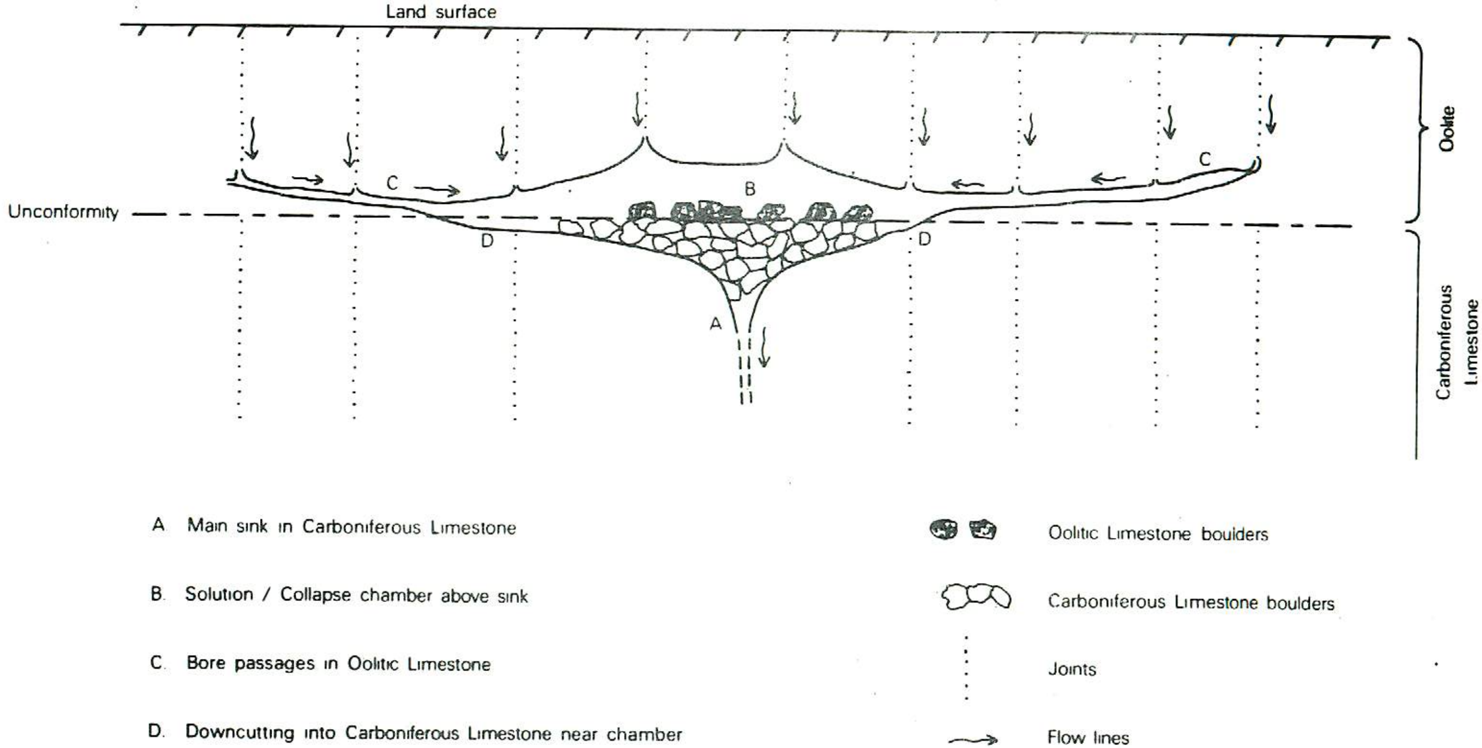


Fig. 28.

lateral widening of the lower section of the passage. Case (1) shows passage development some distance above the actual unconformity and this may be related to a relatively insoluble band of oolite immediately above the unconformity. Ford (1971) suggests that the bed immediately above the unconformity is likely to be soluble and the bed below the unconformity, less soluble.

Cases (3) and (4) occur when joints in the Jurassic and Carboniferous limestones are coincident or only slightly offset. In this instance development will tend to be concentrated in the Carboniferous Limestone except during the initial waterfilled stage. Evolution in this case corresponds to the sequence of development conventionally visualized for normal caves.

Case (5) shows development of passages in the Carboniferous Limestone only. This may occur when flow in an oolite joint is 'captured' by a better developed non-parallel joint in the Carboniferous Limestone. Thus solution will be entirely in the Carboniferous, the oolite above functioning as an aquiclude.

In all cases the initial development is regarded as being via vertical percolation of water from the surface through joints in the oolite and subsequent lateral flow at or near the unconformity surface.

B. The Cave System

Cloford Quarry Cave seems to differ to the majority of other known caves in the Jurassic oolites in that the passages are of the true cave type, solutional in origin, rather than simply pre-existing rifts that may have been slightly enlarged. However, the authors consider that Cloford is not strictly speaking a 'true' oolite cave, but rather a cave whose presence is almost wholly determined by the unconformity. Its shallowness is thus simply a product of the thin cover of Jurassic rocks in this area.

