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Grotto in Kvannlihola 2, Fiplingdal

BRITISH CAVE RESEARCH ASSOCIATION

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KVANNLIHOLA 2 AND OTHER CAVES IN FIPLINGDAL AND OTHER AREAS OF NORDLAND, NORWAY

Compiled and edited by Trevor Faulkner

Abstract

Fiplingdal is a long valley to the south of Mosjøen in Nordland, Norway, previously with only one recorded cave. Narrow and steeply inclined marble outcrops lie along the length of the valley to the east and west of the lakes Nedre and Øvre Fiplingvatn, ideally situated to capture the streams flowing down the valley sides. The many caves discovered at the limestone contacts are described, together with the extension to the known cave of Kvannlihola. Caves found in three other new limestone areas in the southern part of Nordland are also included, together with comments on the remaining caving potential and the organization of expeditions to the area.

INTRODUCTION

This is the report of the 1982 Expedition to Fiplingdal, Norway. The expedition comprised two members of Eccles Caving Club, Trevor Faulkner and Alan Marshall, and Geoff Newton and Vic Battams from BEDROC, a Luton caving club. The aims were to explore a new caving area at Nedre Fiplingvatn, which from the NGO map could have contained ten cave entrances and, whilst in the area of southern Nordland, to investigate other possible sites which had not been visited by cavers.

In order to ensure that the expedition members would enjoy at least one really fine and sporting caving trip whilst in Norway, the itinery also included a visit to the Okshola-Kristihola cave system near Fauske, Norway's longest cave. A subsidiary objective of helping the Cave Diving and Surveying Expedition to Glomdal in Svartisen did not materialise, as at that stage it was felt that insufficient new ground had been discovered to permit such a diversion.

The expedition travelled to Norway by sea from Newcastle to Oslo, driving a total of 2,300 miles in an Avenger saloon car and spent about three weeks in Norway. A total of over 40 new caves were discovered, explored and mapped giving a total new passage length of about 2.8 km. The major discovery of Kvannlihola 2 was found towards the end of the expedition, creating another large cave in the southern part of Nordland.

Previous British visits to southern Nordland have included Hattfjelldal (Heap, 1968, 1969, 1975), Hattfjelldal and Fiplingdal (St. Pierre and St. Pierre 1971), Øyfjell (Heap, 1968), Grane (Faulkner and St. Pierre, 1977), Velfjord (St. Pierre 1979; Faulkner 1981) and Eiteraadal (Faulkner 1980). A review of known caves in the western part of south Nordland is included in St. Pierre and St. Pierre (1980) and Faulkner (1979) summarised knowledge of sumps in the area.

EXPLORATION

Leaving Oslo early in the evening of Sunday, 25 July, we started the drive north on the E6, but then moved over to Route 3, which proved to be a shorter and faster route up southern Norway. A short camp was made that night and the journey via Trondheim resumed in the morning. After driving for most of the day, Fiplingdal was reached via Trofors and camp established west of Nedre Fiplingvatn at 8.30 p.m. Fiplingdal seemed somewhat reminiscent of Eiteraadal, visited in 1978 and 1979 (Faulkner 1980) but with far more farms and weekend huts, and even a shop. However our campsite was rather unattractive, being simply a turning area at the end of the track, with abandoned vehicles and other rubbish lying about. But there was very little choice and we planned to move on if the immediate area was unproductive.

The first two days in Fiplingdal were spent walking north along the limestone, finding many sinks and shakeholes where streams from the western ridge flowed onto the marble. After a tiring ascent on the first day, we were immediately rewarded with a large cave entrance near the sink of the Baatskarelv. More caves were quickly found high on the valley side, although some were only entered after a little digging and in the most promising one we were soon stopped at the top of a very wet pitch without tackle. This was descended on the second day, but progress was again halted by a diggable wet crawl. Instead, we walked on north, finding more small high level caves, and then a short watery stream cave in the centre of the valley near Tøimskar.

By Thursday, 29 July a change of scene was needed, so we drove around to the other side of the lake to find Nyrudhola, a 30 m deep hole formed in marble dipping at 60 degrees. Back by the car we cleaned ourselves up and cooled ourselves down by washing and swimming in the icy cold lake (for a few seconds!).

The time had come to review our progress in Fiplingdal and decide whether to leave. We had certainly found a few caves, but nothing of great extent, and what was found had usually taken quite a lot of work. However, rather than leave a few outstanding leads we decided to spend at least another day on them.

Consequently, 'Two Level Cave' was lengthened by digging and then the crawl at the foot of the wet pitch in Vicgrotta was pushed to a conclusion. Meanwhile, Vic dug into a nearby sink via some rocky squeezes, discovering Tumbledown Pot. Our sleep that night was disturbed at 1.00 a.m. by some local visitors plying us with home-brewed spirits, who later told us of other caves north of Tøimskar, and the probable resurgence of the Baatskarelv. After visiting this sumped rising the next morning, the group split into two to allow Tumbledown Pot to be extended slightly whilst the north Tøimskar area was being investigated. This new area was free of birch forest and five open entrances were found during the day. However, it was also a long walk from camp.

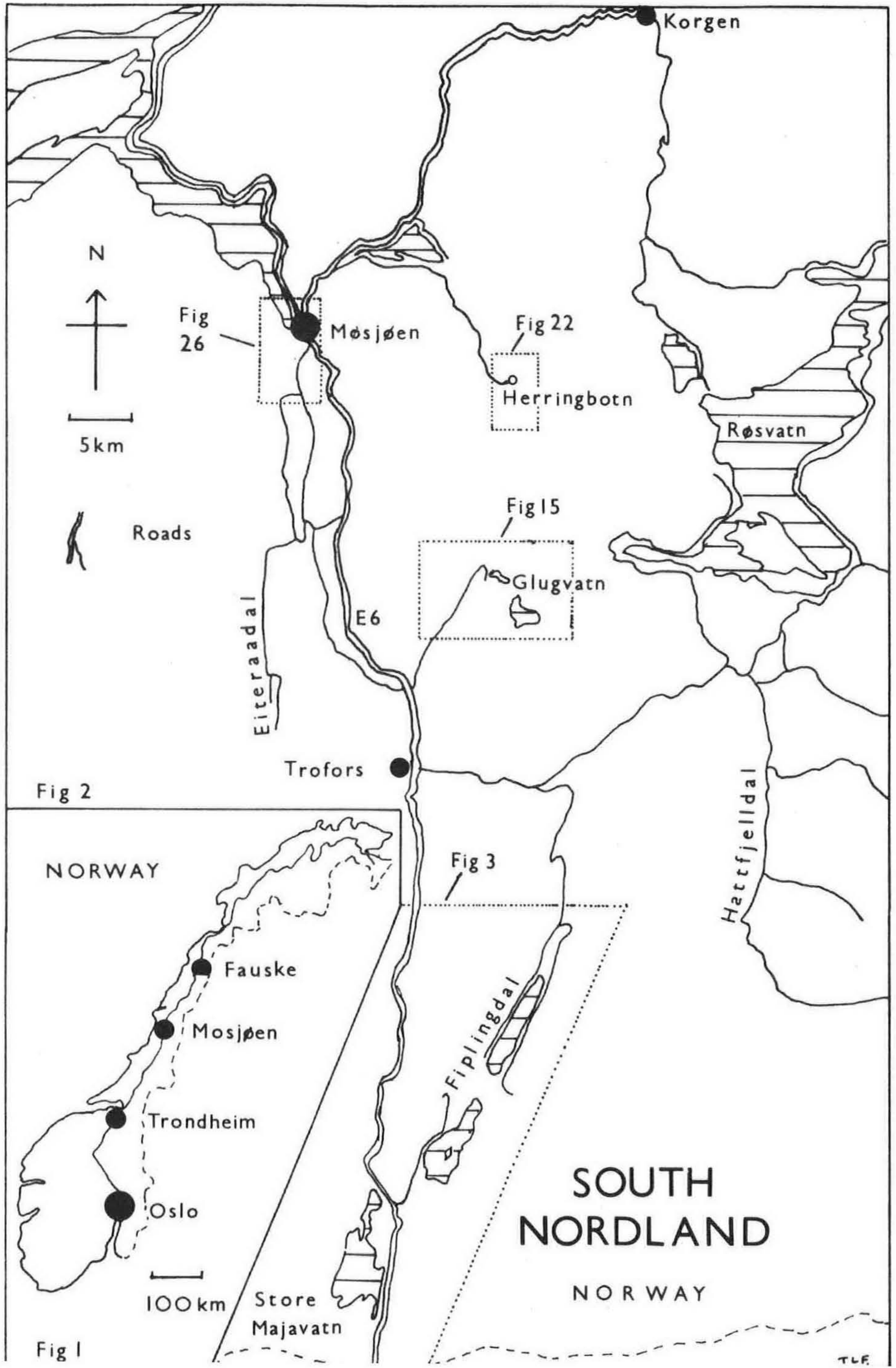
It was by now clear that we would always be able to enter new cave or passage every day if we stayed in the Nedre Fiplingvatn area, but generally the return gained did not match the effort put in. Deciding therefore to make a break, we would move our camp away from the road and up to the nice new area above Tøimskarvatn and stay there one or two nights only. The walk with loaded rucksacks was a sweaty affair, attracting the usual flying insects, with the sun getting hotter and hotter before we reached our chosen spot and pitched the tents below a waterfall. Bedroc went to Tumbledown Pot for the last time whilst Eccles explored Dry Cave, Tøimskar Stream Cave, the extremely sporting (i.e. awkward) Doorway Cave and other smaller sites. The next day was the hottest so far, with a view when we woke of a clear blue sky above a bank of mist lying in the main valley (Plate 1). A surface survey was made, and an attempt to connect Dry Cave to Tøimskar Stream Cave, before we struck camp and returned to the car. Two Norwegian friends gave us coffee and told us of an unrecorded cave "2000-3000" m long near Mosjøen, which we noted for a later day.

Whilst not being exhausted, the Nedre Fiplingdal area had been covered very thoroughly over the previous six days. We had also worked fairly hard, with stints of up to 12 hours per day away from camp, and felt that the time had come to drive to Fauske to visit Okshola. This trip, on 4 August, was a very memorable event. We were joined by Edgar Johnsen, who drove over from his farm in Graataadal, and, after a relaxed start we were soon negotiating a really magnificent streamway in high water conditions. Despite the noise and spray, all pitches were freeclimbed except for that of 12 m and the cave was explored into Syphon Series and the large upper galleries. A setback occurred on the way out when a ladder was dropped into a turbulent 3 m deep pool. Despite all fishing and diving attempts it remains on the bottom, occasionally visible when the water surface smooths over.

The second half of the expedition was now scheduled to visit various places on the way south, starting with a remote site in Misvaer, Skjerstad. Above the hamlet of Espenes the map showed a stream sink at an altitude of 500 m, with a band of marble striking towards it all the way up the hill from the nearby fjord. After a dreadful walk through dense vegetation and then marshy birch forest we eventually found the stream, and its immature sink.

Our next hope was the cave described to us in Fiplingdal as Øyåskjeleren, near Mosjøen. The orienteering map provided showed the cave at the top of a steep cliff forming the side of the river Tveraaen. A tricky ascent in the evening took us to many entrances high in the cliff face, so we made camp by the river and explored this series of ancient phreatic cave passages in the morning, moving our camp to the valley of the Herringelva that evening.

Sunday, 8 August started off overcast, but we soon found an easy path from Herringbotn leading, in improving sunshine, to another potential caving area. Many caves were found that afternoon near Klopfjeldtjern, often in bands of limestone only 3 m wide. Returning that evening directly down the Herringelva, the whole river was found to disappear into an inclined band of marble only 1 m wide,


Korgen
Møsjøen
Fig 26
Fig 22
Herringbotn
Røsvatn
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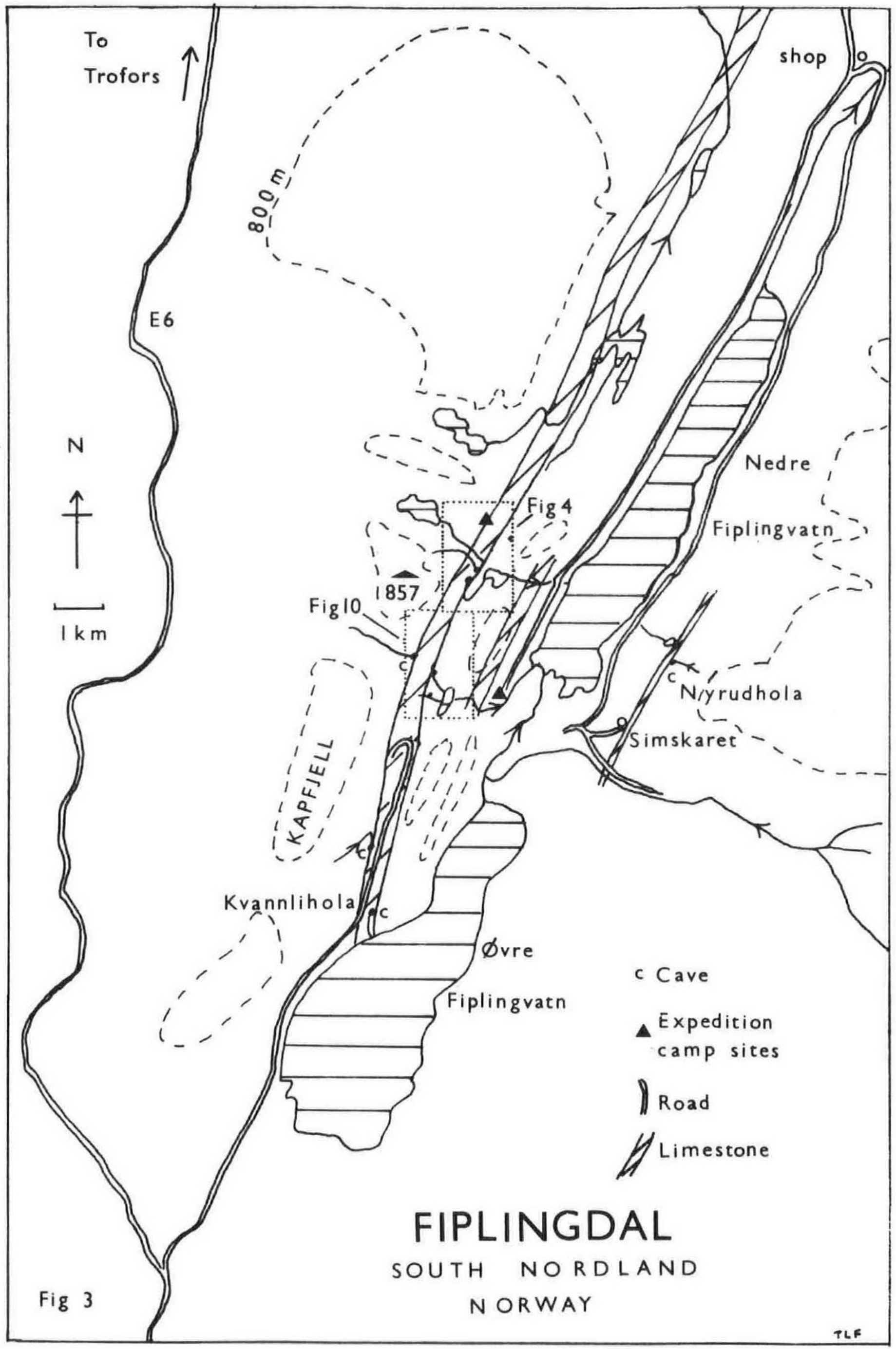
5km
Roads
Fig 15
Glugvatn
E6
Eiteraadal
Trofors
Hattfjelldal
Fig 2
NORWAY
Fauske
Mosjøen
Trondheim
Oslo
100km
Fig 1
Fig 3
Fiplingdal
Store Majavatn
SOUTH NORDLAND
NORWAY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Kvannlihola
Øvre Fiplingvatn
c Cave
Expedition camp sites
Road
Limestone
FIPLINGDAL
SOUTH NORDLAND
NORWAY
Fig 3

but all entrances were blocked by collapse of the overlying gneiss. The next day was spent recovering from the long walk, and driving via Mosjøen to Glugvatn. However, even on this day, 'Expedition Honour' was satisfied as Geoff noticed a black hole in the forest near the road, and rushed off to explore a new cave. Knowing that the possible sites adjacent to Glugvatn would be remote and difficult to reach, the group again split into two. Trevor and Geoff chose the further place and reached it after three hours of slog through midge-infested marshes and birch forest. Interesting caves were found, the underground system being split into two by an intermediate shake-hole carrying the stream. Alan and Vic also reached their objective, finding that the map had exaggerated the underground distance.

