Proc. Univ. Bristol Spelaeol. Soc., 1984, 17 (1), 5-27.

CHARTERHOUSE CAVE
EXPLORATION, GEOMORPHOLOGY AND FAUNA

by

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Charterhouse Cave, Charterhouse-on-Mendip, Somerset.
N.G.R. ST 3775.5620

Altitude 255m O.D. *Length of surveyed passages* 340m.

ABSTRACT

An account of given of the exploration of Charterhouse Cave, including early work by this Society, more recent excavations by the Sidcot School Spelaeological Society, and the final opening in 1981. The accessible passages are briefly described. The cave contains a typical Mendip cave fauna, with a well developed twilight community, and a troglobite fauna comprising two Crustacea and a springtail. The population of the troglophile, *Speolepta leptogaster,* will probably be most sensitive to the opening of the system. The cave is developed in a structurally complex monoclinal flexure, with strong jointing perpendicular to the east-west fold axis. Phreatic remnants are present as high as 240 m AOD, but the local water-table elevation declined gradually with time to below the present end of the system. A sequence of six vadose trenches adjusted to temporary still-stands of the local water-table are proposed, and evidence of nine sometimes spatially discrete fill phases cited to support this contention. These fills also assist in the recognition of a minimum of five separate significant inlets to the system, which have varied in importance through time. Down-dip modification of the existing mature phreatic system is stressed. This evolution scheme is contrasted with that of Ford (1964) for the nearby G.B. Cave, where it may also apply.

HISTORY OF EXPLORATION

In the early 1920s this Society was very interested in the Long House Barn Valley of Charterhouse, where two streams from Blackdown sink at the shale–limestone boundary. Digs were started on the active swallets and in the Great Swallet, a large dry depression further to the south (Tratman, 1921; Baker, 1922). It was in the smaller eastern valley, in July 1923, that cave was first discovered (Perry, 1923). Named after its original explorer, Reginald F. Read, Read's Grotto consists of a low streamway which, after a tight squeeze, gives access to a spacious bedding-plane chamber, Baker's Temple. The stream can be regained below the chamber, but the way soon ends in boulders. In August 1923, there was a break-through in the western swallet, Tyning's Farm Swallet, and a cave of similar length and depth was found, this time ending in a rift that was too tight (Perry, 1923). In 1939 G.B. Cave was entered and the underground flow of Tyning's stream was found (Goddard, 1944).

The eastern swallet was not forgotten, dye tests in the fifties showed that the stream was not seen in G.B. Cave (Gilbert, 1963). Following the discovery in 1966 of the Ladder Dig Series in G.B. Cave (Norton, 1966), the Society dug for a time in the boulders on the west side of the chamber in Read's Grotto, in an attempt to reach the postulated eastern series (Savage, 1966). A tight vadose passage was followed for about 15 m, but the boulders were too loose to be safely dug, and the dig was abandoned. It was left to members of the Sidcot School Spelaeological Society (S.S.S.S.) in 1971 to take up the challenge seriously. Digging within Read's Grotto did not appeal. Instead digging began at two small ciffs 10 m further to the south, in the hope that the boulder jams might be bypassed. After early progress through soft clays and sands they began to run into trouble, when large overhanging slabs of rock were undermined. In 1972 these posed a serious danger and W. I. Stanton assisted the members of the S.S.S.S. by bringing down the rocks with explosives. However boulder collapses continued, and in 1976 the entrance shaft partly collapsed. Following this a superb dry stone wall was built around the east side of the shaft and the entrance stabilized. In February 1977 the S.S.S.S. had some reward for their efforts with the discovery of Bat Chamber. Sadly, all ways were blocked. Work continued on the eastern side of the chamber where, going down through the boulders, the head of a rift was uncovered in February 1978. It was possible to look along the rift for about 5 m and an appreciable draught blew from the rift, but the top was guarded by an intimidating mass of loose rock and it appeared too tight to follow. Without using explosives attention turned to other passages off Bat Chamber but all ended in boulders as bad as anything in Read's Grotto. In 1979 the S.S.S.S. investigated the possibility of opening the chamber to the surface to facilitate digging and in 1980 Stanton conducted another dye test, which confirmed that the Read's Grotto stream does not enter G.B. Cave and proved that it resurged at Cheddar, taking 17 hours in high water conditions (Stanton, 1981).

In October 1981 Alison and Pete Moody, with A. Taylor (Wessex Cave Club), first visited the dig. The cave was in flood and at the rift the stream was cascading through the boulders, so that the way on was a maelstrom of wind and crashing water. They returned on the 17th April 1982 when, with everything dry, they were able to force on to a cross rift. The next day a few minutes' work with a lump hammer knocking off ledges saw the first rift wide enough for most people. On the 24th April two charges were put on the cross rift and the cave beyond was open to them. The further exploration of the cave has already been described (Moody, 1982).

DESCRIPTION

The entrance (Fig. 1) is capped by a blockhouse, into which a small opening has been made to permit the entrance of bats. Inside the blockhouse a short climb down, and hands and knees crawl, leads up into Bat Chamber (marked 'Sidcot Series' in Fig. 1). Straight on the passage quickly chokes, while to the left a small climb down through boulders leads to a 2 m deep rift. The rift is negotiated at floor level as far as a cross rift, where to the right is a squeeze, which gives access to a larger rift running parallel to the first (at −9.8 m). Two inlets end in boulders after a short distance while downstream, after 10 m of walking passage and a crawl under a flowstone blockage, the main stream from Read's Grotto enters from the left. This can be followed upstream past an extremely tight bend to some fine straws and a boulder choke. The main way continues to a wet crawl on the right (The Wallow), but straight on, a hole up through a false floor gives access to Midsummer Chamber, 20 m long and 4 m wide (Frontispiece and Plates 2 and 3a). At the far end of the chamber a low, highly decorated bedding cave ends after 20 m in a grotto with no possible continuation. Due to the vulnerability of the formations which it contains, the Forbidden Passage has been taped off and should not be entered.

Beyond the Wallow, after a further wet crawl and head-first drop down a small pot, a long straight rift leads out into a much larger passage (3 x 4 m) (A, Fig. 1). This descends steeply past Splatter Chamber, where a large run-in has occurred recently. Mud has been splattered high up the walls and bits of wood can be seen on ledges in the chamber.

Below Splatter Chamber the passage turns abruptly left and decreases in size (C. Fig. 1). A series of small cascades brings one down to the ramparts of The Citadel and, passing under a bridge of calcited blocks, the passage opens out into the lower end of The Citadel chamber. Huge blocks litter the floor and ancient flood markings ring the walls 8 m up. The chamber tapers down to a narrow rift and the water is followed through a low crawl which can be 'entertaining' on the return, if the stream is high. An unusual passage in flowstone is followed down to where the stream sinks away into boulders; immediately above this a squeeze leads into the well-decorated Grotto of the Singing Stal (Plate 3b) (the Grotto below), named after a redissolving column which makes strange squeaking noises, as the water flows through it. The Grotto extends back towards The Citadel and is taped off to preserve its fine canopy and formations.

At present further exploration is halted at the Grotto. A massive collapse has occurred which totally blocks the way on. Digging down into the boulders the stream was rejoined, but it could only be followed a few metres before progress was barred by more boulders. An attempt to go over the choke was equally unsuccessful; the collapse appears to extend to the Great Swallet above (Fig. 2). The discovery of a complete fox skeleton in the choke perhaps supports this view.

Returning to the sharp left-hand bend below Splatter Chamber, a 4 m climb leads to the north end of The Citadel (Passage B. Fig. 1). The Citadel (Plate 1) is a very spacious chamber, rivalling the main chambers of G.B. Cave and Lamb Leer. Several holes can be seen high up on the west wall; the largest – The Balcony – proved to be little more than an alcove with a further traverse and slope leading on upwards into boulders. Chiaroscuro Passage enters The Citadel from the north. The First Inlet, gained by a 7 m climb, is on the eastward bend of Chiaroscuro Passage. It terminates in a flowstone choke at −15.2 m very close to Double Passage in G.B. Cave (Fig. 2). The Second Inlet, entered by a 10 m climb at the end of Chiaroscuro Passage, ascends steeply towards the surface before being blocked by fallen slabs at −3.9 m. Both inlets have very vulnerable formations and should not be visited without due reason.

FAUNA

Charterhouse Cave is home to a selection of small creatures typical of Mendip caves. Most numerous of these are craneflies and mosquitos, which are seasonal visitors, and three species of spiders (two *Metas* and *Nesticus cellulanus*) which feed on them. The cranefly, *Limonia nubeculosa,* is a summer visitor, the mosquito, *Culex pipiens,* a winter visitor. These five creatures form part of a 'wall association' of animals which seldom venture beyond the limit of daylight penetration. Other members of the wall association which are likely to be found in the cave during winter months are the tissue and herald moths and the caddis fly, *Stenophylax permistus*. There are other less cave-dependent visitors to the twilight zone, such as woodlice, millipedes and spiders. Since the entrance doline has been capped, the amount of sheltered, damp, dimly-lit living space has increased considerably, and so the numbers of these creatures has increased, and the cave has gained a richer twilight zone fauna.

The true cave fauna, which lives in the completely dark part of the cave, is similar to that of nearby G.B. Cave. It consists largely of animals which are thought to be able to complete their life cycle in caves, but which can also live above ground. Such creatures are termed 'troglophiles'. They are indicated in Table 1 by an asterisk. Most of them are widespread in Mendip Caves, though the beetles *Trechus micros* and *Quedius mesovelinus* are seldom seen in G.B. Cave. The small fungus gnat *Speolepta leptogaster* is often locally abundant in cave passages, close to the surface, but which contain moist air all the year round. The gnat larvae live suspended in a sketchy web, spun across the cave wall. This may make them particularly vulnerable to drying air currents, and therefore to the activities of cavers, as the breakthrough from the surface into a virgin cave may lead to a fatal drying of the cave walls. The Charterhouse Cave population of *Speolepta leptogaster* was small when the cave was first entered, and does not seem to have declined yet, perhaps because the entrance has been protected by a solid gate from the start of the exploration.