A hypothetical sequence of development is as follows:

1. Water percolates down from the surface through the oolite, largely via the joint system.
2. The Carboniferous Limestone initially functions as an aquiclude causing flow to become concentrated at, or close to, the unconformity surface within the oolite joints.
3. Concentrated flow forms embryonic cave passages within the oolite and the uppermost beds of the Carboniferous Limestone by the normal processes of limestone solution. Initial flow was possibly confined to two, major sub-parallel systems. Double Passage—Trench and Oolite Crawl—Tube.
4. A pre-existing sink in the Carboniferous Limestone (possibly at a point where major joints intersect) in the Unconformity Chamber area becomes enlarged by percolating water from above and taps the flow of water in the oolite tubes. The initial capture would be Double Passage—Trench and the later capture the Oolite Crawl—Tube route thus excavating the Link Crawl and reversing the direction of flow in the Tube. There is evidence from the quarry face that such vertical features in the Carboniferous Limestone do occur in this area. At this stage the flow, instead of being sub-parallel, would be centripetal to the main sink in Unconformity Chamber (Fig. 28).

5. As the sink develops so flow rate increases (illustrated possibly by the scalloping shown in plate 9 for Unconformity Chamber) and the portions of the oolite passages nearest to the sink become incised into the Carboniferous Limestone and acquire a 'vadose' appearance. Link Crawl, The Trench and part of Double Passage all show this feature. The incision occurs for about the same distance from the chambers in each tributary passage.
6. As the chamber develops in the Carboniferous Limestone collapse occurs, initially in the lower Carboniferous strata and later in the exposed roof of Oolitic Limestone. That the sequence occurs in this order is borne out by the predominance of oolite boulders at the top of the breakdown and those of Carboniferous Limestone beneath.
7. The system becomes inactive, downcutting ceases and collapse into the sink continues.

The end product of this developmental sequence is shown in Figure 28. An analogy for the hydrological behaviour of this system may be drawn with the drainage pattern of a surface depression in Carboniferous Limestone which is completely infilled with a permeable regolith. Water will percolate through the overburden in the vicinity of the sink until it reaches the bedrock surface when it may move as throughflow along the limestone-regolith interface to the central sink. In the case of Cloford Quarry Cave the oolite cover appears to function to some extent as regolith.

Thus on this hypothesis the whole cave system is essentially a localized hydrologic network centering on one major sink in the Carboniferous Limestone and it cannot be concluded that the development of true cave systems is usual in oolitic limestone.

Of some interest are the possible effects of the mixing of subsurface waters derived from the Oolitic and Carboniferous limestones as there is scope for enhanced solution due to both the 'mixed corrosion' effect suggested by Bögli (1971) and by the mixing of calcium and magnesium waters proposed by Picknett (1972).

ACKNOWLEDGMENTS

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(The cave is no longer accessible. Eds.)