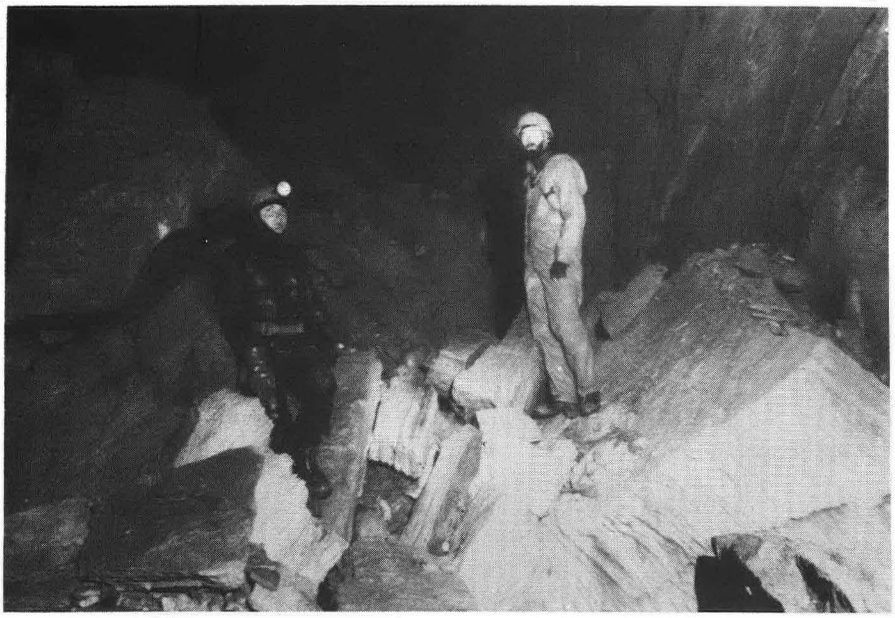
The weather had over the last two days changed completely, with rain and drizzle the norm rather than blazing sun. Now near the end of our available time, we had probably found over 1500 m of new cave passage, with 'new cave every day', but no single discovery was longer than 300 m. Where were we going to find something memorable, rather than just interesting and for the record? The remaining sites on the itinery looked less hopeful than those already visited. We therefore took a chance and returned to Fiplingdal, this time to the Øvre Fiplingvatn area and the short known cave of Kvannlihola.

This resurgence cave is 245 m long and the map showed the river sink to be about 800 m north of the entrance. We went there first: the water went underground in front of a 6 m high cliff. It seemed pretty hopeless, until we noticed the sound of underground water at the foot of the cliff face. Four digs were started in parallel, sharing a crow bar, until after two hours two digs at the cliff face combined and a loose hole down was opened. This was stabilized and we dropped in an hour later to find the largest streamway discovered so far, but it lost height too rapidly and sumped. Disappointed, we continued down the hillside and explored Kvannlihola itself, looking carefully at its terminating sump pool. The premature ending of the sink cave was quite a blow to the team's spirits, which for the only time on the expedition were already suffering due to the changed weather. Morale was restored by hiring a new hytte (a wooden camping hut) at Store Majavatn instead of tenting overnight. Next day saw us investigating the Kvannlihola sump with face mask and hood. The way straight on underwater was blind, but to the left the wall went down for a metre and then rose straight up again to a frothy air surface visible above. Holding a base fed line in one hand, the leader pulled himself under the wall and rose up into an airbell. It turned out to be about 1 metre wide, 3 metres long and not very high, but amazingly at the far end was a small hole just above water level through which the sight and sound of a roaring streamway emerged. The hole was too tight to crawl through but obviously could be easily dived under. We all went back to the car to brew coffee and collect a rope. Alan was then given the privilege of being first through the second part of the sump, and soon returned having secured the rope to a flake in a canal on the far side. The enormous and well decorated passage beyond is fully described later in the report. It was explored by three of the party to another sump on the first visit, together with the side passage near the Top Waterfall. Initial exploration over, and as it was past lunch time, we dived back out and cooked a meal at the car. The next tasks were to survey and to photograph and that afternoon, whilst Trevor and Alan recorded the survey data, Geoff took some pictures, using the surveyors as models. On this trip the cave pearls were discovered, as well as new groups of stalactite formations. Other photographic gear was left beyond the sump overnight and the team hired itself another hytte at 10.30 p.m.

There was now only one day left before we had to drive south for the ferry, and we planned to complete the photography and try to climb up to another side passage. However, we had reckoned without the weather. At 4.00 a.m. it was realised that leaving the camera beyond the sump had been a risky decision, as torrential rain beat down on the roof of our hut. It stopped raining by 7.00 a.m. but later on we found a tremendous flow out of the sump and the water level was up a foot, making free diving unthinkable. Pretty desparate to recover the camera and to take the necessary pictures, we set to work excavating the stream bed adjacent to the sump pool to lower its level and increase the flow rate. Our luck at meeting deadlines held, as several hours later and after lunch the sump was back to its normal level. Three of us dived back through the foaming airbell and canal into Kvannlihola 2 for the last time, successfully completing the photographic work and discovering Forbidden Passage. Once again the day ended late, and rather than start the drive south immediately we gave ourselves the luxury of a third hytte for the night, in celebration at finishing the expedition on such a high note.

1. Tøimskar area looking south with cloud over Fiplingvatn. (photo G.Newton)

2. Baatskarelv sink seen from Baatskarelvgrotta. (photo T.Faulkner)



3. Block pile in Kvannlihola 2. (photo T.Faulkner)

FIPLINGDAL

The valley of Fiplingdal is aligned roughly north to south and lies south of Trofors in Grane, Nordland. The only known exploration previously has been to Kvannlihola on the western side of Øvre Fiplingvatn, which was surveyed by Einar Hortmann in 1962 (St. Pierre and St. Pierre 1971 and 1980). The NGU geological map (Hattfjelldal sheet) shows two lines of marble outcrops running parallel to the valley west of the two lakes, the western-most being over 40 km long with an average width of c. 500 m. This major outcrop was found to be vertically banded and cavernous. A narrower band of marble was also found east of Nedre Fiplingvatn, dipping at 60 degrees to the west. The limestones are strictly all marbles and occur within much more extensive areas of mica-schist and gneissic rocks and have had a marked influence on the local topography, forming coincidental upper valleys. Although Øvre Fiplingvatn flows into Nedre Fiplingvatn to its north, the drainage in the upper valleys is more varied. A major watershed occurs west of the marshy separation of the two lakes, so that the Kvannlihola stream is captured underground after first flowing south (Fig. 3).

TØIMSKAR AREA

This is the most northerly area of Fiplingdal visited by the expedition and lies along an upper valley west of Nedre Fiplingvatn. Although the limestone band here is 500 m wide overall (Plate 1), interlayered impurities of mica-schist are sufficiently extensive to retain cave development within narrower bands about 150 m apart, preventing a lateral integration of the underground drainage. All streams flowing down the valley sides sink at the limestone contact, giving rise to a linear development of sinks and shakeholes. The exception is the large mountain stream, Lille Baatskarelv, which only fully goes underground and sumps where it reaches a permeable band of limestone in the valley bottom. The band of limestone which is responsible for the Baatskar area sinks (q.v.) also captures some streams SW of Tøimskarvatn, probably diverting flow to the north (Fig. 4).

5M POT (24)
02° 47'37"E, 65°28'38"N — Alt. 750m Depth 5m

The most northerly feature along the westernmost line of limestone. A small stream flows down one of four connected holes. One small hole can be laddered into a 4m diameter circular shaft with no way on; the water flows south along the strike.

Tackle: 5m ladder, 10m lifeline, 3m belay
Explored: T. Faulkner, R. Marshall 1 August 1982.

DOORWAY CAVE (23) — Alt. 750m, Length c.14+168m, Depth c 5m
02°47'36"E, 65°20'37"N

At the next shakehole south a stream turns into a door-shaped entrance. 14m of crawling lead to an unpassed collapse caused by the small shakehole containing the exploration entrance (22) where a trickle of water enters. The main cave starts as a flat-out crawl over cobbles from this entrance and soon enlarges to an easy crawl to where the cave passage twists and turns before it becomes an awkward but walking size passage. The cave starts to get more roomy, with a small stream cascading down to some small pitches. The passage then goes to stooping height until it reaches a tall narrow rift which can just be passed at stream or roof level. The roof route is larger but requires a loose exposed climb down at the far end. The rift at floor level has some very vicious bends with sharp, wetsuit-ripping flakes. After the rift the roof lowers to a hands and knees crawl and following about 40m of awkward passage the cave ends in an impassable sump.

Survey: Fig. 5. A. Marshall 1 August 1982
Explored: A. Marshall, T. Faulkner 1 August 1982.

CAMP CAVE (17)
02°47'27"E, 65°20'28"N. — Alt. 750m, Length c.15m Depth c. 5m

A fluctuating snow melt stream flows as a prominent waterfall off the cliff and sinks immediately into a small choked rift in the limestone. Digging was attempted but abandoned due to the immaturity of the site. A few metres south a large snow-filled shakehole contains the entrance to Camp Cave, which consists of a single large but silent chamber floored with dried mud.

Explored: V. Battams 2 August 1982.

A line of shakeholes and shafts continues all the way from Camp Cave until the prominent waterfall on the Lille Baatskarelv is reached, following the approximate line of limestone contact. Sixteen significant shakeholes were noted, numbered from the waterfall northwards (Fig. 4). The following features contained enterable passage.

(1) The large shakehole close to the waterfall. A free-climbable 5 m pitch was followed by a 6 m slope into a large sump trending downwards at 30 degrees.

(2) A 4 m daylight shaft leads to a low wet crawl with stream flowing north. It is tight but might be pushed.

(9) A shake 5 m deep where a stream sinks, with a non-limestone rock wall on the east side.

(10 and 11) Bridged shakeholes. The northern one has a wide 4 m shaft to a 2 m drop and loose passage heading east.

FLAKE POT (12) A small open shaft. A 2 m free climb leads to a 7 m ladder pitch in a loose clean washed shaft. Care should be taken here. At the foot a small stream enters via a too tight passage from the south. Downstream the passage descends steeply to the north for 6 m before becoming tight: it might be pushed. The passage is seen continuing. Explored G. Newton, 2 August 1982.

(13) A large shakehole blocked with breakdown and taking a small stream. A 7 m loose bouldery rift climb reaches a junction. To the north is blocked after 3 m, to the south after 2 m.

(13A) A small hole close to and east of (13). A passage descends for 6 m to the north before becoming too tight.

(15) A 3 m deep shakehole with a snow plug. A low crawl leads to a lower arch after 3 m. This gives onto a narrow canyon which may be followed 4 m in a northerly direction until a corner is reached.

Unless otherwise stated, the above features were explored and recorded by V. Battams and G. Newton, 1 August 1982.

The water draining this line of limestone, and perhaps including that last seen in the sump of Doorway Cave, resurges in a pool (61) at the foot of the impressive waterfall on the Lille Baatskarelv. Clearly a large proportion of this water sinks again along the same limestone band, as the major part of the nearby stream to the south is fed from a large resurgence (63) 50 m further along the strike. A shakehole behind the resurgence (62) exposes the water, but no passage can be entered.

The next band of cave-bearing limestone occurs about 100 m east and parallel to the first band. The area map (Fig. 4) shows that the first capture is nearly as far north as the watershed (31) but the passage formed here is too tiny to enter. The next underground flow can be explored for 10 m (33) as far as a collapse under a shake, and walking further south the next feature of interest is a hole with the sound of the stream audible (39).

TØIMSKAR STREAM CAVE (39) Alt. 670 m, Length c.160 m, Depth c.12 m
02° 47'10"E, 65°20'26"N

The entrance is a 3 m climb to a streamway. About 7 m in, shortly after a bend, a 5 m pitch is reached. This may be free-climbed with care in dry conditions, but is better laddered. A fine marbled streamway carries on, partly as a short oxbow, and becomes a clean rift passage with several small cascades until a low chamber measuring 6 m x 3 m is reached. Surprisingly there is no sign of the passage from the Dry Cave entrance. The passage continues as a flatout crawl for 30 m becoming very wet until a canal is reached with a diminishing airspace which still draughts but cannot be explored on carbide.

From the same shakehole, upstream was excavated into a 14 m low passage to faint daylight below shakehole (38).

Tackle: 5 m ladder, 3 m belay, 15 m lifeline.
Explored: T. Faulkner, A. Marshall, 1 August 1982.
Survey: Fig. 6. T. Faulkner, G. Newton, V. Battams.

DRY CAVE (40) Alt. 670 m, Length c. 41 m, Depth c. 6 m.
02° 47'08E, 65°20'24"N

Walking south a small pool of water is reached at the head of a shallow dry valley ending at a climb down over blocks into Dry Cave. The cave soon narrows to a tall vertical rigt. At floor level this becomes too narrow although it opens out in front. Climbing into the roof it is possible to crawl forward until the way is obstructed by a huge fallen block, with again open passage beyond. From both terminations comes the dull roar of a distant stream, which presumably is that flowing in Tøimskar Stream Cave.

Explored: T. Faulkner, A. Marshall, 1 August 1982.
V. Battams, G. Newton, 2 August 1982.
Survey: Fig. 6 T. Faulkner

The water in Tøimskar Stream Cave reappears as a large flow at a resurgence (44) 150 m from the end of the cave. A few rocks were removed, but a lot more work would be required to make it enterable. As the area map (Fig. 4) shows, there is a short section of underground flow for this stream, and for another 50 m to its east, before the next explorable cave is reached.

HIGH FLOW CAVE (48) Alt. 630 m, Length c.50 m, Depth c. 9 m
02°47'25"E, 65°21'10"N

The entrance is a hole dropping straight into a clean washed passage carrying a powerful stream. Upstream is a wet crawl leading towards the sink (47). A metre high passage leads downstream along the strike to a fine 3 m deep sloping cascade where the stream has turned west, cutting down through a band of impurity. The strike alignment is soon regained along a rocky crawl until the passage turns east and plunges over a wide vertical waterfall. Moving back to the previous alignment, the streamway enlarges and at a large joint splits into two sections: a clean sharp wide crawl directly over the lower streambed. At a second joint 4 m forward the passage becomes reintegrated, the water flowing south fast into a large deep sump pool.

Explored: T. Faulkner, A. Marshall, G. Newton, 28 July 1982
Survey: Fig. 7. T. Faulkner, 28 July 1982.

Walking south along the strike for 120 m, two large connected parallel rifts (65) are found, formed along joints at right angles to the strike. These are 5 m deep windows onto the underground phreas, with, amazingly, water flow to the north. They are fed from a sink (64) 50 m south in the left bank of the Lille Baatskarelv, where part of the flow is captured.

The combined phreatic waters from High Flow Cave flowing south and the Lille Baatskarelv partial sink flowing north, both utilising the same band of limestone, must join and form a course moving east then south again as they reappear from a large deep impenetrable rising 300-400 m away (67). The surface flow is shortlived as the river soon flows into a low opening (68). A tight rift would give access to a deep watery chamber 2 m in, but the way on is almost certainly sumped. The combined flow of the Lille Baatskarelv and its southerly partner also sink among rocks just beyond the rift opening, so that this sink (68) takes all the drainage of the Tøimskar area west of the footpath. A tubular oxbow cave 10 m long (66) at the corner on L. Baatskarelv was inactive when visited in dry weather.

100 m south of the combined sink the river rises from three resurgences (69-71), the outer pair being smaller and impenetrable. It then runs on the surface for over 300 m until it is captured by a low superficial (and unexplored) cave passage 100 m long with windows (73). A tiny proportion of the water sinks at the corner (75) where the river turns sharply north to flow into Tøimskarvatn. West and up the valley side from this corner, two streams flow down and disappear into immature sinks (81,82) when they reach the line of the Tøimskar Stream Cave/ High Flow Cave limestone. 100 m to the north is a prominent long hummock of exposed limestone.

HUMMOCK CAVE (83) Alt. 630 m Length c.10 m
02°46'53"E, 65°19'47"N

A low crawl along the strike from the base of the south end of the hummock, emitting a cold draught but becoming too low.