The animals of most interest in Charterhouse Cave are those which are confined to life in caves and other smaller spaces in the rock. These are the 'troglobites' indicated in Table 1 by a double asterisk. The two Crustacea, *Niphargus fontanus* and *Proasellus cavaticus*, and the springtail, *Onychiurus schoetti,* are widely distributed in Mendip caves, and are frequently seen in G.B. Cave. All three are associated with water. The springtail is often found on pool surfaces; the Crustacea in slow-moving trickles, seeps and pools, as well as (presumably) in flooded cracks of the phreas.

In addition to the species marked with asterisks, Table 1 contains a number of species which are generally considered to be of accidental occurrence in caves. Some, such as the diving beetle, the caddis larva and the water cricket, have been washed in by the sinking stream, the others have wandered in, perhaps attracted by the cool damp conditions to be found in the entrance doline, or have simply fallen in. No doubt many other such 'accidentals' will be added to the recorded list by future collectors, and probably some more interesting species as well.

TABLE 1

Invertebrates collected in Charterhouse Cave during two visits: 7/6/1982 and 26/4/1983.
Collectors: P. Chapman, M. McHale, A. Boycott.

CLASS	*ORDER Family*	Genus and Species	Common Name
OLIGOCHAETA	Lumbricidae	unidentified	earthworm
GASTROPODA	STYLOMMATOPHORA		
	Zonitidae	**Oxychilus cellarius*	snail
	Endodontidae	*Discus rotundatus*	snail
CRUSTACEA	AMPHIPODA		
	Gammaridae	***Niphargus fontanus*	freshwater shrimp
	ISOPODA		
	Asellidae	***Proasellus cavaticus*	water louse
	Trichoniscidae	**Androniscus dentiger*	woodlouse
	Oniscidae	*Oniscus asellus*	woodlouse
DIPLOPODA	ONISCOMORPHA		
	Glomeridae	*Glomeris marginata*	pill bug
	POLYDESMOIDEA		
	Craspedosomidae	**Polymicrodon poly-desmoides*	millipede
ARACHNIDA	ACARI		
	Rhagidiidae	**Rhagidia* sp.	mite
	ARANEAE		
	Agelenidae	*Tegenaria silvestris*	spider
	Tetragnathidae	*Meta merianae*	spider
		Meta menardii	spider
	Argiopidae	*Araneus cornutus*	spider
	Linyphiidae	*Lepthyphantes* sp.	money spider
		Oreonetides abnormis	money spider
		**Porrhomma convexum*	money spider
	Nesticidae	*Nesticus cellulanus*	money spider
INSECTA	COLLEMBOLA		
	Anuridae	**Anurida granaria*	springtail
	Onychiuridae	***Onychiurus schoetti*	springtail
	Isotomidae	**Isotoma* sp.	springtail
		**Folsomia (candida* group) sp.	springtail
	Sminthuridae	**Arrhopalites pygmaeus*	springtail
	TRICHOPTERA		
	Polycentropidae	*Plectrocnemia conspersa* larvae	caddis larva
	HEMIPTERA		
	Veliidae	*Velia caprai*	water cricket
	COLEOPTERA		
	Carabidae	**Trechus micros*	ground beetle
	Staphylinidae	**Lesteva pubescens*	rove beetle
		**Quedius mesovelinus*	rove beetle
		**Ochthephilus aureus*	rove beetle
		Aloconota insecta	rove beetle
	Dytiscidae	*Agabus guttatus*	diving beetle
	Silphidae	*Leptinus testaceus*	carrion beetle
	DIPTERA		
	Tipulidae	unidentified aquatic larvae	leather jacket
		Limonia nubeculosa	crane fly
	Culicidae	*Culex pipiens*	mosquito
	Mycetophilidae	**Speolepta leptogaster*	fungus gnat
		**Speolepta leptogaster* larvae	maggot
	Helomyzidae	*Heleomyza serrata*	dung fly

*Troglophile **Troglobite

GEOLOGY

The Cave is wholly excavated in the Black Rock Limestone, with the Sidcot Series in the more shaly basal members, and the higher portions of the main cave in the purer bioclastic limestones. Dip is to the south, with an average direction between 180 and 200°N and values between 25 and 30° (Fig. 3). It is, however, steeper in the high level sections of Chiaroscuro Passage, north of a possible low angle fault, and in the lower sections of the Citadel. Here a prominent vertical fault (probably the White Passage Fault observed by Ford (1964) in G.B. Cave) cuts the cave, and to the south the beds steepen markedly to 60°. The structure is therefore an east-west monoclinal flexure, with a faulted axis. The major joint set is at 90° to this axis, trending between 160 and 180°N. The fracture density is in many places relatively high, and there is some evidence of a minor flexure which is followed by the Entrance Complex. Most faults and joints are infilled with vein calcite, which is often 20 to 30 cm thick, and frequently contains voids, which offered preferential routes for the initial circulation of cave-forming waters.

GEOMORPHOLOGY

The classic and pioneering work of Ford (1964) on G.B. Cave set the pattern for many subsequent studies of cave geomorphology, and has been influential in more recent attempts to produce a general theory of cavern

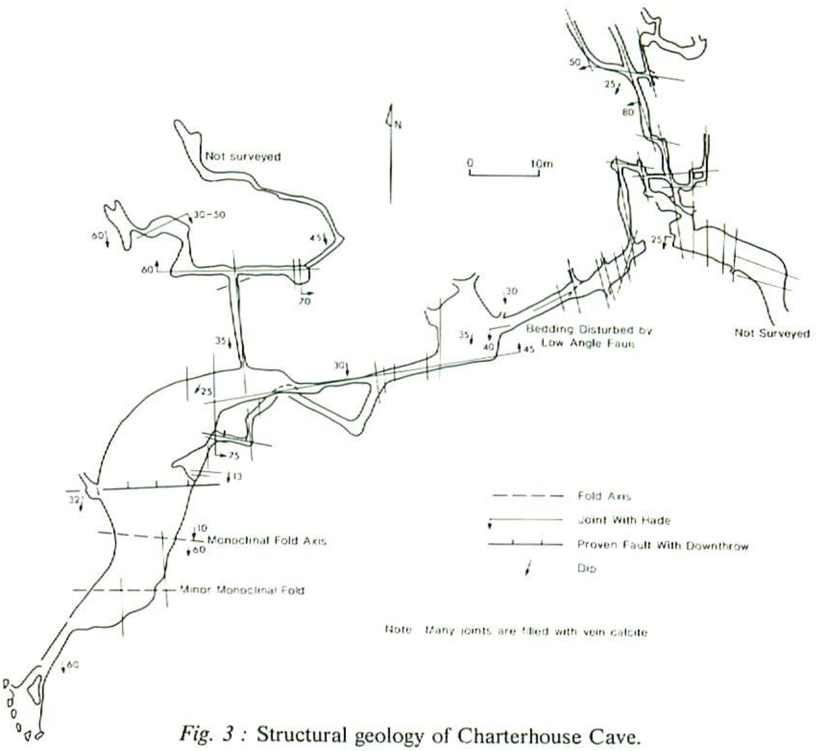

Fig. 3 : Structural geology of Charterhouse Cave.

evolution (Ford and Ewers, 1978). These authors consider G.B. Cave the 'type example' of a drawdown vadose cave, in which the major part of the cave is developed under vadose conditions from an almost complete phreatic skeleton. With the discovery of Charterhouse Cave, there arises the possibility of testing many of Ford's basic ideas on the development of the G.B. Cave. In writing this paper the author has therefore deliberately attempted to develop alternatives to some of the suggestions made by Ford, with the aim of indicating significant problems in the accepted interpretation of cavern development at this type site. The ages and possible palaeo-climatic implications of the sedimentary fill sequences present in both Charterhouse and G.B. Caves are the subject of a further paper, which is at present under preparation with other workers.

PHREATIC DEVELOPMENT

The Initial Phreatic Network

The phreatic passages with greatest elevation in Charterhouse Cave are the complex of small phreatic tubes less than 1 m in diameter which comprise the Second Inlet in Charterhouse Passage (Fig. 4 and Fig. 7).

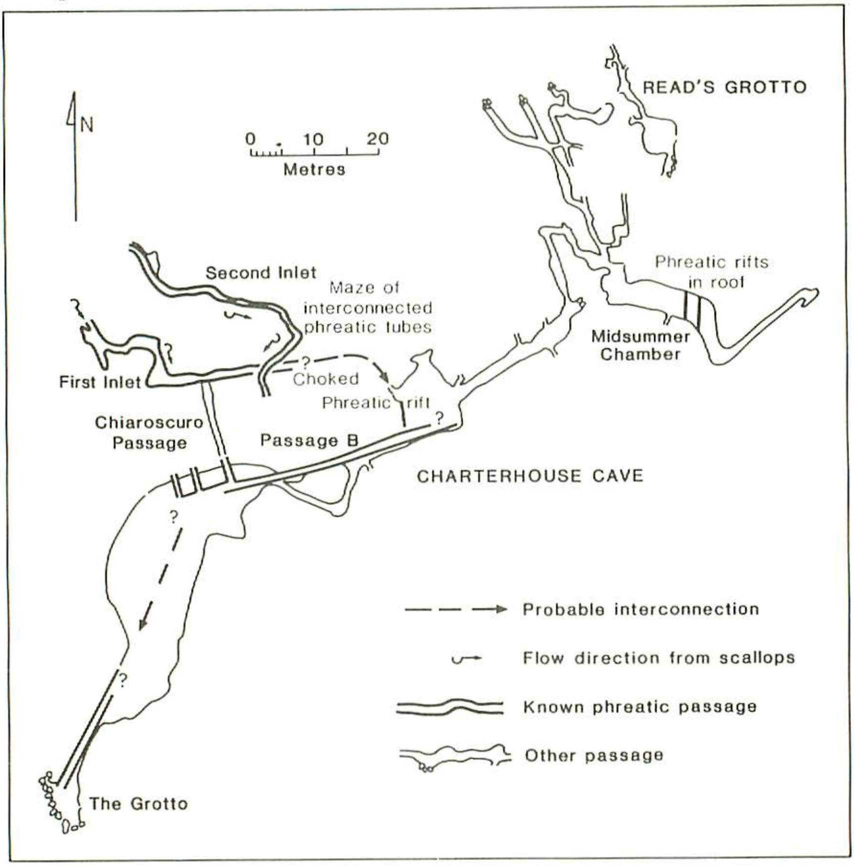

Fig. 4 : Phreatic passage in Charterhouse Cave.