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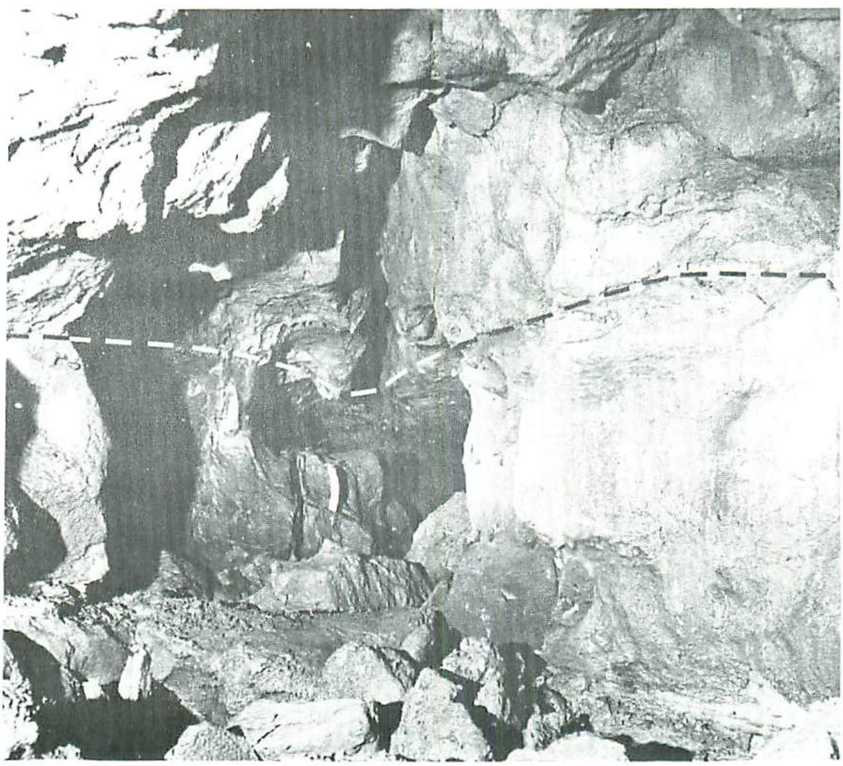
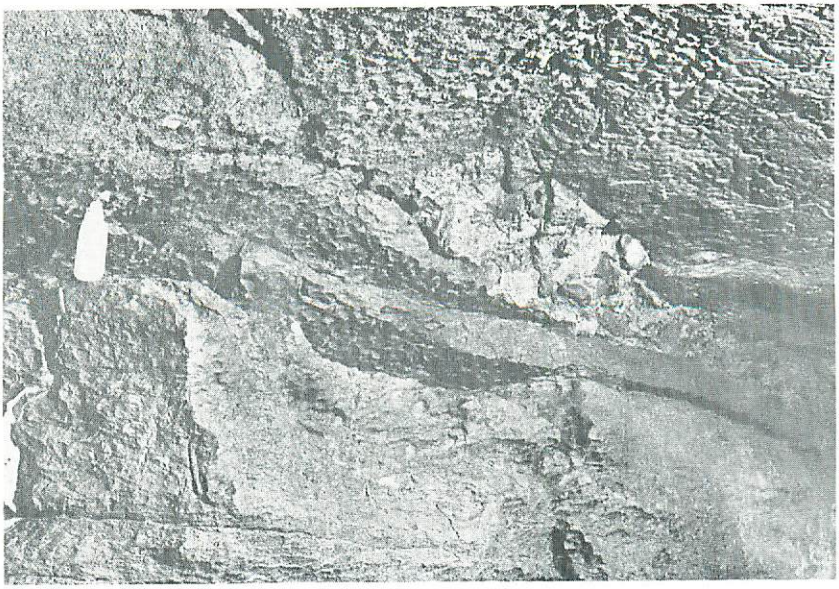
Pl. 7. The Tube viewed from the Entrance Chamber. This crawl is developed solely in Oolitic Limestone.

Photograph D. I. Smith.



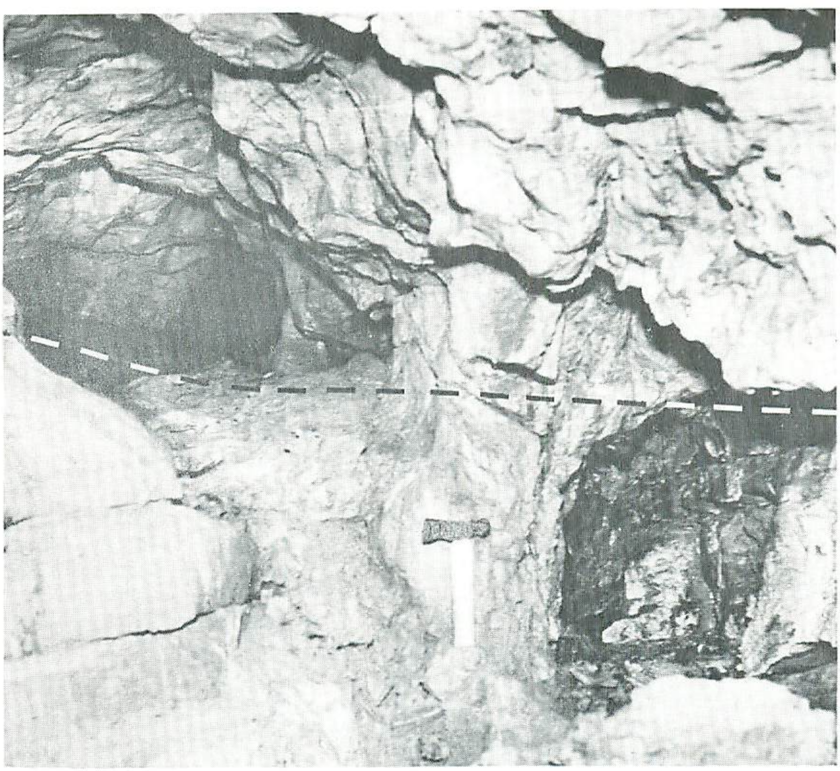
Pl. 8. Cross-section E-E′. View from Unconformity Chamber. The plane of the unconformity is marked. Note offset joints by the candle.

Photograph R. A. Philpott.



Pl. 9. Scallops developed in the plane of the unconformity. The location is in the NE corner of Unconformity Chamber.

Photograph R. A. Philpott.



Pl. 10. A portion of Double Passage. The plane of unconformity is marked. Differences in passage form are shown. Left—Oolite, right—Carboniferous Limestone.

Photograph R. A. Philpott.