Explored: V. Battams, 28 July 1982

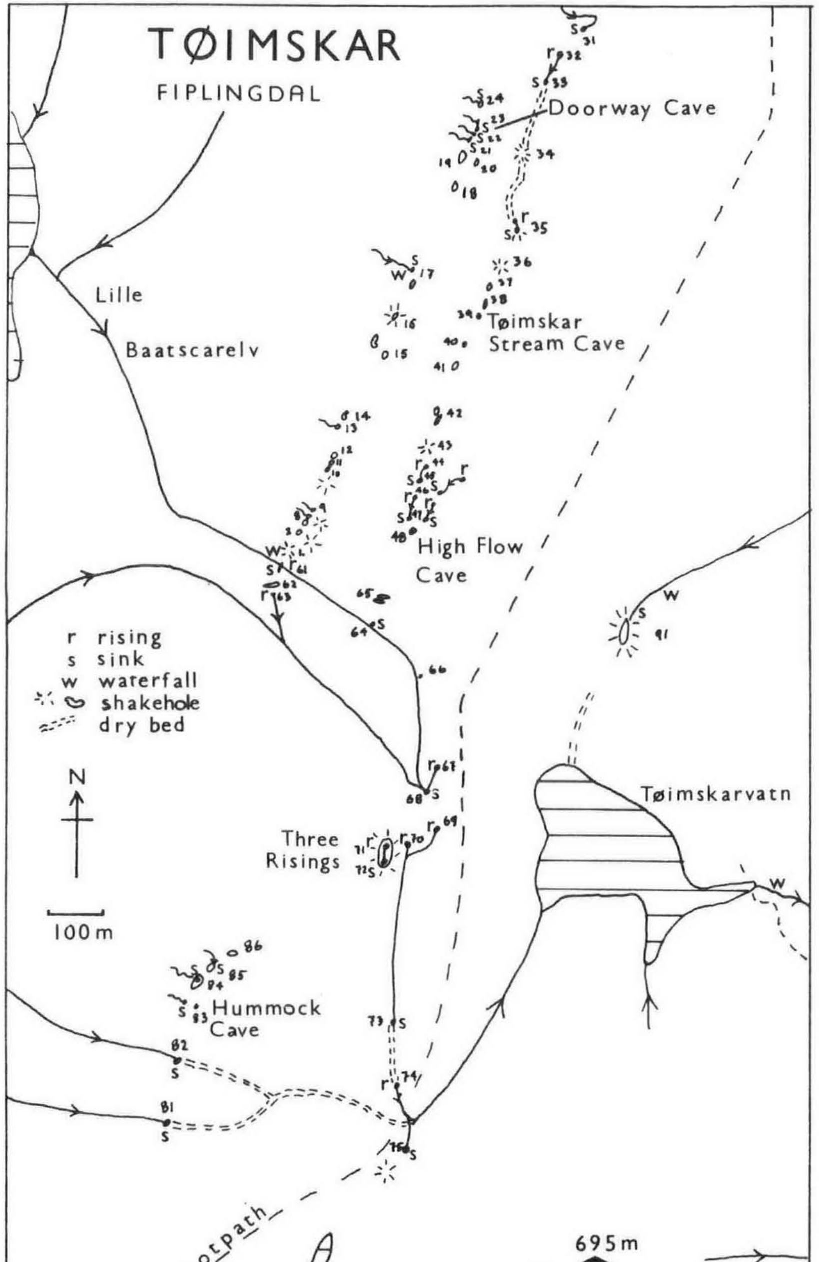


Fig 4

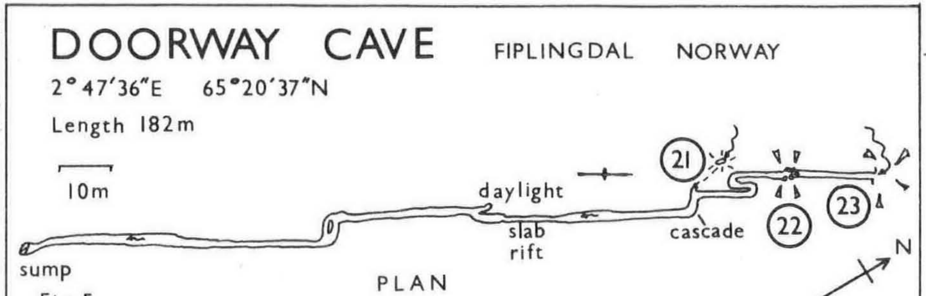


Fig 5

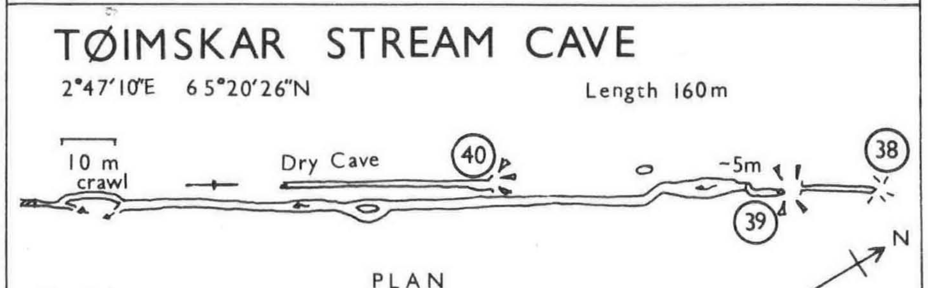


Fig 6

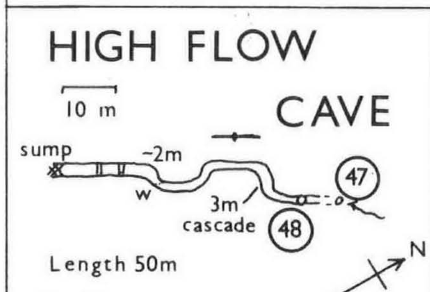


Fig 7

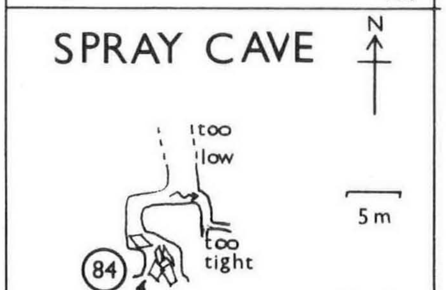


Fig 8

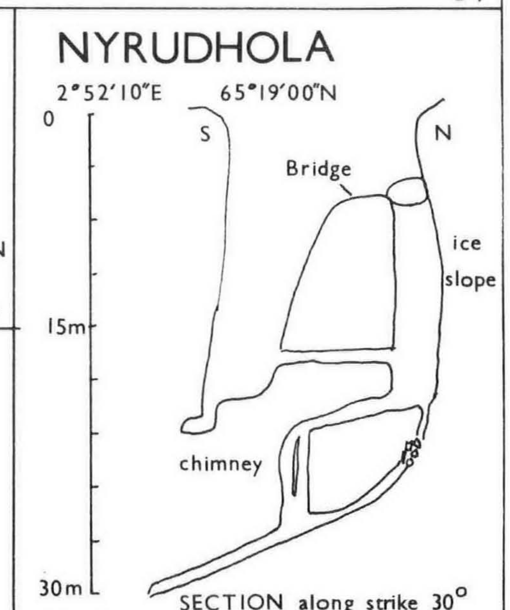


Fig 9

BCRA GRADE 2

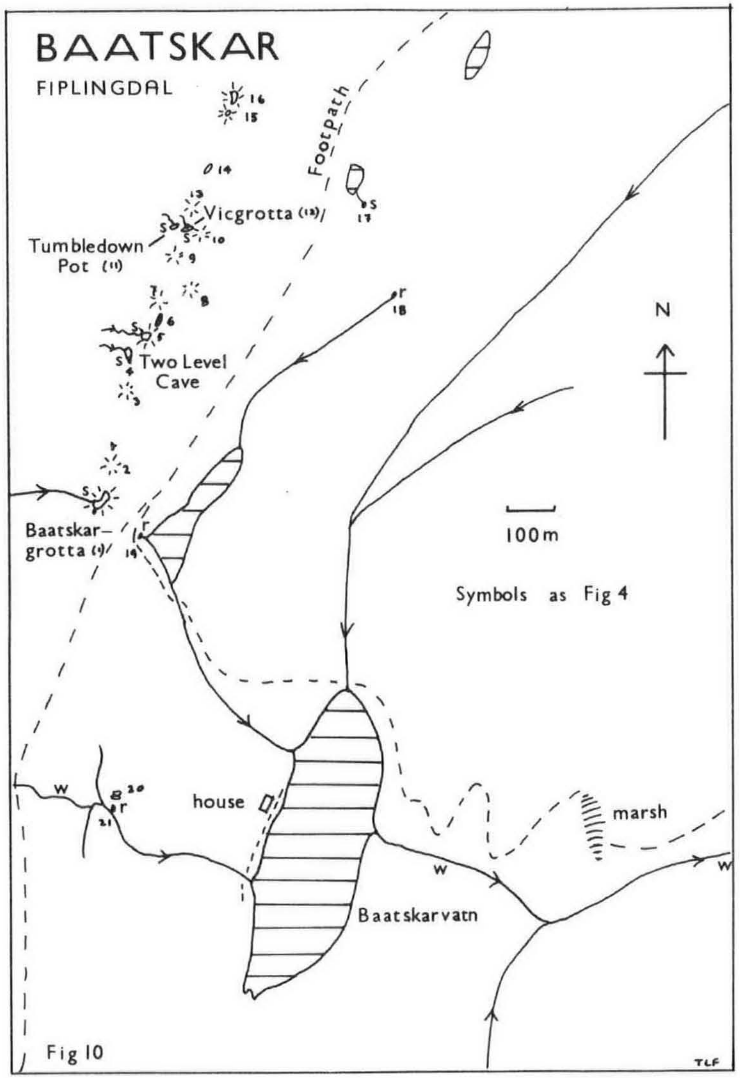


Fig 10

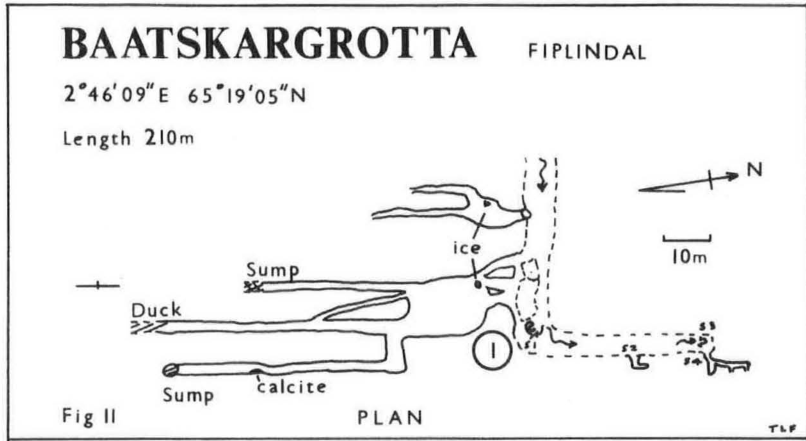


Fig 11

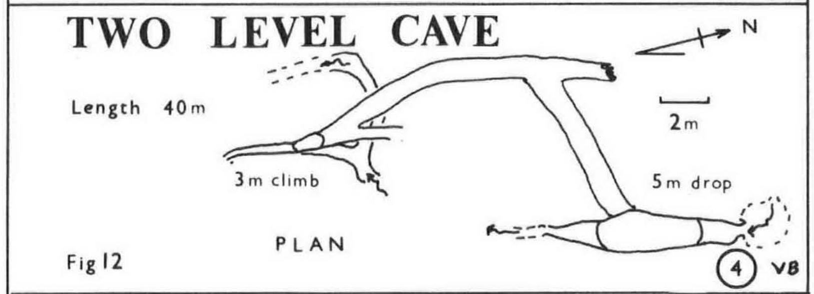


Fig 12

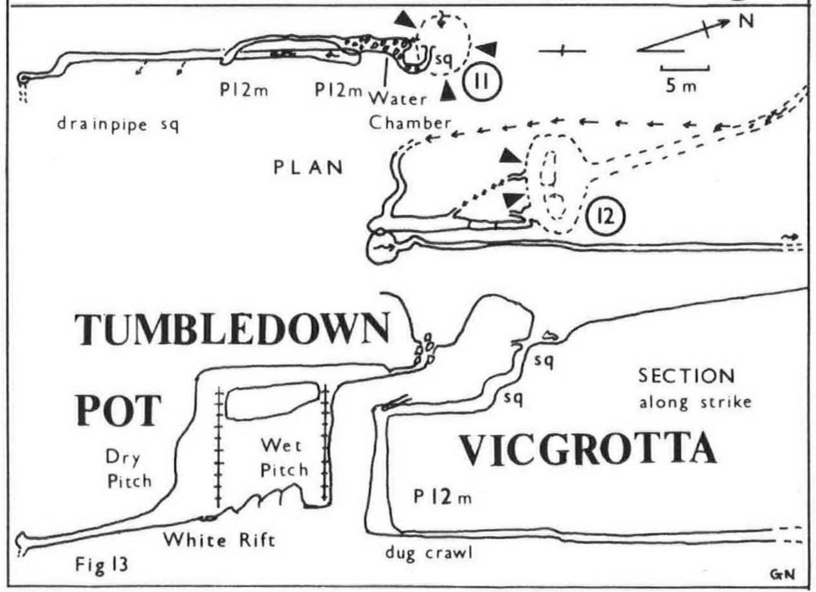


Fig 13

BCRA GRADE 2

SPRAY CAVE (84) Alt. 630 m, Length c.15 m, Depth c. 5 m
02° 46'53"E, 65°19'49"N

On the west edge of the hummock a large stream drops into a spray-filled hole which can be climbed down to a slot leading to a wide chamber. This becomes too low and muddy to the north. The water flows south for 2 m along a passage becoming too tight and a dry rift turns sharp left just too narrow to enter.

Explored: G. Newton, A. Marshall, T. Faulkner, 28 July 1982
Survey: Fig. 8, T. Faulkner, 28 July 1982.

Another stream sinks into a shakehole 50 m north (85) and several 3 m shafts can be descended, but no passage was entered. Another dry shake (86) to the north was descended for 3 m down a steep snow slope. The destination of the waters from the hummock group of caves is unclear, but is probably the 'three risings' area west of Tøimskarvatn.

The only features noticed east of the footpath were just north of Tøimskarvatn, where a stream running SW sinks in a big shakehole below a waterfall (91), and a dry gorge is seen to the south. The study of these small possibilities was left for another occasion.

BAATSKAR AREA

The upper valley and limestones from the Tøimskar area continue south, the band containing High Flow Cave being the most important as it captures all the streams flowing down from the 857 m peak at the north end of Kapfjell. A linear sequence of holes and sinks is observed in the dense birch forest along the valley side, feeding two major risings in the valley bottom. (Fig. 10).

BAATSKARGROTTA (1) Alt. 570 m Length c. 210 m
02°46'09"E, 65° 19'05"N

The Store Baatskarelv flows into a long depression when it reaches the limestone, finally sinking at the north end (Plate 2). This fossil cave is entered by climbing down a snow slope behind a large block at the southern end of the depression. The large entrance cavern measures 10 m wide by 3 m high and contained two large ice columns when visited. Three passages go along the strike from the rear end of the chamber, gradually descending until they sump or have minimal airspace with no draught in static water. West of the main entrance a large hole drops into a smaller cave, displaying an ice sword, which splits into two strike passages with vocal contact, each becoming too tight in places which could be dug.

BAATSKAR SINK 1 Length c. 8 m

A partial sink in a spray filled drop just below Baatskargrotta, it leads to a dry squeeze over a large sloping slab to a chamber under the depression where the water disappears among the gravel down a hole in the floor.

BAATSKAR SINK 2 Length c. 3 m

A dry overflow sink on the right bank of the depression which soon chokes.

BAATSKAR SINK 3 Depth c. 4 m

The present final active sink at the north end of the depression. Two drops between rocking blocks lead to a choke.

BAATSKAR SINK 4 Length c. 14 m

A flatout squeeze under the east side of the cliff at the north end of the depression lead to a 3 m joint slot choked at the bottom. A flatout crawl continues leading to two separate holes on the east side. The unentered streamway can be heard but both holes are too tight to pass.

Exploration of Baatskarelv features: V. Battams, T. Faulkner, A. Marshall, G. Newton, 27 July 1982
Survey: Fig. 11. T. Faulkner, 27 July 1982.

60 m along the strike is a small shakehole with a silent triangular hole (2) going down 10 m as a corkscrew shaft, with no draught.

TWO LEVEL CAVE (4) Alt. 600 m, Length c. 40 m, Depth c. 8 m
02°46'13"E, 65°19'15"N

A stream flows into a small hole in a small depression leading immediately to a 5 m free-climbable pitch. At its foot, a rift chamber contracts to a constricted meandering stream passage where tortuous progress may be feasible either at floor or roof level. From the right wall of the rift chamber a dug entry leads to an upward crawl over rubble to a cross passage. Right is blocked, and left is a narrow crawl to the roof of another passage. Left soon chokes whilst right passes over a hole in the floor to a continuation in mud becoming too tight. Down the hole, a 2.5 m climb leads to floor level. The tiny streamway is rejoined and progress downstream was halted after 4 m at a tight corner.