Scallop evidence of flow direction is confused, but appears to be generally to the south and east with high velocities (1 to 2 cm scallop length), suggesting a steep hydraulic gradient. These passages pass directly over Chiaroscuro Passage itself, in a southwards direction. There is apparently no phreatic interconnection with the lower major phreatic tube (2 m x 3.5 m) which forms the roof of the east–west segment of Chiaroscuro Passage between the First and Second Inlet passages. Scallop evidence suggests this is fed from First Inlet, which comprises a series of interlinked vertical and hading phreatic rifts terminating in a mud and breakdown choke. The eastern end of the Chiaroscuro Passage tube is lost in flowstone-cemented breakdown seen in an alcove some 6 m above the passage floor adjacent to the 10 m climb into Second Inlet.

Parallel to Chiaroscuro Passage, a well developed phreatic roof is evident in Passage B leading to The Citadel, but it is unclear if this originates in Splatter Chamber itself or from an alcove in the south-east corner of the Chamber. Downstream, the Passage B tube is lost in the breakdown roof of The Citadel, although three joint controlled phreatic connections are visible entering from the north. Phreatic pockets are seen in the bedrock roof adjacent to the Grotto, and a large tube modified by breakdown rises up-dip into the roof of The Citadel. There is no evidence of significant phreatic passages in the Entrance Complex, but probable phreatic rifts are present in the roof at the eastern end of Midsummer Chamber. These cannot be followed westward due to extensive breakdown.

The major phreatic circulation, therefore, was eastward from First Inlet along Chiaroscuro Passage to Splatter Chamber, where it turned south and then west into Passage B leading to the roof of The Citadel (Fig. 4). Some short-circuiting of this indirect route occurred along small tubes into the roof of The Citadel, and tributary flow probably entered from the east. The major route continues steeply down to the Grotto. Although flowstone present in the breakdown blocking the airy alcove on the west wall of The Citadel suggests significant cavern development to the west, its nature and function is not known. The phreatic circulation was therefore relatively deep, ranging from 240 to 187 m AOD.

The route is probably contemporary with the highest phreatic passages in G.B. Cave, best represented by Double Passage at an elevation of some 238 m AOD. The downstream continuation of this passage cannot be followed in G.B. Cave. It is probable that it maintained its south-easterly trend, passing over the head of the Gorge (224 m AOD), and entering the western end of Chiaroscuro Passage (Charterhouse Cave), which has a similar cross-sectional area. Previously Ford (1964) had proposed that Double Passage fed into the head of the Gorge. However, careful observation and direct exploration (Gilbert, 1963) suggest that the narrow East Passage – Art Gallery – Whitsun Folly phreatic rift system forming the top of the Gorge can be adequately explained by the observable roof-level links to Mud Passage and Stream Passage. There is also a marked contrast in morphology between Double Passage, a deeply pocketed and well-rounded tube similar to those in the main phreatic route in Charterhouse, and the narrow, rifty passages in the roof of the Gorge.

The initial circulation in the limestone was probably along dip tubes developed at the intersection of the north–south joints with bedding planes (Ford, 1968). These routes were initially very immature and some had high hydraulic gradients. In response to differential heads in the dip tubes, they became integrated along the strike by passages developed in the calcite veins of the east–west faults, and by limited segments on bedding planes. The Second Inlet passage contains classic examples of this early diversion and integration, showing a complex series of flow directions in many interconnecting tubes. This passage did not however develop into a major route, but was abandoned little modified prior to the much slower circulation that developed following integration of flow in the limestone. Using models, Ewers (1978) has shown that such dynamic development is expected prior to the linkage of a major through system, but that a relatively stable passage network will then be established. It is suggested that the Double Passage – Chiaroscuro Passage – Citadel route is this major route in the upper part of G.B. and Charterhouse Caves, and that the rather smaller Rhumba Alley – Bertie's Pot – Ladder Dig conduit formed a sub parallel north–west to south–east trending system from a second point input. At this time, little further mature passage was present, but there was an extensive, partially interlinked, three-dimensional network of evolving passages, with limited circulation due to the lowered hydraulic gradients (Fig. 8A). The remains of the initial network can be widely seen by traversing in the roofs of many passages within G.B. Cave and in places guides vadose percolation flows. This view differs from that of Ford (1964) and Ford and Ewers (1978), who suggest that all of the major passages in G.B. Cave had significant mature phreatic precursors.

Models of Water-Table Drawdown

The position of the water-table, here defined as the surface separating water-filled phreatic cave passages and partially air-filled vadose passages, is of paramount importance in cavern genesis. Below the water-table, phreatic pressure flow in confined conduits permits water circulation in any direction (including up) providing there is a positive head differential. In the vadose zone, gravitational flow dominates, and passages can develop only downward. This gives rise to characteristic differences in both network form and passage morphology. There are three main factors which may control the elevation of the water-table in any particular karst area: external base-level (usually the lowest point of discharge from the karst), the degree of karstification (governing the number of potential routes available for cavern development) and the maturity of particular cave conduits (defined by the degree of adjustment between conduit capacity and discharge).

In G.B. Cave, Ford (1964) was only able to recognise two stable water-tables, that at 238 m AOD, discussed above, and a second at just above the Ladder Dig at 137 m AOD. Charterhouse Cave is not yet explored to sufficient depth to demonstrate this lower level. Ford suggests that the level of the upper water-table was controlled by the low initial permeability of the limestones, and that once mature phreatic routes were developed from sink to resurgence, heads were reduced giving a rapid drawdown to the base-level controlled Ladder Dig water-table level.

This view is no longer tenable for three reasons. First, mature caves are known in the southern margin of the limestone at a similar elevation to the highest water-table, suggesting well-established circulation even at this early stage. For instance, Whitebeam Slitter Cave (Cheddar Gorge) at 217 m AOD, and Westbury sub Mendip (245 m AOD, Bishop, 1982). Stanton (1965) has also described a cave of Triassic age, indicating some very early solutional development of the limestone. Second, there is no reason why these earlier levels were not base-level controlled. Ford and Stanton (1968) describe two possible bench levels at 152-163 m AOD, and 205-230 m AOD along the south flanks of the Mendip Hills, indicating pauses during excavation of the impermeable Mesozoic rocks flanking the limestone. These are well above the 95-104 m AOD Wattles Hill Bench, associated with the Gt. Oones level at Cheddar resurgence and the Ladder Dig water-table at G.B. Cave (137 m AOD) (Ford, 1964). If the Gt. Oones–Ladder Dig correlation is in fact correct (the water-table gradient is rather steep compared to those observed at present, even in the weakly karstified Eastern Mendips (Barrington and Stanton, 1977)), the highest bench would be associated with a swallet water-table level of at least 255 m AOD. Finally, two observations support the view that 'drawdown' (rapid lowering of the water-table following development of a mature cave (Ford and Ewers, 1978)) of the initial water-table was not rapid but occurred slowly. The rate of cavern enlargement suggested by solution studies in G.B. Cave (Stenner, 1973), and the Cheddar catchment (Atkinson, 1971) is quite slow, and it therefore seems unrealistic to suggest that the extensive series of captures and enormous volumes of rock removed to create the Gorge in G.B. Cave occurred in a relatively limited time period. This contention is also supported by the interesting observation of Atkinson (1967) in August–Longwood Cave, that above the 137 m AOD water-table the cross sectional area of phreatic passages increased with depth. This suggests (assuming constant discharge) that the lowest levels remained in the phreas for a considerably longer period of time, permitting greater solutional development.

In view of this threefold criticism, an alternative view is proposed (Fig. 5). External base level, controlled by the impermeable Mesozoic rocks burying the south flank of Mendip, fell from an initially high level at a realtively slow and probably intermittent rate (B0, B1, etc. in Fig. 5). These changes were propagated within the limestone as a series of periodically falling levels of the water-table, controlled by abandonment of specific phreatic links at the resurgence and in the conduit system (compare Fig. 5, 2 and 3 with constant base-level B1). They do not therefore necessarily reflect an instantaneous adjustment to base-level change, and large differences between systems draining via different conduits to the same resurgence could occur (compare St. Cutherbert's Swallet and Swildon's Hole resurging at Wookey Hole). However, as circulation in the limestones continues, developing solutional fissures, large differences in head are not readily maintained (Ford and Ewers, 1978), and there is a tendency towards a less lagged and more uniform response in water-table levels to base-level changes (Fig. 5.4). This is clearly the case at lower levels in the Charterhouse-upon-Mendip area, where the same water-table levels can be recognised in G.B., Longwood and Manor Farm caves (Smart and Stanton, 1974).

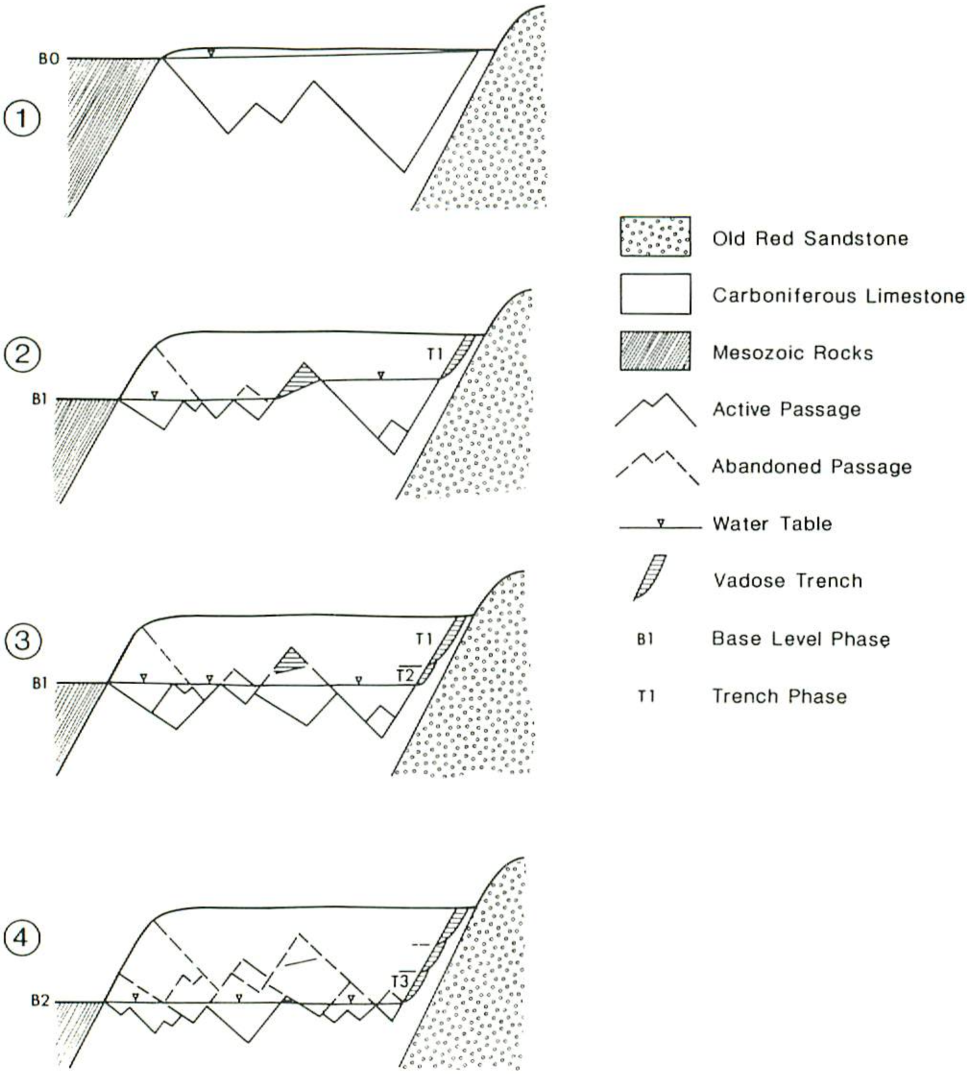

Fig. 5: Development of cave passages following base-level lowering (Section). Note the lag in response to base-level change between 2 and 3, and the effect of increasing solution permitting development of alternative routes.

VADOSE DEVELOPMENT

The vadose development of Charterhouse Cave is dominated by two inter-related processes: the progressive initiation and incision of vadose trenches with lowering of the water-table, and down-dip migration of passages. The development is punctuated by a succession of clastic and speleothem fills, which may eventually permit the dating of the vadose evolution of the cave, and give evidence of the contemporary swallet entrance.

Vadose Development with Lowering of the Water-table

At only one point in Charterhouse Cave is it possible to recognise a lateral vadose to phreatic transition in passage morphology. Downstream of Splatter Chamber at the base of a 3.6 m climb (Fig. 1), the vadose trench turns southwards into Passage C, and passes downward into a smooth phreatic tube, which rises westward towards the floor of The Citadel. The present downstream passage, however, continues southward as a predominantly vadose feature to the Cascades. This transition could therefore indicate a local structural perching, prior to development of a through vadose route. A surprisingly similar feature is also present in Manor Farm Swallet (Smart and Stanton, 1974). Alternatively, the water-table was temporarily stabilised at this level, and the passage has later been the subject of a vadose capture after lowering of the water-table.

The probability of lateral vadose to phreatic transitions being preserved in a cave modified by later vadose erosion and collapse is relatively low, because they occur over a limited wall area. However, the remains of vadose trenches adjusted to this level are much more extensive, and may be used to indicate past positions of the water-table. In a dipping tube, vadose trenches

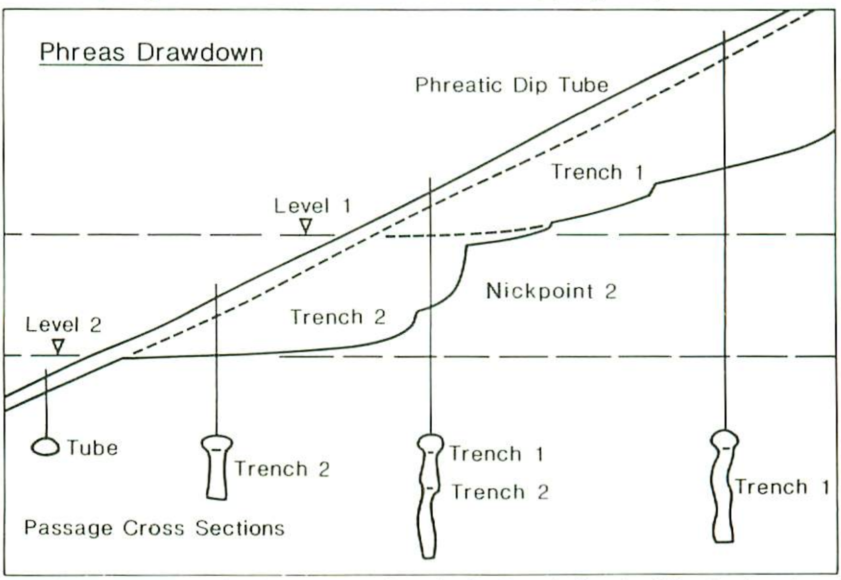

Fig. 6 : Development of vadose passages in a simple phreatic dip tube following lowering of the elevation of the phreas (Section).

propagate upstream from the water-table level, becoming progressively deeper and ending in an active nick-point, often marked by a series of cascades (Fig. 6). Such cascades indicate the upstream limit of a vadose trench adjusted to the contemporaneous water-table level. Unfortunately, nick-points may also be structurally and lithologically controlled, due to differences in resistance to erosion of the bedrock; the chert controlled waterfalls, so much a feature of Co. Clare caves, are of this type and cannot be interpreted as indicators of water-table levels. Later vadose erosion can often significantly modify and lower the trench floor, but often benches are preserved. A classic example of a vadose trench adjusted to a water-table level can be seen in NHASA gallery (Manor Farm Swallet), where the active vadose stream passage issues from a trench onto the floor of an almost unmodified phreatic conduit (Smart and Stanton, 1974). Atkinson (1967) also quotes examples from August – Longwood Cave.

The highest trench (T1) recognised in Charterhouse Cave is that in the floor of Midsummer Chamber at 241 m AOD, to which the Entrance Complex is also developed (Fig. 7). This level correlates remarkably with the highest observed phreatic elements in both G.B. and Charterhouse caves, suggesting a single contemporaneous system. Below this, a nick-point is evident downstream of A (Fig. 1), the trench grading to Splatter Chamber (T2). This feature could be structurally controlled, but the trench floor at the north-east end of Chiaroscuro Passage is also developed at a similar level (228 m AOD, also T2). The prominent bench and steepening of the gradient in the downstream (north–south oriented) parts of this passage represent upstream migration of the subsequent nick-point from The Citadel (T3). The floor of the trenched phreatic passage entering The Citadel is at 219 m AOD (Passage B), fixing the level of T3. This trench is by-passed to the south by Passage C, where the now choked vadose passage can be seen in the north-west end wall of the passage at 213 m AOD (T4). The Cascades passage with a prominent bench at about 207 m AOD grading to the floor of The Citadel, represents the next level (T5). A bedrock trench is not seen below this point, but the lower rifts are developed below 190 m AOD, to which level the lowest nick-point evident in the climbs by the Bridge is related (T6).

It is thus proposed that a series of vadose trenches are present in Charterhouse Cave, which developed over an extended period of time in response to an intermittently lowering water-table level, to which they were adjusted. This contrasts markedly with Ford's (1964) interpretation in G.B. Cave, where the complex sequence of incision and capture were proposed to occur in an extensive vadose zone developed after the rapid fall of the initial water-table. However, in G.B. Cave, the Ooze Passage capture with a vadose to phreatic transition at 213 m AOD shows the same pattern of adjustment to a falling water-table, as is proposed for Charterhouse Cave. Furthermore, the Extension Passage, which shows classic features of a trench adjusted to a particular level (basal expansion of cross-section, downstream reduction of gradient, independence of vadose and phreatic profiles), could not have been graded to Main Chamber, whose roof level is at least 3 m below the base of the trench. The implication is therefore that the passage cut down to a level controlled by a sump at about 195 m AOD.