Explored: T. Faulkner, G. Newton, 27 July 1982
V. Battams, A. Marshall, 30 July 1982
Survey: Fig. 12 V. Battams, 30 July 1982

POLYSTYRENE SINK (5) Alt. 590 m
02°45'15"E, 65°19'16"N

The next stream north flows over the limestone a short distance before falling into this large shakehole, named after the small pieces of yellow polystyrene found at the bottom. An hour and a half were spent removing rocks along a route under an overhang until a point directly under the waterfall was reached. This dig would probably 'go' with a day's work, but the only safe method would be to excavate on the surface under the waterfall. Many more shakeholes occur over the next 200 m north (Fig. 10) but no entrances or easy digs were found. The next two caves are more difficult to find, being in very dense birch forest.

TUMBLEDOWN POT (11) Alt. 630 m, Length c. 60 m, Depth c. 25 m
02°46'21"E, 65°19'10"N

A stream sinks in a 4 m deep conical shakehole and the pot is entered by squeezing down between excavated boulders and then squeezing into the Water Chamber at the head of a steep rocky descent leading to a walking size passage. Almost immediately the stream leaves the passage via a slope and 12 m pitch to the left. There are ample belay points for the pitch but care should be taken with loose material on the approach slope and walls of the shaft. The pitch can be extremely wet, particularly in the afternoon when snow melt has increased. Alternatively the very narrow but dry passage ahead may be followed for 10 m until it terminates at a 12 m dry pitch. The problem here is finding a safe belay as all the rock is very brittle and shattered.

The wet pitch lands in a fine chamber in white marble. A climb over a boulder pile in a spacious rift leads to the foot of the dry pitch. The rift carries along the strike for 20 m gradually becoming lower until it is a crawl. Water sinks at several places in the floor of the rift. The only way on however is a tight tube in solid rock at the end of the crawl. This sometimes takes the stream, but may be blocked by gravel. It was pushed for 2 m, reaching a small jagged chamber in white rock. The way on is an excessively tight and jagged crawl in the floor of the chamber following the stream. The whole cave is noteworthy for a strong draught disappearing into the final lead, and lies along the limestone contact, a dark brown wall of schist forming the right side of the lower rift.

Tackle: 12 m ladder, 30 m double lifeline, 3 m belays.
Explored: V. Battams, T. Faulkner, G. Newton, A. Marshall, 30 July 1982.
G. Newton, V. Battams, 31 July and 1 August 1982.
Survey: Fig. 13. G. Newton, 31 July 1982

VICGROTTA (12) Alt. 625 m, Length c. 70 m, Depth c. 25 m
02°46'23"E, 65°19'08"N

A small stream to the NE usually sinks in its bed before reaching a small cliff adjacent to Tumbledown Pot. A dry squeeze on the left down into a rift is followed by another squeeze and drop to the head of a very wet 12 m circular pitch, the water flowing from an awkward passage entering on the far side of the pitch shaft.

It was originally thought that this water came from the Tumbledown Pot shakehole, but a dye test was negative. Instead, it was proved that the flow is from the small stream. With higher flow rates, the stream also runs along the surface to fall down a 3 m hole at the foot of the shakehole and reaches the near side of the pitch via a cleft only 10 cm wide.

The foot of the pitch is a clean marbled chamber but the way on is a low crawl which may require digging to enter. This is an extremely sporting passage, passable only by thin individuals. The roof gradually rises, but at 41 m from the pitch the way forward is barred by a rift which is relatively high but too tight. Prospects are good for slim persons here.

Tackle: 12 m ladder, 20 m lifeline, 3 m belay.
Explored: V. Battams, 27 July 1982
T. Faulkner, G. Newton, A. Marshall, 28 July 1982
A. Marshall, G. Newton, 30 July 1982
Survey: Fig. 13, G. Newton, 30 July 1982

The next feature to the north is a large rectangular depression along the limestone contact with a huge snow plug (14). A short but large passage at the south end drops to a collapse of limestone blocks. A short distance further are two adjacent deep shakeholes (15,16), with a huge choked arch passage leading from the foot of the northerly one back towards to the other.

No more features are seen to the north until the limestone hummock area is reached, described under the Tøimskar area.

The water draining the small lake east of the snow plug depression sinks (17) but very insignificantly.

The hydrology of the Baatskar area has not been determined with certainty, but two major risings were examined.

BAATSKAR NORTH RISING (19) Alt. 555 m
02°46'14"E, 65°19'03"N

This feeds the small lake below Baatskargrotta, flowing impenetrably from below the main footpath. It is likely to bear the waters from Polystyrene Sink and Tumbledown Pot, and possibly Two Level Cave. The water in Vicgrotta is last seen flowing north, so it is possible that the watershed underground occurs somewhat south of that on the surface, so that Vicgrotta and the other features (when active) may feed toward the hummock area and possibly on to the 'three risings' area west of Tøimskarvatn.

BAATSKAR SOUTH RISING (21) Alt. 540 m
02°46'09E, 65°18'47"N

This is a large resurgence from a sump pool two to three metres deep on the north bank of the southerly stream entering the west side of Baatskarvatn. 30 m north along the strike are two shafts (20) 3 and 4 m deep, but no way to water nor a draught were found. The South Rising is almost certainly the issue of the Baatskarelv which sinks at the Baatskar Sinks some 650 m to the north (but only about 15 m higher) and possibly also of the Two Level Cave water.

KVANNLI AREA

The limestone band from the Baatskar area crosses another watershed to the south and occupies the base of one of two valleys between Kapfjell and Baatskarryggen. A very large stream flows off Kapfjell and sinks at the end of a blind valley near to the gravel road (which has now been extended almost as far as the watershed overlooking Baatskarvatn). (Fig. 3).

The stream reappears from the sump in the known cave of Kvannlihola, which is about 550 m to the south and 20 m lower.

KVANNLI SINK CAVE Alt. 410 m, Length c. 75 m, Depth c. 10 m
02°44'40"E, 65°16'40"N

The stream flows much further down the valley than is shown on the NGO map J19 and sinks at the base of a rubble cone at the foot of a cliff face. A three hour dig from the top of the rubble gave a 5 m climb down an unstable hole to the start of a large sloping chamber 2 m high and carrying the stream over clean washed striped marble. 40 m from the entrance a large deep sump pool is reached as the roof lowers. To the left a low opening goes to a parallel section of low sump with a very slight draught out. Returning to the entrance, openings to the left of the chamber lead to another rocky sloping gallery.

Explored: T. Faulkner, G. Newton, A. Marshall, V. Battams, 11 August, 1982
Survey: Fig.14. T. Faulkner, 11 August 1982

Across the road and south a little from the sink, a small hole was descended for 5 m down a vertical shaft to where it opens out horizontally but is too awkward to follow.

KVANNLIHOLA Alt. 390 m, Length 245+639 m Vertical Range +19 m
02°44'40"E, 65°16'20"N

The known cave is located 67 m down from the road, soon after a 'gate' across the road is passed. The cave has a large resurgence entrance and consists of a spacious, if watery, stream passage leading to a sump 200 m in.

The sump is passed by standing at the far end of the sump pool and diving down under the western wall to reach a small airbell. An eyehole at the end of the airbell gives the sight and sound of the upstream passage which is reached by diving down to the left of the eyehole. A flake of rock in the canal beyond the eyehole provides a convenient belay for a heavy line which can be used for free diving if sufficient slack is left to allow the airbell to be used en route.

Beyond the canal a wide crawl over cobbles extends 15 m and then the passage opens up dramatically. Initially, the stream runs over slippery black boulders in a passage 6 m wide and 4m high. At Whiteway, the streambed is white marble and formations are seen in the roof. The passage ascends and grows to 10 m wide and up to 10 m high at the start of the Blockpile (Plate 3), a large collection of collapsed, mainly rectangular, blocks which need to be climbed over whilst the stream flows underneath. The western wall of the passage is well decorated, with one particularly fine group of stalactites, and stalagmites which are very rarely discovered in Norway (cover photo).

Reaching the top of the Blockpile, the eastern wall is found to be well (Plate 8) calcited with a long curtain and finally at Whitehall, the whole wall comprises gleaming white flowstone for about 10 m. It is now necessary to drop back to streamlevel and cross a deep pool, before attempting the 2 m Greasy Climb up a vertical slab, with a splash in the pool the reward for a lost handhold. Above the next cascade (Plate 4) a roof passage can be seen going east. This starts from a wide high ledge only reached with difficulty by climbing the loose wall and crossing calcite and flowstone deposits. Large banks of silver-coloured sand lie along the ledge and the roof passage starts as a narrow trench 1 m high, with sandy banks on each side. This 'Forbidden Passage' has not been explored, as to do so would destroy a superbly delicate array of small gour pools occupying the floor of the passage and extending as far as can be seen. The thin gours are only 1 cm high and 20 cm wide, and remain to be photographed.

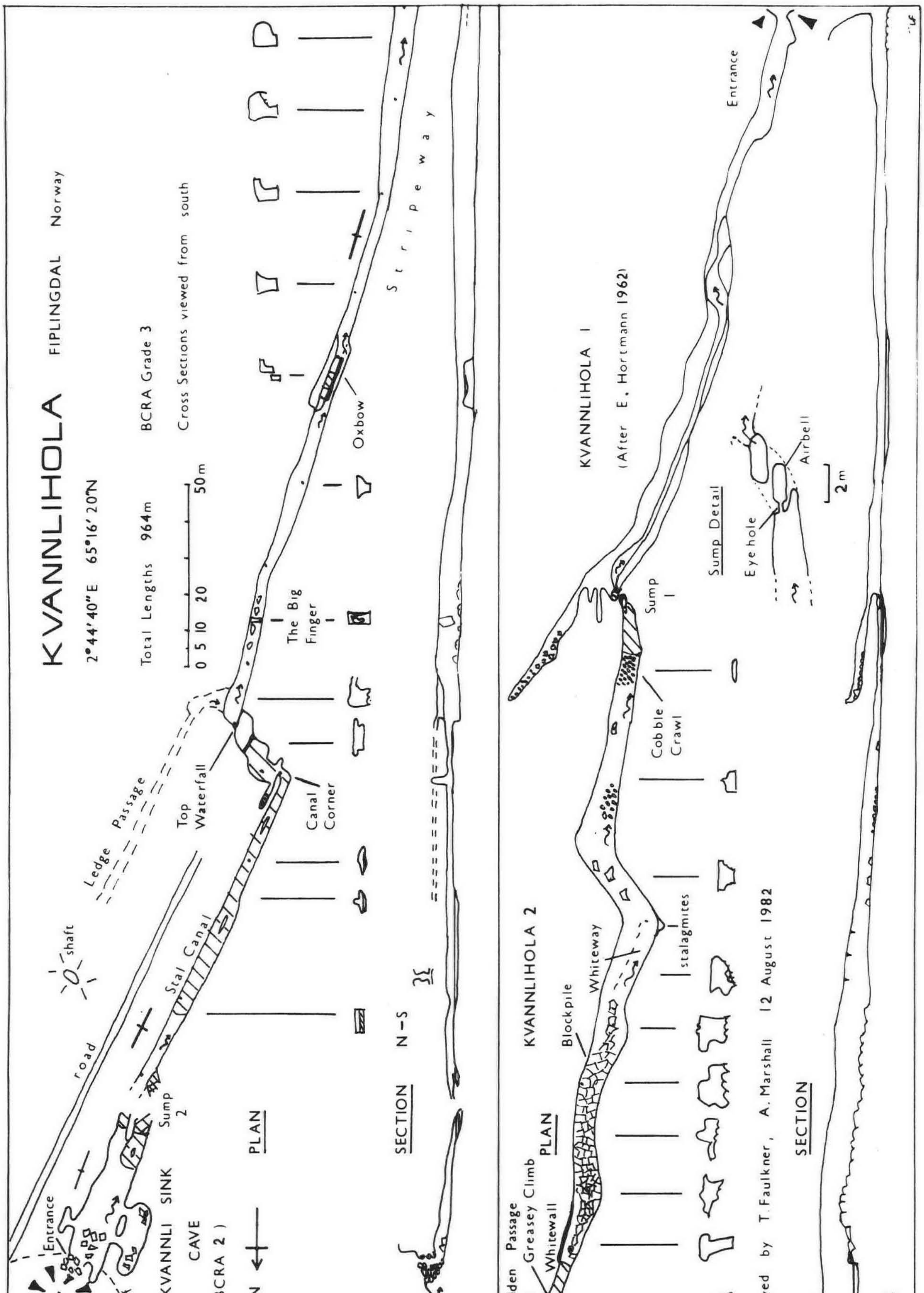
The Stripeway, the next 200 m of stream passage, is aligned directly along the strike of the limestone, which is beautifully banded and clean washed, giving an especially striking appearance if the water is not too deep (Plate 6). Half-way along, the active passage does slip to the left a little, but an abandoned section continues straight on as an oxbow 2 m higher. Near the end of Stripeway a large fallen chunk of roof points down, firmly wedged between the walls: The Big Finger (Plate 7).

The 2 m Top Waterfall (Plate 5) marks the end of Stripeway and is formed where the water has cut across layers of dark brown impurities. The passage lowers considerably and a wide low duck leads to a tall strike-aligned rift, ascending to the north as a choke 5 m above. Beyond this rift the streamway turns sharp right as a deepening canal, with stalactites along the line of a gothic arch. The passage ends at a blank wall, the water flowing from Sump 2 under the western wall. From calculation based on measuring calibrated paces along the road, it is clear that Sump 2 is very close to the sump in Kvannli Sink Cave. However, the water in the Sink Cave is last seen flowing south along the strike whereas it reappears from Sump 2 flowing east, across the strike.

One other significant side passage was explored, starting from a ledge just downstream of the Top Waterfall. A tiny stream flows along a passage 1 m high and 3 to 4 m wide. This was pushed for about 50 m until it becomes too tight. The survey shows this point to be close to the 5 m shaft just east of the road near the Kvannli Sink.

The cave passage between the two sumps, Kvannlihola 2, is very significant in the Norwegian context. Its large size dwarfs the cross section of the previously known cave, although as bedrock is not seen in Kvannlihola 1 down-stream of the sump it is likely that the entrance passage is much bigger than it appears, with deep sediments being held back by rock falls in the surface valley. The dripstone formations, including a nest of cave pearls, occur in a variety of forms and the previously mentioned group is one of the best in the country. Fortunately these inner attractions should remain protected by the natural gating afforded by the sump. Note that after heavy rain the level of the sump pool rises by 30 cm and the froth line indicates that the airbell and canal would be under water.

The whole Kvannli Sink/Kvannlihola systen now approaches 1 km in length, without a large contribution from side passages. As the two discovered side


KVANNLIHOLA
FIPLINGDAL Norway
2°44'40"E 65°16'20"N
Total Lengths 964m
BCRA Grade 3
Cross Sections viewed from south
0 5 10 20 50m
Oxbow
The Big Finger
Top Waterfall
Canal Corner
Ledge Passage
Stal Canal
shaft
road
Stripeway
Sump 2
Entrance
sink
cliff
KVANNLI SINK CAVE (BCRA 2)
N
PLAN
SECTION N-S
30m
10
KVANNLIHOLA 1
(After E. Hortmann 1962)
Entrance
Sump 1
Sump Detail
Airbell
Eye hole
2m
Cobble Crawl
stalagmites
Whiteway
Blockpile
KVANNLIHOLA 2
Forbidden Passage
Greasey Climb
Whitewall
PLAN
Surveyed by T. Faulkner, A. Marshall 12 August 1982
SECTION
20m
0
Fig.14

passages in Kvannlihola 2 join the main passage adjacent to places where the stream has had to cut across thick bands of impurities, they probably represent early sinks of the main stream. This pattern is repeated at Sump 1 where the original passage goes on along the strike east of the non-marble layer holding back the sump and ends close to the surface. Hence the whole cave has developed by northward and some westerly erosion from the present entrance (or beyond) with three major captures of the mainstream as each of three massive layers of impurity was breached.

Tackle: 15 m rope for free diving.
Explored: T. Faulkner, A. Marshall, G. Newton, 12, 13 August 1982
Survey: BCRA Grade 3 Fig. 14. T. Faulkner, A. Marshall, 12 August 1982

NEDRE KVANNLIHOLA Alt. 385 m, Length c. 30 m
02°44'40E, 65°16'15"N

The water that flows from Kvannlihola sinks once again lower down the valley, about 150 m away and in line with the 'gate' on the road. The stream drops into a hole and then runs into a low boulder ruckle filled passage, rising again about 30 m from the sink at a tunnel which could be entered.
NOTE: Permission to explore the Kvannlihola system must be obtained at the blue house at Kvannli Gård.

EAST OF NEDRE FIPLINGVATN

A limestone band on this side of the lake is too narrow to be shown on the NGU 1:250,000 Hattfjelldal sheet but was found by the expedition to extend northeast along the hillside with a width of several tens of metres. Unlike the outcrops on the west side of Fiplingdal which are vertical, this band is steeply inclined with a dip of 60 degrees to the west. No features occur where the Simskarelv and the Jacobelv cross the limestone (Fig. 3).