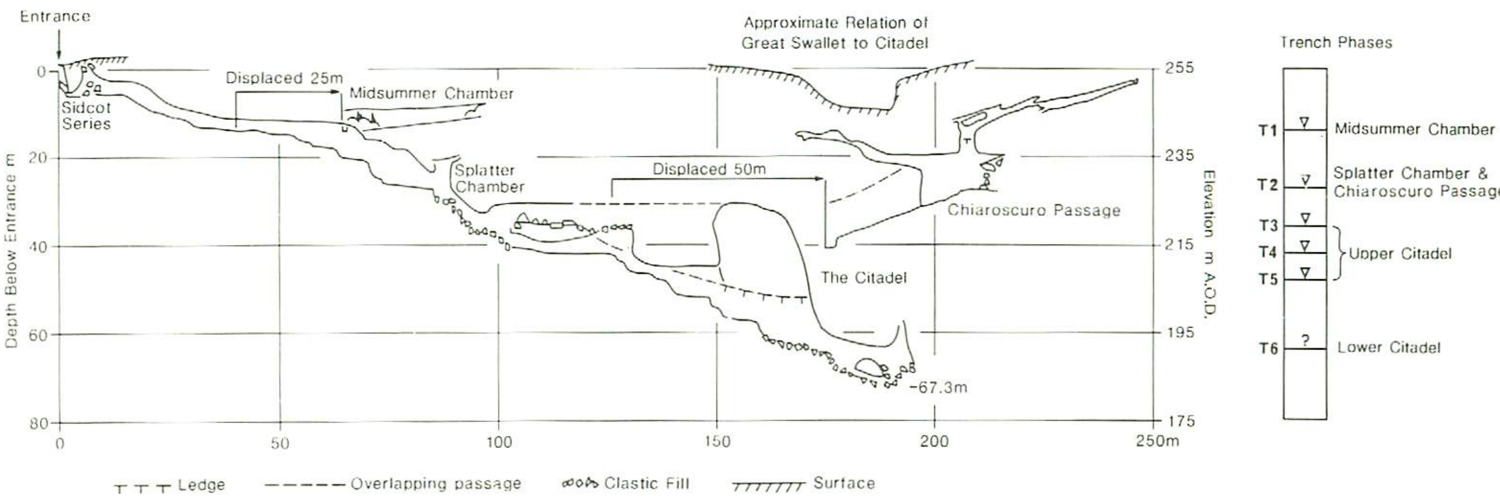

Fig. 7 : Extended elevation of Charterhouse Cave showing sequence of trench incision.

There is, however, evidence of aggradation by clastic fill in this passage. In August – Longwood Swallet, Waterfall Chamber appears to be graded to an elevation some 10 m above the floor of a vertically extensive chamber, a feature again readily explained by the presence of a contemporaneous water-table at this elevation (149 m AOD). There is thus considerable evidence in support of the slow drawdown model proposed.

Down-dip Migration of Vadose Passage

There is little significant vadose modification of the Double Passage inlet to Chiaroscuro Passage, suggesting that captures down-dip into the Rhumba Alley – Ladder Dig system occurred. This is a pattern evident elsewhere in both caves and forms the basis for Ford's (1964) sequence of captures in the G.B. Cave entrance series. It is also the cause, for example, of the very steep trench linking The Citadel and Chiaroscuro Passage, which is excavated from the floor of an initial dip tube, short-cutting the original circuitous phreatic route.

Vadose waters dominated by gravitational flow tend to utilise any available openings which run downhill, however immature. Thus strike passages (which often function only by pressure flow) are abandoned on change to vadose conditions, except where gravitational flow can occur, and dip tubes and joint rifts become the favoured routes for development. This causes a strong re-orientation in cave development, which is particularly marked in G.B. Cave, the mature phreatic routes trending to the south-east, but the later passages running predominantly east-west along the major joint set, and south down-dip. However, these new routes are often of limited capacity, and are unable to cope with the available discharge without backing up. Thus conditions initially are paraphreatic (ephemeral phreatic development within the vadose zone, Tratman, 1957). The limited period for phreatic solutional development of these passages gives rise to a morphology markedly different from the mature phreatic routes described above. The passages are generally of smaller size, rift-like in form, and lack extensive pocketing. Once capacities have increased, heads decline and the immature phreatic passages are subjected to vadose development processes. This process is illustrated in Fig. 8C. This proposal is contrary to the view of Ford (1964) who considered all the phreatic passages in G.B. Cave to be developed prior to vadose drawdown.

However, not all immature phreatic passage morphologies can be explained by paraphreatic conditions, new phreatic routes can develop within a laterally extensive phreas as the solution porosity develops (Fig. 8B), or as inputs to the limestone shift through time (e.g. Extension Passage in G.B. Cave). These have a limited phreatic lifetime because of the falling water-table level. As suggested in Figure 8, differentiation between these two situations requires the identification of a graded trench or stable vadose-phreatic transition which can be related to the phreatic passage. This has not proved possible in either G.B. Cave or Charterhouse Cave where much of the available evidence has been destroyed by collapse.

In Charterhouse Cave, the network modification process is well demonstrated by the sequence of trench captures discussed above, particularly those near The Citadel (Fig. 7; T3, T4 and T5). The strong north-

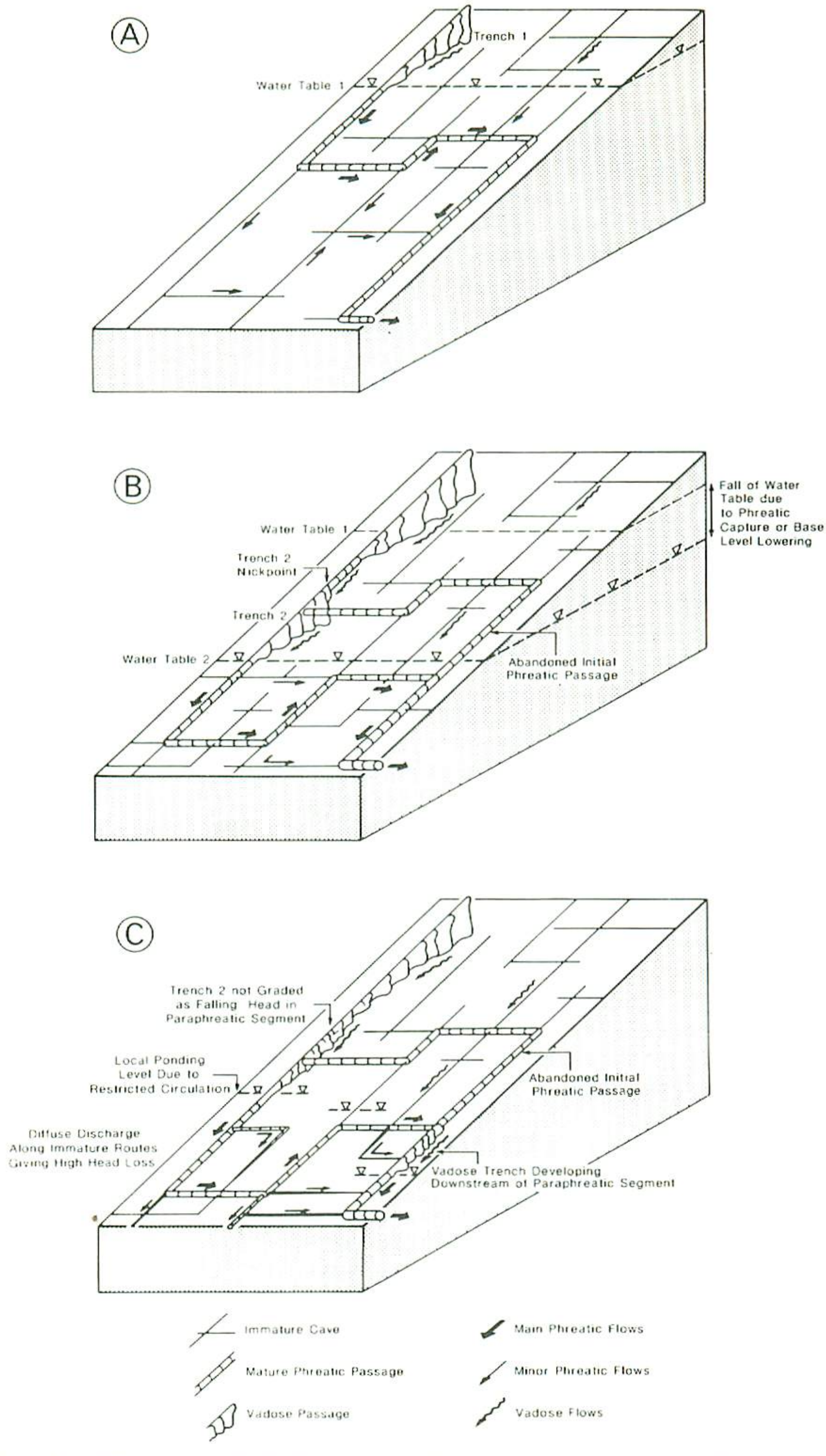

Fig. 8 : Modification of mature phreatic systems by solution in the phreatic zone and paraphreatic development in vadose zone (isometric sketch).

A) Conditions after development of initial mature phreatic route.

B) Progressive solutional development permits initiation of new phreatic route in depth, and abandonment of initial mature system.

C) Paraphreatic development following lowering of water table level gives declining head through time, limiting the development of mature phreatic features and preventing formation of a stable adjusted trench.

south jointing gives many potential immature routes for movement of water down-dip on the major east-west passage line. However, little circulation occurs in such routes until a significant head difference develops with lowering of the water-table. Passage enlargement then occurs, resulting in a down-dip capture of the vadose flow, which adjusts to the position of the new water-table level. Further drawdown increases the head difference over lower segments of the dip tube, and a second capture can occur giving a nick-point in the floor of the upper trench.

Modern, active down-dip captures, known in both G.B. and Charterhouse Caves, are not related to specific phreas levels but occur in a vertically extensive vadose zone, as originally suggested by Ford (1964). For instance, the G.B. stream follows an unknown route beneath the floor of the upper Gorge, before emerging in the east wall of the Gorge, upstream of the Ooze Passage junction – a route down-dip from the existing cave. Similarly in Midsummer Chamber (Charterhouse Cave), a small percolation inlet is drained down-dip into a tight vadose trench, whereas the major vadose discharge route had prevously been to the west. The water probably resurges under pressure flow (paraphreatic) along a calcite vein just above the cascades approaching Splatter Chamber, but has not been traced. Any trench formed in such a passage is thus adjusted to the floor level of the major passage, and not a contemporary level of the phreas, as was proposed above. These two situations should be separable morphologically by examination of the relative incision of the capture and downstream trenches. This is not, however, possible in Charterhouse Cave, where extensive collapse in the Citadel has destroyed the evidence.