NYRUDHOLA Alt. 480 m, Length c. 30 m, Depth c. 30 m
02°52'10"E, 65°19'00"N

A small stream runs west down Bolskarakslen and sinks in its bed east of Nyrud just before reaching this series of large deep holes in the hillside. The main shaft can be climbed down with care and splits into two near vertical sections at a bridge. The first shaft is 20 m deep and ends in a choked passage. Crossing the bridge, a window leads to the second shaft which is descended via an ice slope and drop to a floor with a crawl above leading to the first shaft. An excavated crawl at floor level leads to a tight 5 m deep chimney which must be approached feet first. A quite large passage at the bottom lowers to a choke after 8 m and in the other direction gives vocal contact to the foot of the second shaft. The stream sinking outside was not seen in the hole which was completely dry, but presumably it is active during the spring melt. The springs feeding the little lake below Nyrudhola were insignificant, and probably unrelated to the Nyrudhola sink water which flows in an unknown direction.

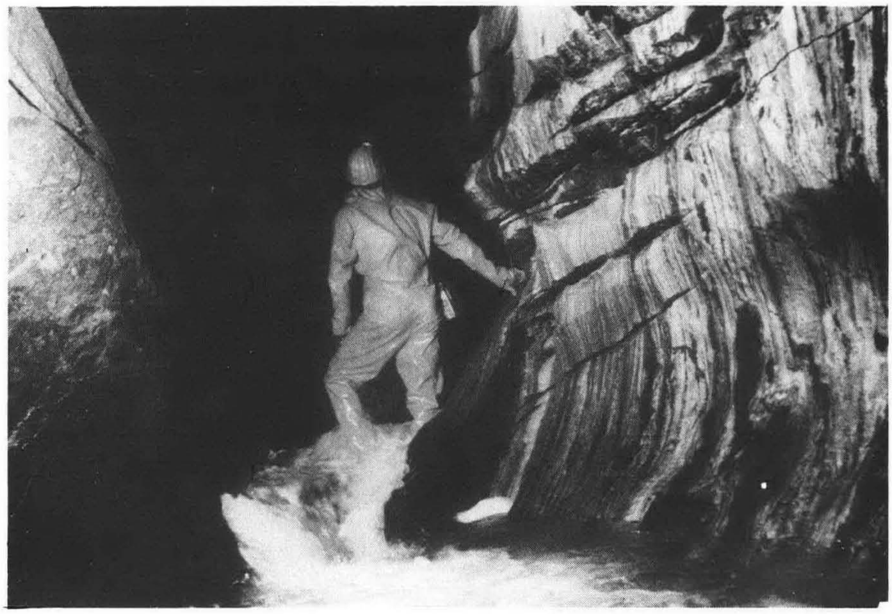
Explored: T. Faulkner, G. Newton, A. Marshall, V. Battams, 29 July 1982
Survey: Fig. 9 T. Faulkner, 29 July 1982

BJORNHULLET Alt. c. 420 m? Depth c. 10 m?
02°51'00E, 65°18'40"N (?)

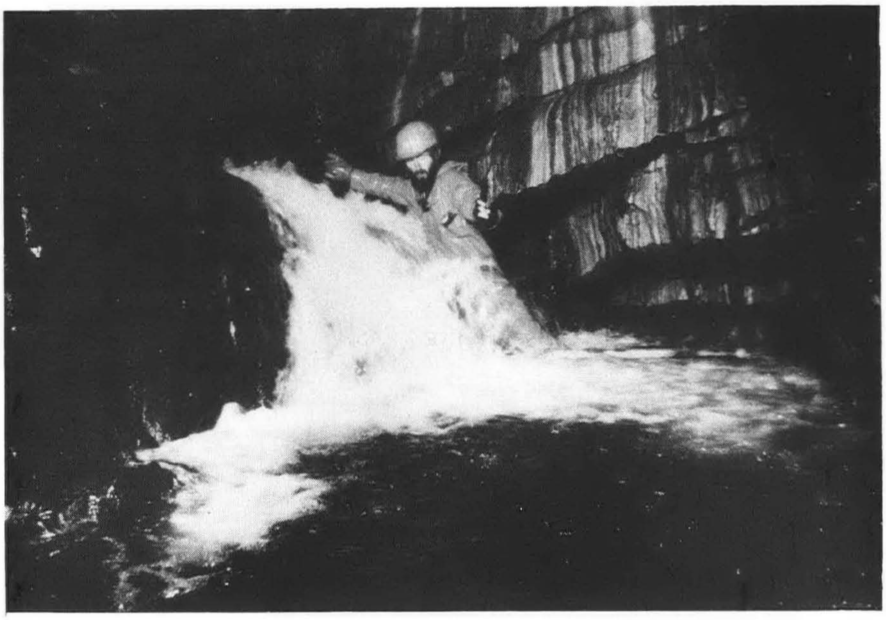
Not visited, but reported as a deep hole and very difficult to find. Information should be sought in Norwegian at the farm Simskaret, from which the hole is about 1 km to the north. It is possible that this hole is in fact Nyrudhola.

GLUGVATN

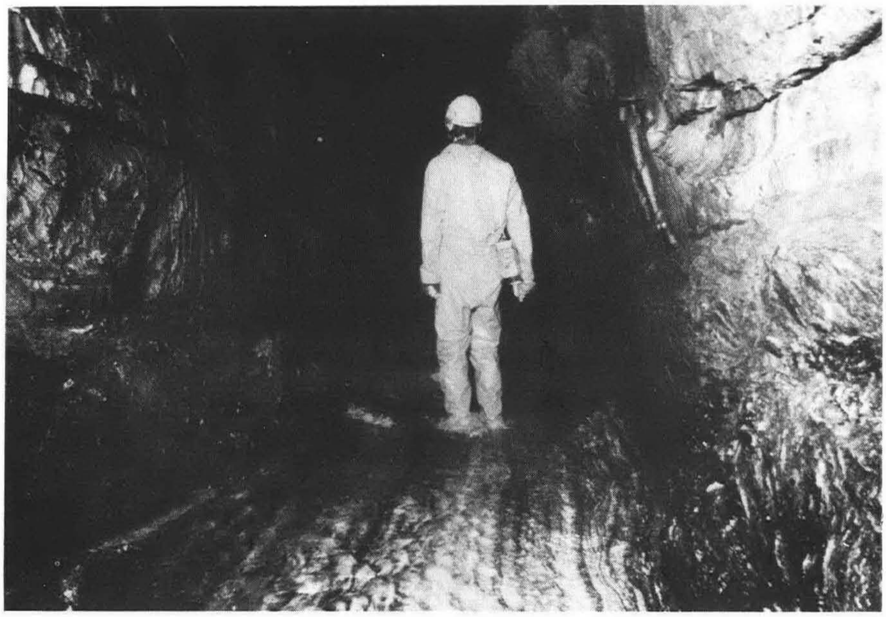
Three sites are grouped together for convenience. The limestone bands in this area generally run NE-SW, with widths up to 300 m. The scenery is one of birch forest or scrub with hills in the distance. The drainage is into the lakes Fiskløsvatn and Glugvatn and then via the very large valley of the Gluggvasselv, which is itself almost dry due to exploitation by the hydroelectric authorities. Note that the naming of Glugvatn probably derives from the narrow aperture between the two halves of the lake rather than from anything speleological. Refer to Fig. 15.



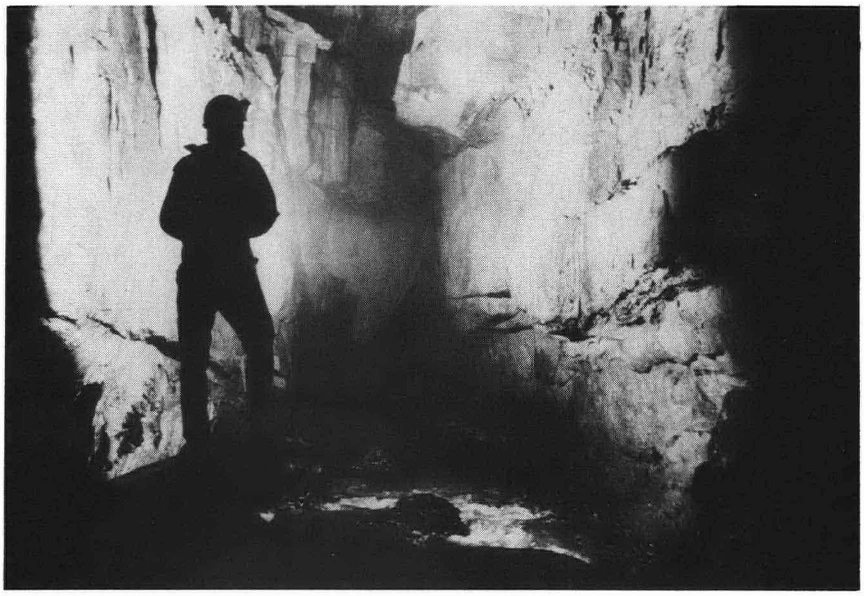
4. Streamway in Kvannlihola 2 just above the Greasy Climb.
(photo T.Faulkner)



5. Top waterfall in Kvannlihola 2 (photo T.Faulkner).



6. The Stripeway in Kvannlihola 2 (photo T.Faulkner).



7. Looking downstream to the Big Finger, Kvannlihola 2.
(photo T.Faulkner).

8. The White Wall, Kvannlihola 2 (photo T.Faulkner).

9. Øyåskjeleren tube behind the upper cliff entrance.
(photo A.Marshall).

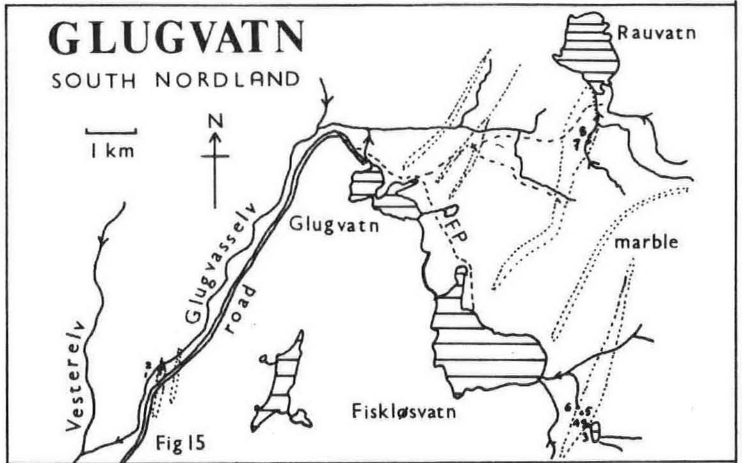


Fig 15

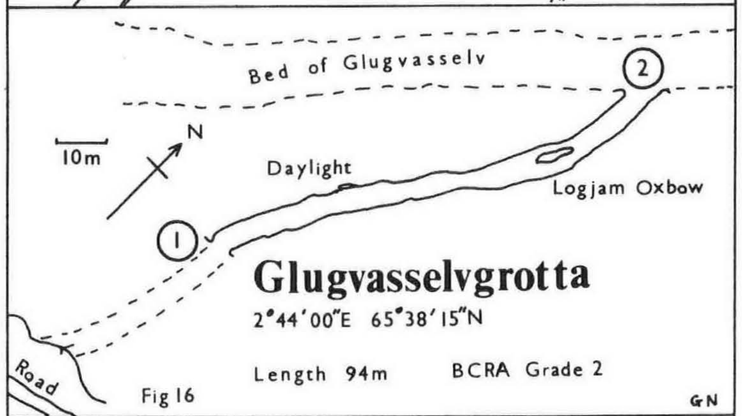


Fig 16

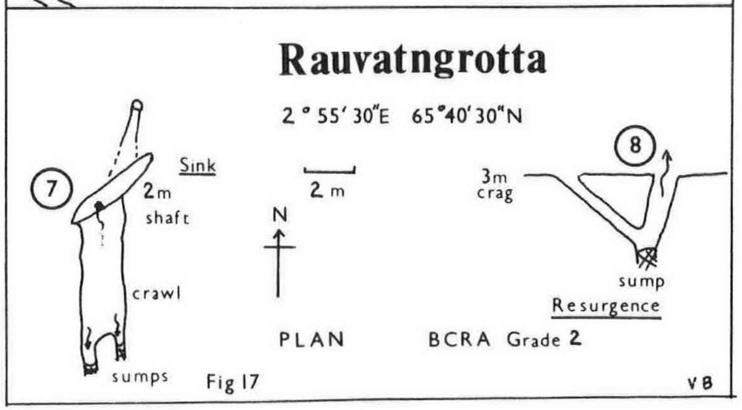


Fig 17

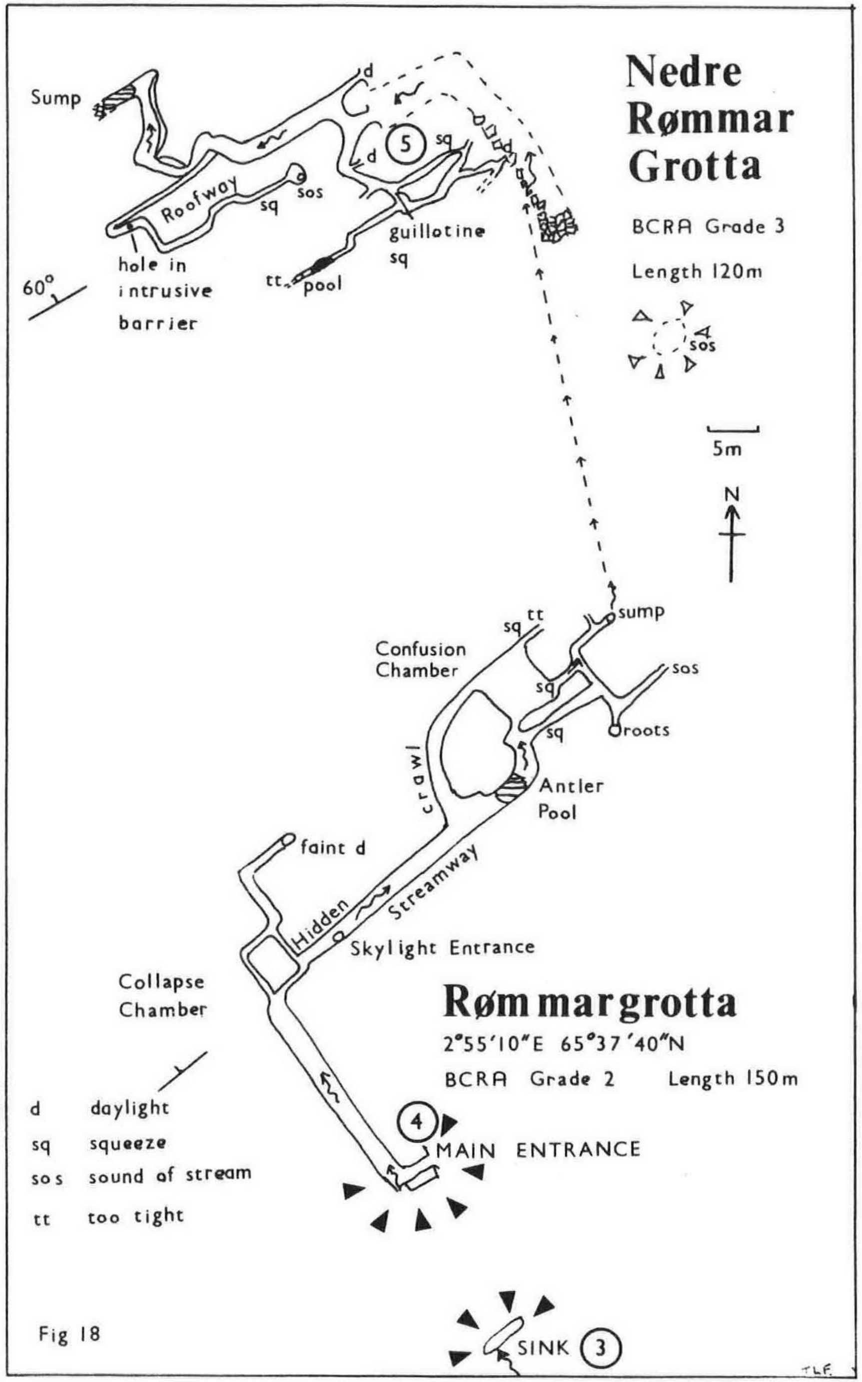


Fig 18

GLUGGVASSELVGROTTA (1)　　　Alt. 300 m, Length c. 94 m
02°44'00"E, 65°38'15"N

Seen as a black hole in the forest west of the gravel road beside the Gluggvasselv, the cave has two main entrances, the further upstream one (2) being found by following the Gluggvasselv through a gorge until it is seen on the left bank. The cave is basically one passage. Daylight may be seen 30 m from the downstream entrance but a climb out was not attempted. From the lower entrance the small stream flows into a small tributary of the Gluggvasselv.