It is unclear how much of the ramparts of The Citadel comprise breakdown, and how much is carved from solid bedrock. The lateral extent of this chamber may be partly due to the sequence of captures, which have isolated masses of rock permitting stoping down-dip into the floors of the trenches. Undercutting of the eastern wall continues at present. There is a prominent bedding surface developed below the northern wall, which indicates the extent of this process north of the original fracture line guiding the passage. It is, however, the steepness of the dip in the lower section of the Chamber which is the key factor. Not only did this ensure that vadose trenching of the original steep tube was predominantly vertical because of the steep floor gradient, but it prevented the development of a stable cantilevered roof. The collapse in the west and south wall of the Citadel does not appear to be important in its enlargement. It is, however, tempting to suggest that in G.B. Cave, the Great Chamber collapse could be explained by the confluence of the Charterhouse and G.B. streams.

Sequence of Infills

The sedimentary succession, represented by cave fills, must be interpreted from a fragmentary and tantalisingly incomplete record, preserved within the cave, using normal principles of stratigraphy. The most significant of these is that of the superposition of strata; the youngest rocks are highest in the stratigraphy. By following individual sedimentary units laterally, and by comparing their composition and nature, it is possible to

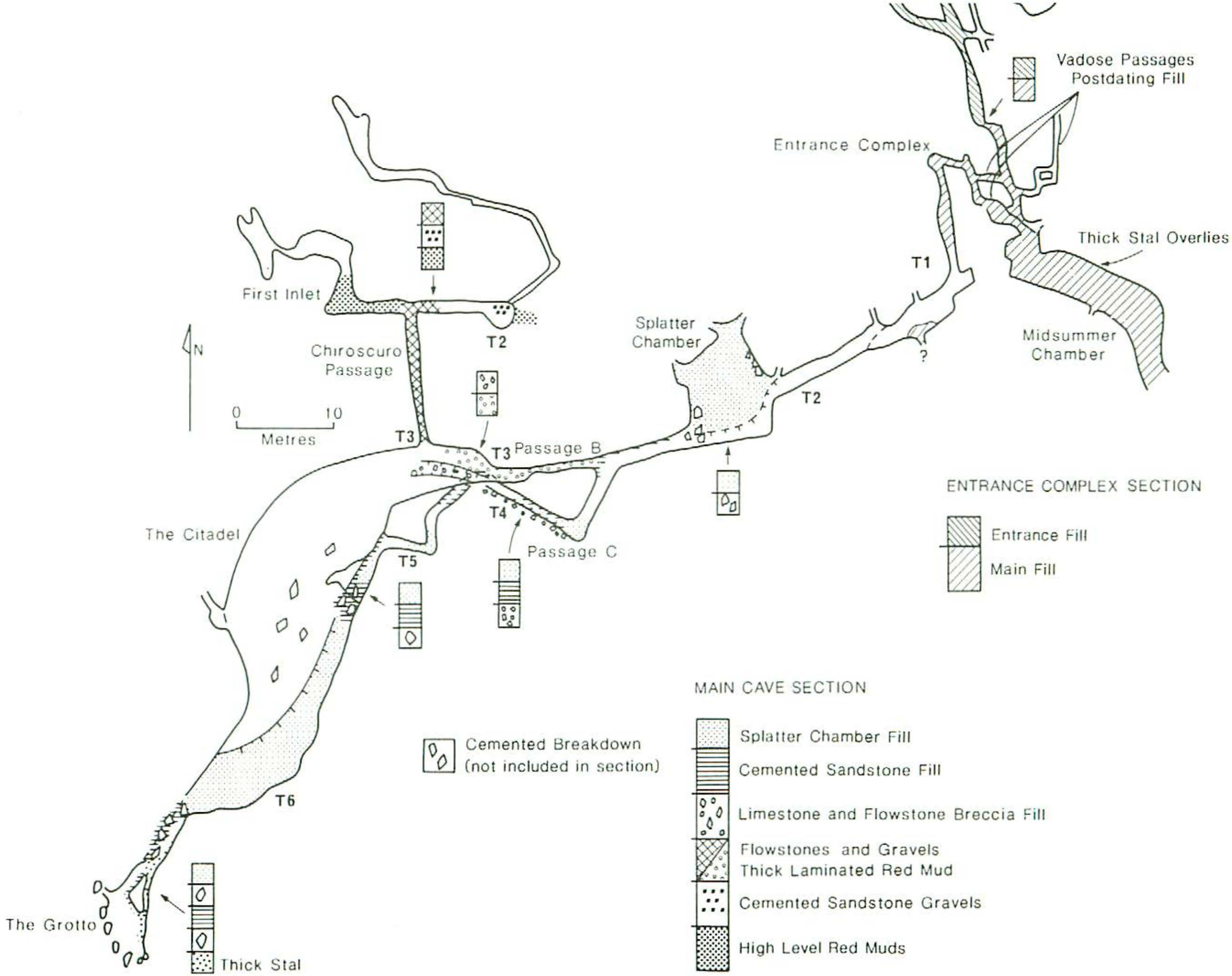

Fig. 9 : Contiguous clastic fill units recognised in the Charterhouse Cave.

establish the sequence of sediment fills occurring. This is particularly assisted in the Mendip Hills by the cementation of the upper portions of sediment fills by stalagmite formation after deposition. The lower uncemented parts are, however, often removed by later erosion, and further fills accumulate below the stalagmite false floor formed on the earlier fill. Finally, by dating the flowstones capping the sediments using uranium series methods, otherwise unrelated fills can be correlated, and the complete sequence fitted into a radiometric chronology within the 350 ka limit of the method. No dates are yet available for Charterhouse Cave.

Continuous clastic fill units recognised in the cave are shown in Fig. 9. Where several fills are recognised in a single passage it is generally possible to establish the succession. The most recent fill, found in the lower cave below Splatter Chamber, is currently being excavated by the cave stream, leaving a lag of coarse Old Red Sandstone gravel in the lower parts of the Citadel. The collapse of this fill upon excavation has given Splatter Chamber its distinctive wall decorations, and its erosion is well displayed by the succession of thin false floors developed on the walls of the Citadel. It comprises a sequence of muddy Old Red Sandstone and Lower Limestone Shale gravels interbedded with gritty muds, and is remarkably similar to that exposed in the Doline III collapse at the head of the Gorge in G.B. Cave. This fill overlies a cleaner washed, cemented Old Red Sandstone gravel, again found throughout the lower cave below Splatter Chamber. It forms a distinctive false floor ledge in the Grotto, and filled the Citadel to at least the level of the Bridge. Both fills appear to have entered from a surface swallet near Splatter Chamber. They must post-date the trenching of the Citadel by a considerable period as they overlie several metres of flowstone spectacularly exposed in the small stream trench in the grotto and flowstone covered breakdown boulders present at several points in the cave.

In passage C (Fig. 9), an earlier fill dominated by limestone breakdown and flowstone, but also containing some rounded Old Red Sandstone, can be seen. This cannot be followed elsewhere in the cave but must truncate the laminated red mud fill several metres thick, seen in the overlying passage B. A similar red mud fill occurs at a higher elevation in the roof of the Chiaroscuro Passage and in First Inlet. This predates a cemented, muddy Old Red Sandstone – Lower Limestone Shale deposit which completely blocks the trench at the eastern end of Chiaroscuro Passage. Downstream of this fill is a complex sequence of gravels interbedded with thick flowstones at the base, and subaqueous pond calcites at the top. The gravels may well be derived from excavation of the earlier fill by a later, flowstone depositing, percolation inlet. This deposit is at least 3 to 4 m thick in the floor of the trench entering the Citadel, and must represent a substantial blockage to *c.* 224 m AOD, caused, perhaps, by collapse in the Citadel. It is not possible to establish the relative ages of the thick laminated red mud and flowstones and gravels.

Finally, the most spectacular fill in the cave is seen only in Midsummer Passage and the Entrance Complex. It is largely composed of well-rounded Old Red Sandstone in a cemented sandy matrix, and is at least 4 m thick. It forms prominent false floors in the roof of passages in the vicinity of the Wallows, where the fill has been extensively removed by a complex sequence of later vadose trenches. This has caused widespread collapse of the thick overlying stalagmite deposits. The enormous volume of these formations strongly suggests this is one of the most ancient fills in the cave. The fill appears to have entered from a major, but unknown, swallet some way to the east, although the entrance passages were also extant at this stage. This unknown swallet also served as the inlet for the excavating stream, although the tight rift passages to the east of the Entrance Complex was newly developed at this time. Only one other minor fill is known in the Entrance Complex and this post-dates the major fill.

Two general points can be made about the sequence of fills. Firstly, it is apparent that even in this relatively simple cave, at least five significant, but totally separate, points of engulfment have been employed by the vadose swallet waters. This is a point also stressed by Ford (1964) for G.B. Taken as a single swallet complex, the G.B. – Charterhouse Caves system embraces a minimum of fourteen major points of engulfment (ignoring the multiple inlets of the Sidcot Series), over a distance of some 300 m. The blockage and reutilisation of these routes must depend significantly on the extensive infill of the blind swallet valley, which diverts sinking streams to new positions. This is readily apparent at present where the extensive deposits seen in Doline III have allowed development of two separate streams leading into Reads Grotto and Tyning's Swallet. Such a situation would not be possible in the adjacent Longwood Valley, where significant infill has not occurred. The second point is that the spatial localisation of the fills within the cave provides limited support for the hypothesis of slow draw-down of the water-table postulated above. The Midsummer Passage fill, for instance, does not occur below the level of the 241 m AOD trench (T1), while the limestone and flowstone dominated fill is only seen blocking passage C (T4). Finally, the calcite pond deposits appear to post-date the 228 m AOD trench (T2) but are related to simultaneous accumulation of red muds in passage B (T3). In turn, these are cut through by the limestone and flowstone dominated fill of the next trench (T4 in passage C). The implication, therefore, is that fills are preserved predominantly in those sections of passage which are vadose at the time of emplacement, a combination of reduced transport efficiency and erosion during later vadose incision limiting preservation in the phreatic zone.