Explored: G. Newton, 9 August 1982
Survey: Fig. 16. G. Newton, 9 August 1982

RØMMARGROTTA (4)　　Alt. 560 m, Length c. 150 m, Depth c. 6 m
02°55'10"E, 65°37'40"N

The route to this sink cave below Rømmartjern involves finding the correct fishermen's paths from Glugvatn to Fiskløsvatn and then walking through dense birch scrub and midge-infested marshes beside the large lake until the appropriate streams can be followed. The Rømmartjern stream sinks at a large depression (3) but the way into the cave is from another depression 20 m forward (4).

The cave is entered via a cleft into a passage and large chamber from which a climb over the edge of a huge block leads to a strange void where the stream runs around three sides of the block before disappearing. From the far side a passage leads back to daylight (diggable). The continuing Hidden Streamway is revealed by climbing back up the huge block in Collapse Chamber and dropping down 3 m at one corner. Downstream from here along a fresh and clean passage a 4 m climb up reaches the Skylight Entrance. Continuing, a 3 m wet crawl is soon reached leading to Antler Pool, which can just be crossed in dry gear in comfort. Reindeer antlers were found here on the far side. A sinuous streamway then goes to Confusion Chamber where the stream is lost, but a crawl on the right reaches the stream again and a very sedimented sump. From Confusion Chamber a large dry passage with a floor of rounded pebbles soon leads back to the streamway just before the 3 m wet crawl, and other connecting routes can also be found in this area.

Explored: T. Faulkner, G. Newton, 10 August 1982
Survey: Fig. 18. T. Faulkner, 10 August 1982

There is no obvious dry valley leading on from Rømmargrotta,but the water is seen again to flow through a long depression about 100 m away. There is no way in at the rising here, but a noisy shakehole before the depression is reached could be dug. The stream itself flows into an obvious cave entrance at the north end of the depression.

NEDRE RØMMARGROTTA (5)　　Alt. 550 m, Length c. 120 m, Depth 10 m
02°55'10"E, 65°37'4 "N

This is a nice clean stream cave with a large passage descending and changing direction several times before an uncompromising sump is reached. A much smaller upper series of dry tunnels and low dry passages continuing south beyond the present entrance indicate earlier stages of stream flow.

To the north of the cave there are few features to be seen until after c.100 m the resurgence is reached where the water flows from an inviting (apart from its remoteness) sump pool 2 m wide and 1 m high above a boulder floor, probably getting bigger inside (6).

Survey: Fig. 18. BCRA Grade 3 T. Faulkner, G. Newton, 10 August 1982

Both caves occur in the same broad band of limestone, which dips at 60 degrees to the west with thick intrusions seen in cave walls. The water flows along both dip and strike passages, utilising the strike in both directions, and achieving a generally northerly route. The surface survey was not made with any great accuracy and it is possible that the two caves are much closer than shown, and indeed they may be connected via the dry passages.

RAUVATNGROTTA (?)　　Alt. 480 m, Length c. 5 m + 8 m
02°55'30E, 65°40'30"N

The sink is an elliptical rock shaft 2 m deep reached by following fishermen's paths from Glugvatn. The stream falls attractively over the lip as a spout and drains into a bedding plane trending back south underneath itself, finally disappearing into two adjacent sumps 5 m in. A nearby small hole leads to a short passage becoming too tight. The stream resurges at the foot of a 3 m high crag 30 m NNE of the sink (8). A sump is found 4 m in which can also be reached by a dry alternative entrance.

Survey: Fig. 17 V. Battams, A. Marshall, 10 August 1982

HERRINGBOTN

This area to the east of Mosjøen is approached via a gravel road running along the southern shore of Fustvatn. The NGO 1:1000,000 map J17 indicates a disappearing stream flowing west off Klubben (917 m) and the geological map shows one narrow band of limestone running north to south within a broader band of gneiss along the valley between the granitic masses of Klubben and Hjartfjell (877 m) (Fig. 22).

A tiny spring (1) feeds the northern tip of Klopfjeldtjern with several collapse openings to the north along the line of a 2 m wide band of marble. To the east is a gorge along the line of a vertical marble band, this time 3 m wide, which has several explorable caves along its length.

UPPER ARCH CAVE (2) Alt. 510 m, Length c. 79 m.
02°50'20"E, 65°46'10"N

A through cave, the north entrance collecting a small stream. A single rift passage up to 8 m high is passed by climbing and chimneying in places, with awkward climbs over boulders at the south entrance.

Explored: V. Battams, G. Newton, 8 August 1982

ARCH CAVE (3) Alt. 510 m, Length c. 29 m
02°50'20E, 65°46'10"N

The stream from Upper Arch Cave flows along the floor of a gorge formed by the removal of the 3 m wide limestone band, under a large arch, and then drops into this small entrance which is a 3 m climb down. After 10 m the passage lowers to a crawl. The passage is blocked 3 m further ahead but the water flows into a low wet crawl from which it is possible to regain the original passage after 5 m. All ways on become choked shortly afterwards. The cave basically consists of a single passage divided into parallel passages by igneous intrusive rocks.

Explored: V. Battams, G. Newton, 8 August 1982
Survey: Fig. 19. G. Newton, 8 August 1982

Walking south along the limestone gorge, the stream reappears at a junction with another dry valley and then sinks again.

SHORT DROP CAVE (4) Alt. 490 m, Length c. 22 m, Depth 5 m
02°50'10"E, 65°46'05"N

The entrance is a few metres from the sink in an 'amphitheatre'. During dry weather the stream is not seen in the cave. After 12 m a 2 m pitch may be free climbed with care giving access to a relatively spacious lower passage and a further 1 m drop leads to a chamber with no way on. Just beyond the entrance a high level passage chokes after 5 m.

Explored: G. Newton, 8 August 1982
Survey: Fig. 20. G. Newton, 8 August 1982

POOL CAVE (5) Alt. 485 m, Length 15 m, Depth 6 m

Lower down the amphitheatre the water cascades into a rocky shakehole. A 3 m crawl from the end of the shakehole leads to a 3 m pitch which may be free climbed carefully. A spacious passage then descends to a 1 m drop into a chamber with a sump pool. The way on could not be found. At the far end of the chamber it is possible to climb into the roof and a point is reached 4 m above the sump with no way on and ample signs that the cave fills to the roof in wet weather. On the surface the stream reappears from the foot of a cliff close by and flows above ground to enter an EW fault-directed gorge dropping down to Klopfjeldtjern.

Explored: G. Newton, 8 August 1982
Survey: Fig. 21. G. Newton, 8 August 1982

East of these features is a large crater-like depression area below the Klubben ridge with only superficial intermittent drainage and it is clear that the NGO map exaggerates the potential of the site.

GJOBERG SINK (6)   Alt. 440 m, Length 6 m
02°50'35"E, 65°46'35"N

The 2 m wide band of limestone seen at the north end of Klopfjeldtjern continues north and appears to have been responsible for the development of a deep valley containing the long lake Gjobergtjern. The water from this lake flows from its north end into a route engineered through boulders gaining the streamway but becoming too low.

Explored: G. Newton, 8 August 1982

GJOBERGGROTTA (7)   Alt. 445 m, Length c. 75 m
02°50'35"E, 65°46'35"N

50 m north along the strike from the sink is a large shakehole with a large entrance at its north end. The stream is soon joined and followed along a wide passage until a 4 m shaft to daylight is reached. Near the shaft an aven has some interesting calcite deposits on its walls and beyond the shaft a hole drops down into a cold, low, wide, canal passage becoming flatout and then too low after 41 m. The 4 m shaft leads to a small alternative entrance which contains the 5 m Earth Cave in the same shakehole.

Explored: T. Faulkner, G. Newton, 8 August 1982
Survey: Fig. 23. T. Faulkner

100 m to the north the stream reappears impenetrably and then flows through the 10 m Canal Cave (7a), a passage below a rock arch about 1.5 m high with water over 1 m deep.

BRANCHES CAVE (8)   Alt. 375 m, Length 19 m
02°51'40"E, 65°47'15"N

An opening obstructed by branches at the foot of a 6 m cliff where a large stream flowing off Skankknaet sinks. The cave inside is in cleanwashed limestone with many large brown intrusive impurities. The 1 m high chamber and passage ends where the water runs into a blind pool.

Explored: T. Faulkner, 8 August 1982
Survey: Fig. 24. T. Faulkner

This cave may be formed in the same limestone band as the Gjoberg features, although here the marble is only 1 m wide and inclined away from the vertical. The resurgence is lower and feeds the main Herringelva where the river splits to flow around a large island in the valley floor.

Walking down the west of the river, the dry Gneiss and Limestone Cave (9) is found on the valley side. Here the marble is inclined at 45 degrees, between Gneiss above and mica-schist below and is still only 1 m wide. 6 m deep with two entrances, the cave is really just a collapse of square gneiss and marble blocks into spaces between.

The huge river Herringelva soon reaches this line of marble itself, completely sinking when it does so (10), to leave a continuing dry bed of huge boulders along the valley bottom. Several collapse holes can be entered at the sink, but any lower streamway must be collapsed along most of its length. The dry valley later swings west away from the line of marble and one walks instead down huge dry slabs of mica-schist until the river is rejoined.

MOSJØEN

The area immediately south of Mosjøen on the west side of the Vejsn has only been partly recorded before, the account of Øyfjellgrotta (Heap, 1968) being the only known English reference. This cave is described as being in an isolated outcrop of limestone at Øyfjell and is of mature age,containing large abandoned upper passages and a lower vadose streamway leading to a sump. Two km southeast of Øyfjell the river Tveraaen has cut its way deeply through the mountain ridge, exposing limestone at the top of a steep cliff at Øyas. This limestone is possibly related to the long outcrops in Eiteraadal (Faulkner, 1980), although they are not contiguous. (Fig. 26).