CONCLUSIONS

Four significant differences in interpretation exist between this account of the geomorphology of Charterhouse Cave and that of Ford (1964) for the immediately adjacent G.B. Cave:

1) Ford (1964) suggested a complete network of phreatic passages existed prior to vadose development. Here it is proposed that only two mature phreatic routes were present, Double Passage – Chiaroscuro Passage – Passage B – Citadel – Grotto, and Rhumba Alley – Bertie's Pot – Ladder Dig – Bat Passage. However, an extensive skeletal network of solutional fissures was also developed.

2) Water table levels in the limestone were, according to Ford (1964), initially controlled by the lack of significant cave development, and fell

rapidly to a stable base-level controlled elevation after breakthrough of the mature cave system. Here it is proposed that base-level has always been the major control of water table elevation, but that this is initially mediated by essentially random cut-offs and captures within the passage network, the effects of which decrease systematically with time as solutional development permits the development of an integrated phreas. Water table levels have therefore fallen both slowly and intermittently.

3) In G.B., Ford (1964) proposed that vadose development occurred in a vertically extensive vadose zone from a complete pre-existing phreatic network. The interpretation now proffered is that the vadose zone expanded vertically with time as the water table fell, with paraphreatic then wholly vadose modification of an initial skeletal network of solution fissures based on joints and dip tubes.

4) The sequence of captures and trenches developed in G.B. Cave were thought to be unrelated to the water table. In Charterhouse Cave it is proposed that a sequence of trenches related to the declining water table level can be identified.

Whilst with the development of ideas it is possible to reinterpret earlier work, it should be emphasised that the value of the pioneering work of Ford lies not in the detailed interpretation of this specific site, but in the methodology and approach adopted. Furthermore, Ford suffered from the plague of all cave geomorphologists, he knew only of the explored parts of G.B. Cave (which excluded Bat Passage), and had no means of predicting the form or even the existence of Charterhouse Cave. Nevertheless, the elevation of individual sites to a 'type example' status in the literature is dangerous, in that it begs the possibility of different interpretations.

There are also considerable problems in establishing reliable criteria to support some of the above proposals. The sequence of trench development in particular may grossly over-interpret what are a series of random or structurally controlled steps. There is also a tantalising absence of evidence at critical points in the cave systems discussed. Therefore, some of these contentions can be considered no more than educated opinions, based on individual interpretation. Nevertheless, it is important to consider alternative explanations to those previously enshrined in the literature, and by actually stating these alternatives in papers such as this, it is possible to formulate hypotheses to test by direct observation in the future. It is hoped that this paper stimulates future work and discussion in the same manner as Ford's earlier classic study.

ACKNOWLEDGEMENTS

P. L. Smart: I would like to thank the many individuals who accompanied me into Charterhouse Cave during this work, and assisted with the troublesome surface survey. Simon Godden drafted the diagrams and the survey to his usual high standard, while Tim Atkinson, Tony Boycott, Derek Ford and Willie Stanton made helpful comments and additions to the initial manuscript.

P. D. Moody & A. A. D. Moody: P. Morris for his notes on the history of the S.S.S.S. digging at the site. Also to P. Hann, A. Lavender, T. Large, M. Madden, C. Milne, A. Mills and A. Taylor for their contributions to the discovery and exploration of Charterhouse Cave.

NOTES ON THE SURVEY

Cave Survey by Suunto compass and clinometer read to 1°, and 30 m Fibron tape read to 0.1 m. Station positions precise to 0.1 m. Detail measured at stations, and sketched between. There are no closed traverses. Grade BCRA 5C.

Surface survey location of entrances fixed in relation to G.B. Cave Blockhouse, and wall intersection to southeast of Charterhouse entrance using Wild T2 Universal Theodolite, and precise to ±0.5 m horizontally and 0.05 m vertically. Elevation of G.B. entrance (centre of inner cill of Blockhouse, 0.15 m below external ground level) taken as 253.0 m AOD. (Locations of precisely heighted and located benchmarks of the original Crickmay and Bendall (1951) survey are not quoted by the authors, nor are the original details available; these could therefore not be relocated.) Surface detail in vicinity of Charterhouse Cave from automatic level survey using horizontal circle to ±0.5° and distances ±0.5 m from stadia tacheometry. Remaining surface detail and G.B. survey from Savage (1969) after Crickmay and Bendall (1951). The Imperial surface contours have been converted to metres. Surface survey datum for Charterhouse Cave is centre base of front girder of roof in front of blockhouse door. This point is 2.13 m above the G.B. cave datum.

Note: it is probable that surface topography was not added by Savage (1969) in the area underlain by the Ladder Dig Series.

ACCESS

The following rules have been laid down by the Charterhouse Caving Committee, who control access to the caves on land belonging to the Bristol Water Works Company Ltd.

Access to Charterhouse Cave is only available through approved Leaders. Each Member Club (of which the U.B.S.S. is one) has two Leaders.

Each Member Club shall have one key. This shall be shared by the two Leaders, the intention being to limit the number of parties in the cave at any one time. Party size is limited to four, including the Leader. No acetylene (carbide) lamps are permitted. No novices are allowed into the cave. The rules regarding permits for the neighbouring caves apply also to Charterhouse Cave.

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Plate 1. Charterhouse Cave. The Citadel viewed from the balcony in the west wall.
Photo. P. Hann

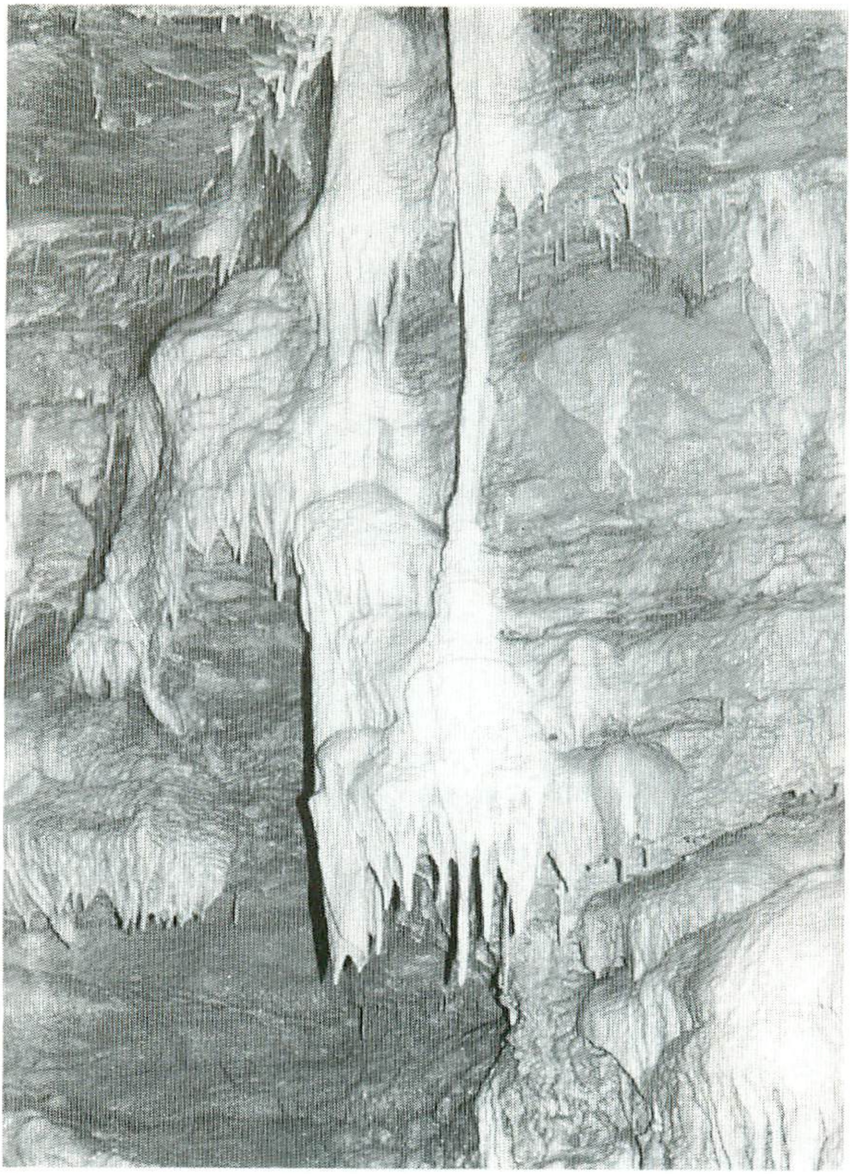

Plate 2. Charterhouse Cave. Stalactites in Midsummer Chamber. *Photo. A. Boycott*

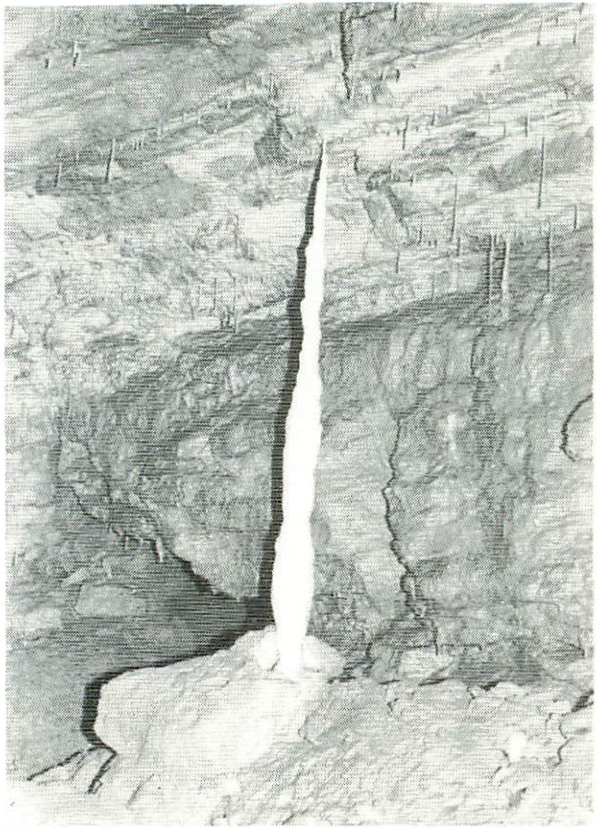

Plate 3 a. Charterhouse Cave. Column in Midsummer Chamber.