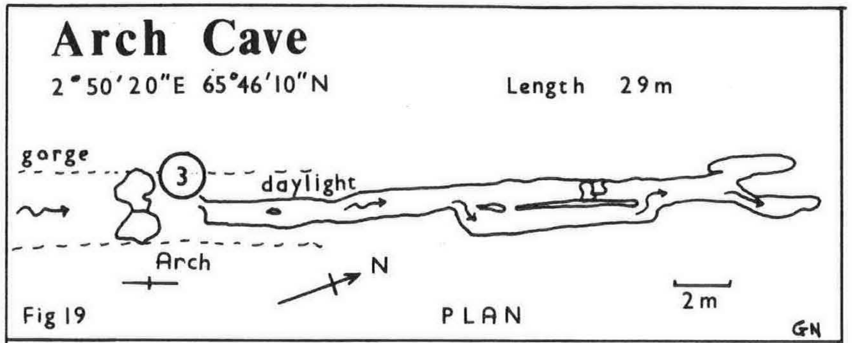


Fig 19

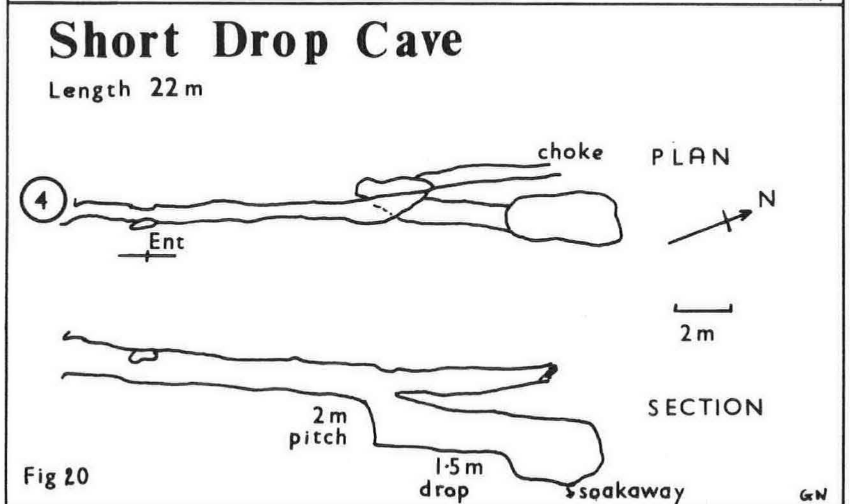


Fig 20

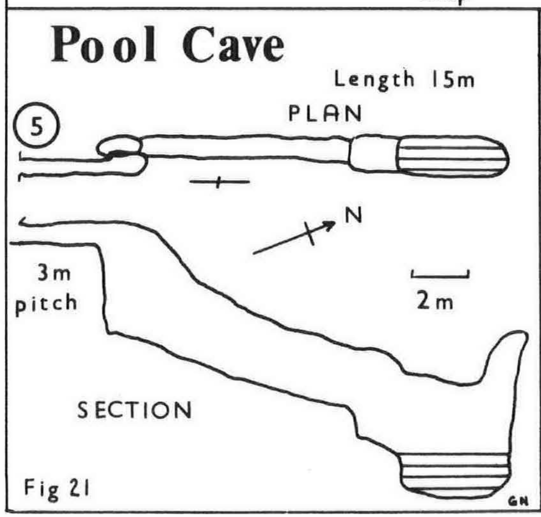


Fig 21

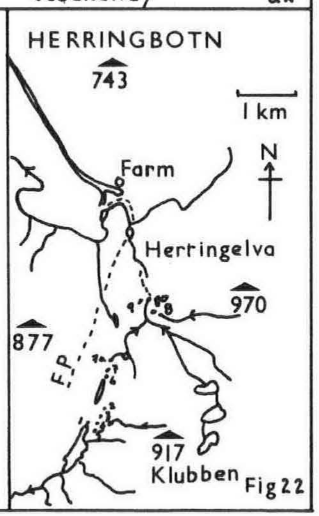


Fig 22

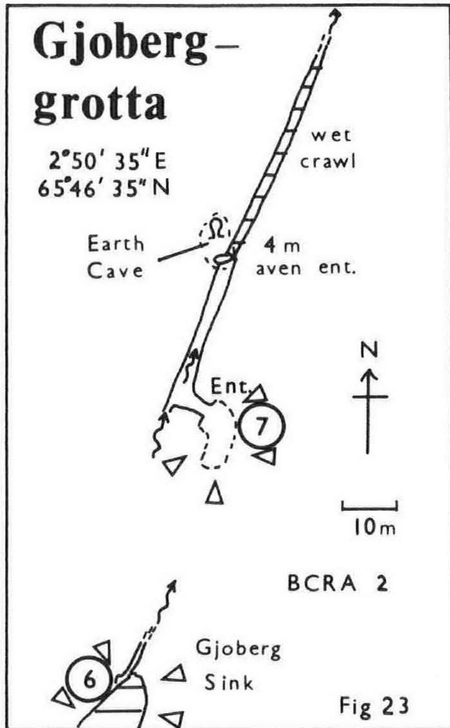


Fig 23

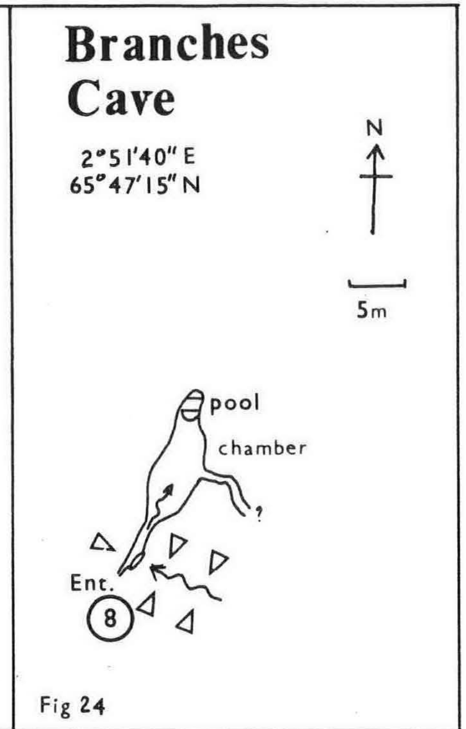


Fig 24

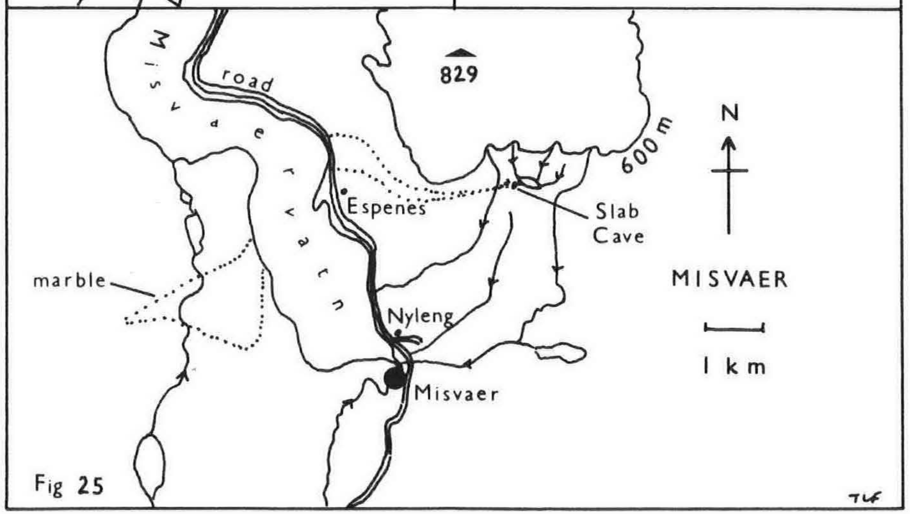
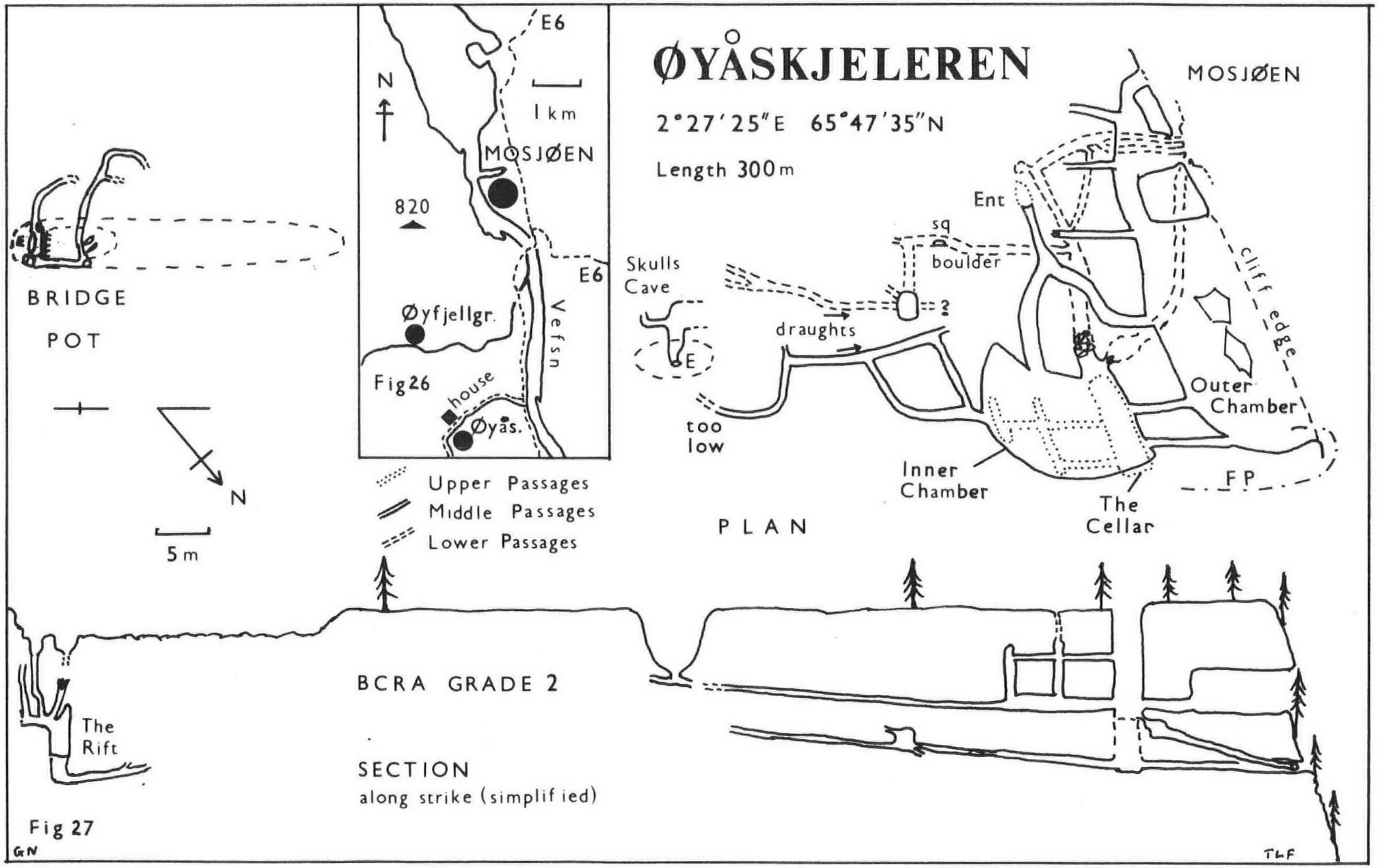


Fig 25

BCRA Grade 2


ØYÅSKJELEREN
2°27′25″E 65°47′35″N
Length 300m
MOSJØEN
Ent
sq
boulder
Skulls
Cave
E
draughts
too
low
cliff edge
Outer
Chamber
Inner
Chamber
The
Cellar
FP
PLAN
E6
1 km
N
MOSJØEN
820
E6
Øyfjellgr.
Vefsn
Fig26
house
Øyås.
Upper Passages
Middle Passages
Lower Passages
BRIDGE
POT
N
5m
BCRA GRADE 2
The
Rift
SECTION
along strike (simplified)
GN
TLF
Fig 27

ØYÅSKJELEREN Alt. 100 m, Length c. 300 m, Depth c. 15 m
02°27'25"E, 65°47'35"N

This is a dry complex cave formed at three levels and situated at the very top and edge of the cliff, 100 m above the Tveraaen and directly opposite a house. It is approached via a very steep walk up a gorge in the forested cliff wall. 15 m back from the cliff face is the 10 m deep Cellar Entrance, which needs a ladder if used. From the foot of the Cellar two passages (Plate 9) lead to the huge Outer Chamber, which is 25 m long and up to 4 m high and gives an impressive view out across the valley through a frieze of fir trees. Four other passages lead into the cliff from the Outer Chamber, one of which goes up to another entrance, in line with the Cellar, and also round to a low but wide Inner Chamber which is behind the Cellar.

A very low series of gently ascending crawls was forced from the Inner Chamber until the way was too low although draughting strongly, presumably from Skulls Cave (q.v.) 5 m above Inner Chamber, narrow rifts lead up to low joint plane passages best reached from the Cellar ladder.

From the lowest part of the Cellar, various metre high passages lead to openings in the cliff directly below the Outer Chamber, and another ascending and awkward low crawl was pushed past a squeeze beside a boulder to a standup chamber. The crawl continues but splits and becomes too low.

Despite not extending as far as local folklore had mentioned, Øyåskjeleren is an interesting example of an abandoned phreatic system, clearly formed during the earliest stages of downcutting of the Tveraaen. A shallow collapse limestone ravine continues south of the Cellar, containing the entrances to Skulls Cave and Bridge Pot. A small stream is envisaged to have originally flowed down this ravine and been captured first by the Cellar and then by Skulls Cave. A later capture at Bridge Pot could then have formed the lowest level of crawl passage, giving a possible potential of a further 75 m length.

Tackle: 10 m ladder, 15 m lifeline.
Explored: V. Battams, T. Faulkner, A. Marshall, G. Newton, 6, 7 August 1982
Survey: Fig. 27. T. Faulkner, V. Battams, 6, 7 August 1982

SKULLS CAVE Alt. 100 m, Length 6 m
02°27'25"E, 65°47'30"N

From the foot of a shakehole south of the Cellar, an earthy entrance crawl leads to a low joint plane at right angles to the entrance passage. The passage slopes at an angle of 15 degrees towards Øyaskjeleren, but is too low for progress in any direction. Two skulls were found in the entrance passage (probably fox).

BRIDGE POT Alt. 100 m, Length 50 m, Depth 10 m
02°27'25"E, 65°47'25"N

Walking along the line of shakeholes a small rockbridge above the south end of one of the most southerly holes is found. Behind this is an open shaft about 2 m in diameter and 1.5 m deep. At the bottom of this is a narrow corkscrew chimney which descends to a ledge above a climb down into a wide passage. Uphill to the left the passage passes a small oxbow before bending to the right and contracting to a small tube which became too tight. Two avens may be entered in the vicinity of the entrance chimney and these can be climbed up to near the surface although exit is not possible.

Downhill to the right is a spacious walking size rift gained by a 1.5 m climb. This slopes down at an angle of 30 degrees to a choke. To the left of the choke a squeeze gives access to a tube trending back uphill. It eventually splits in two and becomes too tight.

Explored and Survey: Fig. 27. G. Newton, V. Battams, 6,7, August 1982

MISVAER

This is an area of Beiarn where the NGU map indicates a band of marble stretching from the edge of Misvaerfjord at Espenes eastwards across the southern flank of Kletkovfjell (829 m). Several streams flow down the fjell to enter a lake at 538 m altitude. A suface outlet is not shown, but the lake is in line with the limestone outcrop, which is very thin at this point and dipping at 40 degrees to the west. A tiny stream sinks into a low wide sloping passage, 6 m long before being blocked by rocks. 10 m south a dry opening was opened and 12 m of crawl, Slab Cave, can be entered before the way is too tight. The water from these features almost certainly joins the stream to the west which itself sinks and rises several times as it crosses the limestone. Other disappearing streams were noticed in the area, but no other enterable features. Refer to area map, Fig. 25, and to St. Pierre and St. Pierre, (1981), for a report of an area 6 km SW of Misvaer.

CONCLUSIONS AND RECOMMENDATIONS

The major conclusion from the expedition is that it is still possible to explore new cave in Norway at the rate of about 1 km per week with a small team travelling in one vehicle. This is despite the work of previous expeditions in exploring the more obvious sites and easily accessible caves. However, the best places in south Nordland have probably now been visited and further cave discovery will require diligence and a detailed knowledge of previous explorations. Whilst the expedition did find many caves with open entrances, it also had to spend effort and time to pass obstacles to enter new cave, particularly in Fiplingdal. The passing of Kvannlihola Sump 1 was an extremely fortunate occurrence leading to a significant discovery which it may be possible to repeat in other known caves. However, our experience of finding that digs at sinks would usually be successful within 2-3 hours, even if the cave opened up turned out to be short, is a pointer to the future. In the south Nordland area, many promising sites have been examined by earlier expeditions and rejected due to collapse or blockage at the sink. These may now repay a second look with the intention to invest time in digging.

Regarding future work in the areas visited, the expedition would not recommend early returns to most of the later places described in this Report. However, the hydrology of the Tøimskar and Baatskar areas of Nedre Fiplingdal was left largely surmised and unproven. It would be an interesting project, perhaps for a school party, to answer the outstanding questions by water-tracing and measuring flow rates. The caves there are sporting and often could be extended with determination, and the prospect of camping at Tøimskar in good weather is one to relish.

ACKNOWLEDGEMENTS

The expedition members would like to record our gratitude to the following: The Sports Council, for grant aid; the Ghar Parau Foundation, for grant aid and hire of a Marachel tent; Ernst Alfles for hospitality and advice in Fiplingdal, and Svein Kvannli for advice about access to Kvannlihola.

NORWEGIAN MAPS

The following 1:100,000 maps published by the NGO, Norges Geografiske Oppmaling, were consulted extensively for the areas shown:

Gradteig	K13 Bodø	: Misvaer area
	I17 Mosjøen	: Mosjøen area
	J17 Røsvatn	: Herringbotn and Rauvatn areas
	J18 Hattfjelldal	: South Glugvatn and Tøimskar area
	J19 Børgefjeld	: Fiplingdal south of Tøimskar

The Hattfjelldal sheet of the 1:250,000 map published in Oslo in 1925 by the NGU, Norges Geologiske Undersokelse indicates the limestone and marble outcrops for the Fiplingdal, Glugvatn and Herringbotn areas.

For planning expedition routes within the major caving region, the Cappelens tourist map Nordland sheet 7-8 in the Norway series and printed at 1:400,000 is invaluable. A new issue has just been published showing more accurately than before the extent of the nearly completed roads and tracks.

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A more extensive list of references for the Velfjord area is included in St. Pierre and St. Pierre, 1980.

Trevor Faulkner,
Four Oaks.
Wilmslow Park,
Wilmslow, Cheshire.

Appendix 1 EXPEDITION REPORT

Most surveys in this report are to BCRA Grade 2A. For these, paces or body lengths were counted during exploration, with directions related to the strike of the limestone. The survey was then sketched immediately on return to the surface. Kvannlihola 2 and Nedre Rømmargrotta are to BCRA Grade 3B. For these surveys, traverse lengths were measured to 0.1m using a fibre tape and bearings were taken to the nearest 5 degrees using a Silva oil-damped compass aligned along the tape and read from above. All measurements, and plan and cross-section sketches were recorded by the surveyor in a pre-prepared survey note book whilst the assistant located the next forward station and noted its position. Vertical ranges and passage dimensions were estimated to 0.5m. Magnetic declination has been ignored as it is much less in Nordland than the 2.5 degree bearing tolerance used. The Kvannlihola 2 survey data was transformed to north and east coordinates and altitudes using a simple program run on the compiler's personal computer before plotting.

The larger scale maps of the Tøimskar, Baatskar and Øyås areas were prepared from pace and compass data recorded in the field. Paces were calibrated on the open fell at Tøimskar as follows, using a 30m tape.

a) Level ground 38 paces = 30m i.e. 1 pace = 0.8m on plan.
b) Down 30 degree slope 37 paces = 30m i.e. 1 pace = 0.7m on plan.
c) Up 30 degree slope 48 paces = 30m i.e. 1 pace = 0.5m on plan.

The Tøimskar area survey has a misclosure of 150m horizontally over a loop distance of 1800m (31 stations), giving an error of about 8% for this pace and compass survey. At Kvannlihola the distance opposite the Kvannlihola 1 and Sink Cave entrances was counted along the road as 840 paces and pace calibration gave 35 paces = 30m. A distance of 720m between the entrances has been assumed, giving a crude estimate of the length of Sump 2 as 15m (+/- 15m).

All longitudes given in the report are measured from Oslo, which is 10° 43'22.5"E of Greenwich.

Underground photographs were taken from colour slides. 400 ASA speed film was usually used with a single flash and the camera set to Brief.

The whole report has been prepared as a joint exercise by the expedition team, with individual contributions indicated on surveys and by underlining the name of the author of each cave description. The text has been processed on the compiler's computer, mainly by listing pairs of A4 pages as an individual BASIC program and making changes by the EDIT facility. Later written sections were entered and amended as individual A4 pages via a SCRIPSIT word processing package. In this way it was easy to distribute page copies for comment and amend the text from back up copies held on cassette tape.

Appendix 2 NEW CAVE SUMMARY

FIPLINGDAL			
Tøimskar			
Doorway Cave	182		
TSC + Dry Cave	201		
High Flow Cave	50		
Others	116		
	549	549 metres	
Baatskar			
Baatskargrotta	210		
Two Level Cave	40		
Tumbledown Pot	60		
Vicgrotta	70		
Others	41		
	421	421	
Kvannli			
Kvannli Sink Cave	75		
Kvannlihola 2	639		
Others	35		
	749	749	
Nyrudhola	60	60	
GLUGVAN			
Glugvasselvgrotta	94		
Rømmargrotta	150		
Nedre Rømmargrotta	120		
Others	13		
	377	377	377
HERRINGBOTN			
Upper Arch Cave	79		
Gjoberggrotta	75		
Others	101		
	255	255	255
MOSJØEN			
Øyåskjekeren	300		
Others	56		
	356	356	356
MISVAER	18	18	18
			2785

Lengths measured in metres.

Appendix 3 EXPEDITION ACCOUNTS

		£
INCOME		
Grant aid Sports Council		110.00
Ghar Parau Foundation		50.00
From Expedition Members		
Sterling		380.00
1350 Norwegian Kroner		126.17
		666.17
EXPENDITURE		
Sterling		
Petrol, oil and tolls		22.71
Ferry Newcastle - Oslo return (4 passengers plus car)		368.00
Car and passenger insurances		64.90
Photo copying		1.30
		£456.91
Norwegian Kroner		
Petrol and oil	1447.76	
Camping fees	590.00	
Food en route	198.23	
	2235.99 N.Kr. =	209.26
		£666.17

Note The account excludes the bulk of expedition food (purchased both in England and Norway), photographic expenditure and all post-expedition expenses.

CAVE SCIENCE

Transactions British Cave Research Assoc. Vol. 10, No. 3, September 1983

THE IRON AGE IN MATIENZO, NORTHERN SPAIN

by Peter Smith

ABSTRACT

Iron Age remains have been found in four caves in Matienzo (Santander) mainly by successive British caving expeditions. The finds include pottery, human remains, metal objects and paintings, possibly related to rituals during the use of caves for burials. They can be dated in the Early Iron Age, starting about 900 or 800 B.C.

RESUMEN

Se han encontrado restos de la Edad de Hierro en cuatro cuevas de Matienzo (Santander), principalmente por las expediciones espeleológicas. Los hallazgos incluyen cerámica, restos humanos, objetos de metal, y pinturas, posiblemente relacionados con los rituales durante la utilización de las cuevas para los enterramientos. Se pueden fechar a principios de la Edad de Hierro, que comenzaría aproximadamente 900 u 800 antes de Cristo.