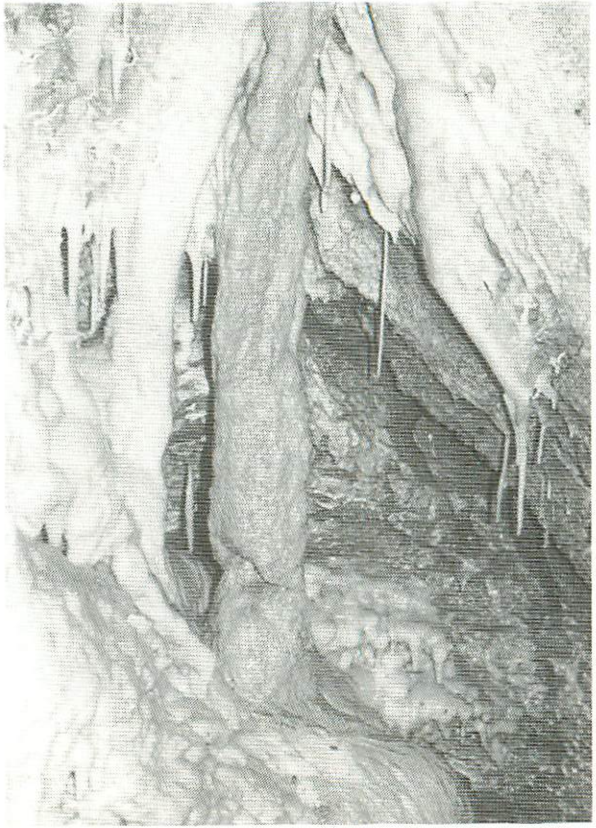

Plate 3 b. Charterhouse Cave. The 'Singing Stal'.

Photos. A. Boycott

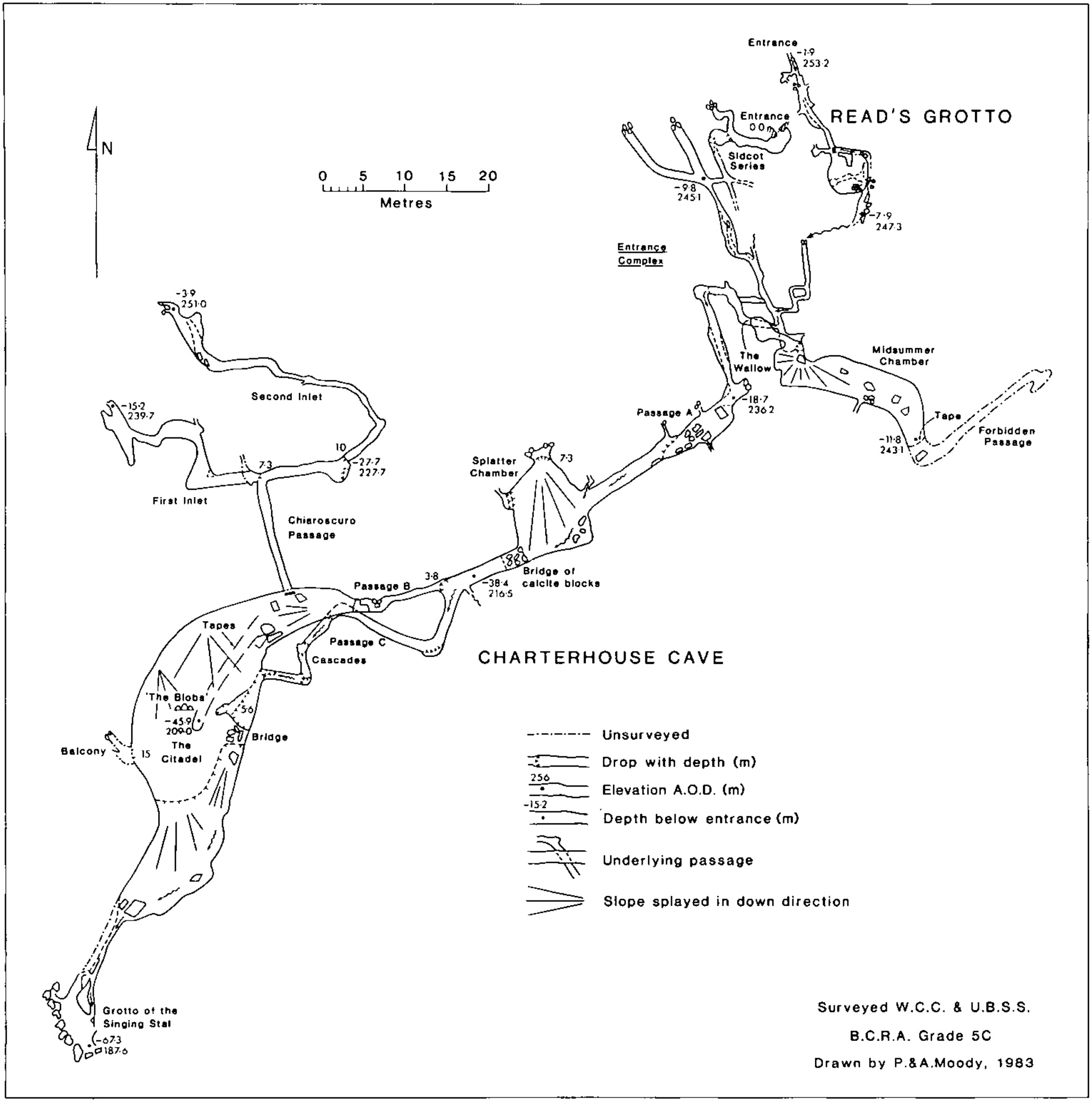

Fig. 1 : Plan of Charterhouse Cave.

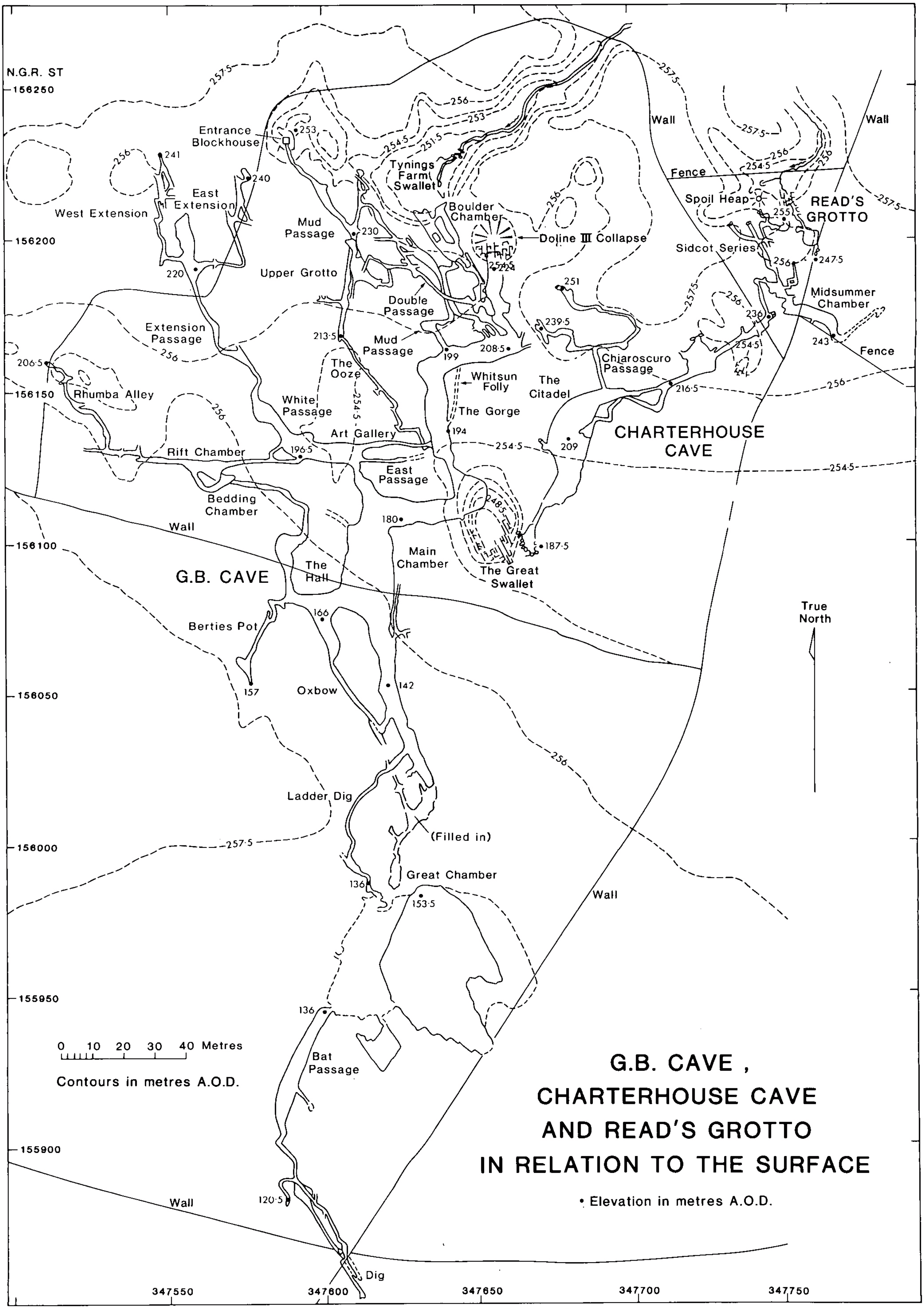

Fig. 2 : G.B. Cave and Charterhouse Cave in relation to the surface.