INTRODUCTION

The village of Matienzo lies in the Cantabrian Mountains about 25 km. to the southeast of Santander. It is in a karst-enclosed depression which contains many caves of varying sizes and lengths. These have been studied, first by a Santander caving group, la Seccion de Espeleologia del Seminario Sautuola, and later by a series of British expeditions, which have been summarized in B.C.R.A. Transactions (Corrin et al, 1981). Important archaeological remains have been discovered during the caving exploration, and these have mainly been of the Bronze and Iron Ages (Fig. 1).

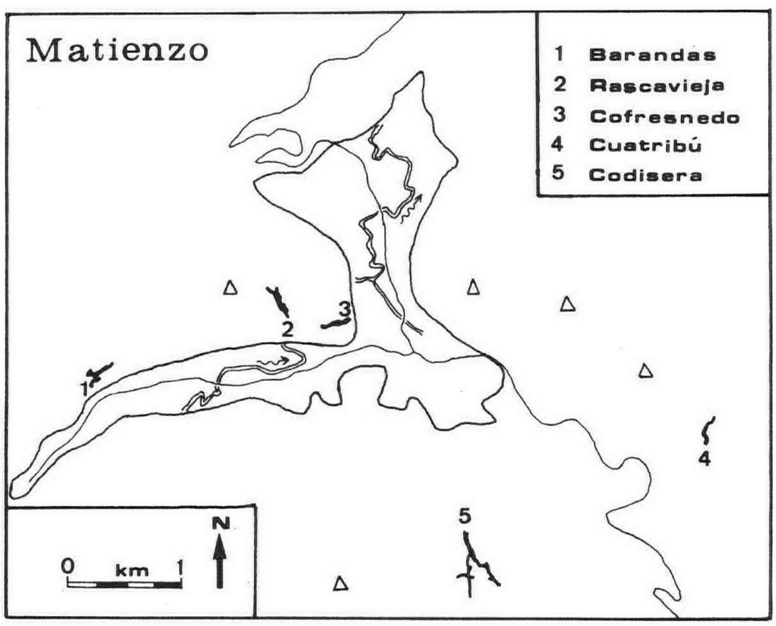


Fig. 1. Area map with cave locations.

The first finds were in the Cueva de Cofresnedo and consisted of abundant fragments of pottery (Begines, 1966) and human remains (García Caraves, 1966). The pottery was then attributed to the end of the Neolithic or the beginning of the Bronze Age, and the skeletal remains appeared to belong to two persons, a youth and an adult. They also reported finding pieces of pottery in another cave, Rascavieja, although they gave no further details.

The next find, a human skeleton, was also discovered in Rascavieja during the English expedition of 1975. It was studied by R. Rincón, who thought that it could be of a youth about 12 years old, and dated it in the Bronze Age. However, it has never been published in any detail, apart from a short note about the discovery (Mills, 1975).

In 1978 A. Pintó found some pieces of pottery in the Cueva de Codisera. Apparently these constituted three or four sherds. They were deposited in the Museum of Prehistory in Santander, but have never been published.

During the winter of 1980-81 more fragments of pottery were found in the Cueva de Cofresnedo. These sporadic finds concluded, in October 1981, with the discovery of some paintings on the cave walls, as well as human remains, by E. Muñoz and other members of the "Colectivo arquelógico" C.A.E.A.P., M. Ortiz and P. Smith (Peñil, Muñoz and Smith, 1982).

RECENT DISCOVERIES

After this latest find, others have been made,which we can summarize as follows:

1. 6th December 1981, Cueva de Codisera. A copper arrowhead. (M. Ortiz and P. Smith).
2. 10th January 1982, Cueva de Cuatribu. Schematic- abstract paintings (Smith).
3. 12th August 1982, Cueva de Cofresnedo. Various iron artifacts, pottery and human remains (David Hartnup and L. Mills).
4. 9th September 1982, Cueva de Codisera, Pottery (Smith).
5. 10th October 1982, Cueva de las Barandas. Pottery and human remains. One week later, a copper strip (Julie Bridgman and P. Smith).

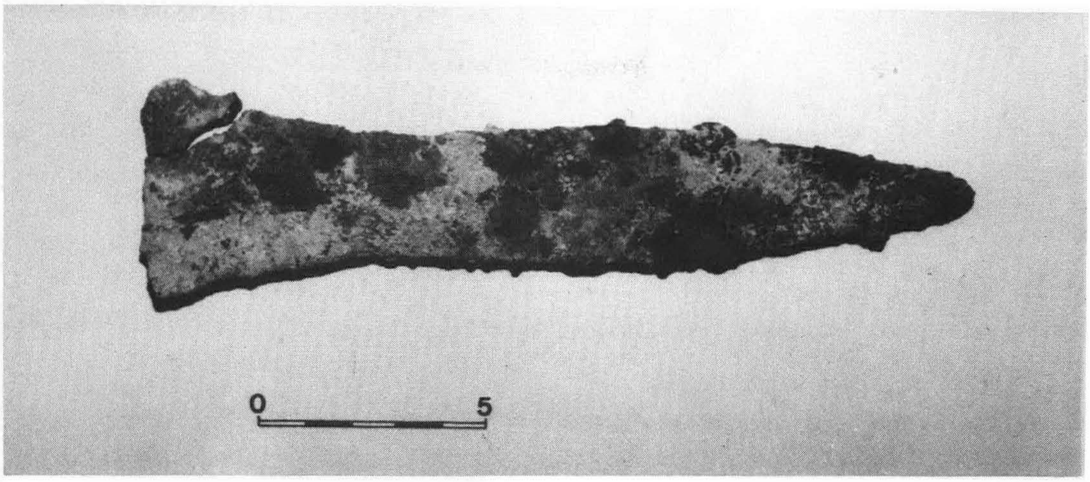
These finds have increased greatly our knowledge about the Iron Age in Matienzo and Santander, and are, in fact, among the most important Iron Age finds in caves anywhere in Northern Spain.

CUEVA DE COFRESNEDO

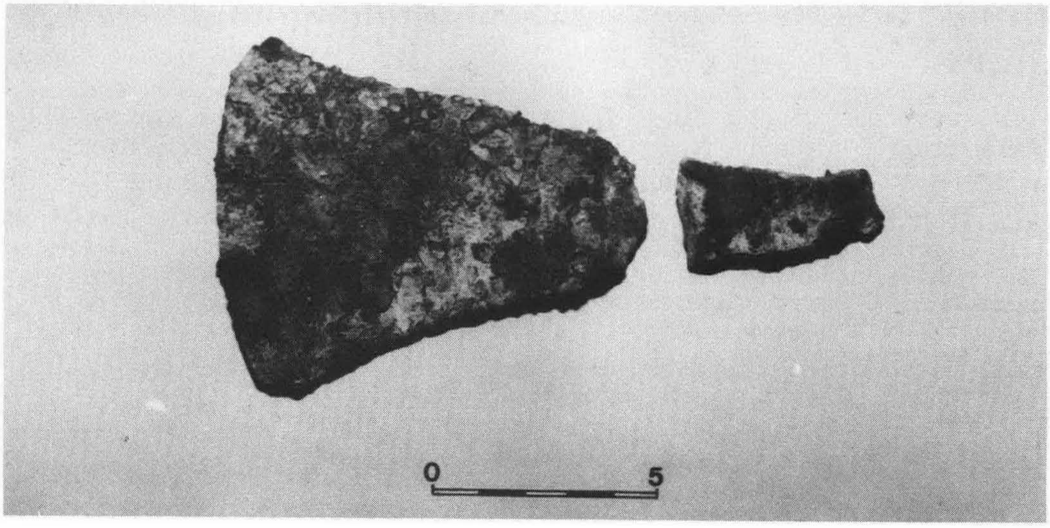
This cave is near the centre of the Matienzo depression, formed in the sides of the Monte Enaso (Fig. 2). The entrance is at 235 m. above sea level, and faces east. It is a large cave, reaching a width and height of 30 m, and is 275 m long. It is an abandoned, fossil cave, dry apart from the drips of water which fill the gour pools in the winter. Also it has many large speleothems.

The Pottery: Fragments of pottery have been found almost everywhere in the cave; at the top of flowstones, at the end of narrow alcoves, in the gour pools, or simply strewn on the floor of the main passage. This dispersion has been explained with the hypothesis of a powerful current of water which destroyed archaeological levels at the entrance and spread the remains throughout the cave (Begines, 1966). Recently this theory has been criticized (Peñil, Muñoz and Smith, 1982) precisely because the cave must have been left fossil long before the Bronze or Iron Age, so it is difficult to imagine a current so powerful acting since then. The pots were placed on the flowstones or in the alcoves, according to the rituals and beliefs of the time, and their later dispersion, within a relatively small radius, is due to the action of the water-drips or animals or more recent human activity.

1. View of La Vega, Matienzo, with, from left to right, the caves Barandas, Rascavieja and Cofresnedo.



2. Iron dagger from Cofresnedo.



3. Iron axe-head from Cofresnedo.
scale in cm.

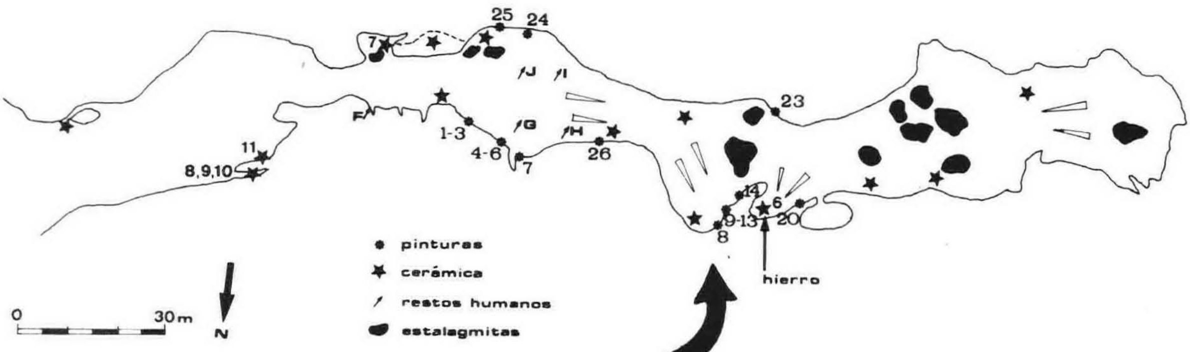


Fig.2.

Cueva de Cofresnedo

topografía S.E.S.S.-G.J.E.

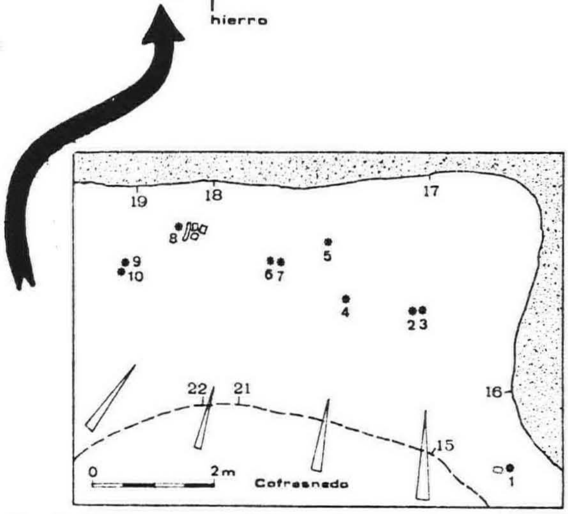


Fig.5. Enlargement of Cofresnedo cave plan showing finds of iron objects, other artifacts and wall-paintings.

Begines recognized five main types of pottery. In summary they are:

1. The most common, a large pitcher (about 50 cm high), with a large, open mouth finished with a rim which turns outwards. Not connected with any kind of decoration.
2. Pottery with two layers; the inside dark grey and the outside an orange colour. This outer layer is decorated with deep and irregular finger marks, and is also pierced with holes.
3. Pottery decorated with a raised band, marked at regular distances by deep excisions.
4. Some edges of a straight-sided jar.
5. Another small edge, which forms an obtuse angle with the body of the pot.

We have found some other types of pottery, which do not exactly correspond with those studied by Begines, although the majority are of his type 1, i.e. with the rim turned outwards (see Fig. 3 and also Appendix 1).

6. The mouth and rim of a pot found next to the iron artifacts. The rim is high, almost vertical, and a fine, incised line goes round the top of the rim (Photo 4).

7. A rim which is notably thicker than the body, also with a line round the rim. From the first chamber on the left of the main passage.

8. Various pieces which could be the rim, base and body of the same vessel as No. 7. The body apparently was decorated with fingernail impressions, similar to the excisions of type 3, but over a wider area rather than limited to a raised band. From a narrow alcove on the right of the entrance chamber.

9. A single piece of rim, with fingernail impressions on the edge of the rim and on the outer side. From the same narrow rift.

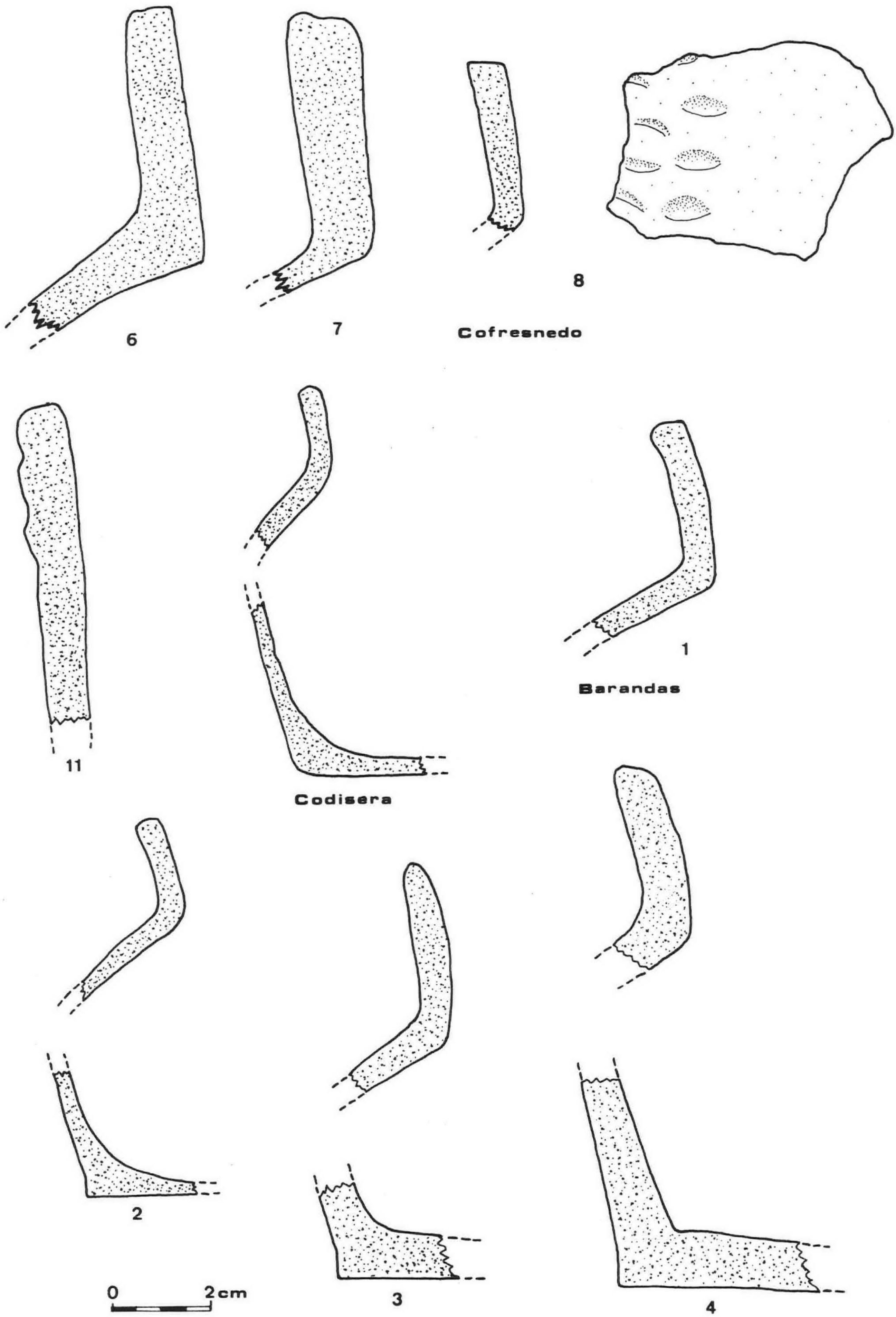


Fig.3. Pottery found in Cofresnedo, Barandas and Codisera.

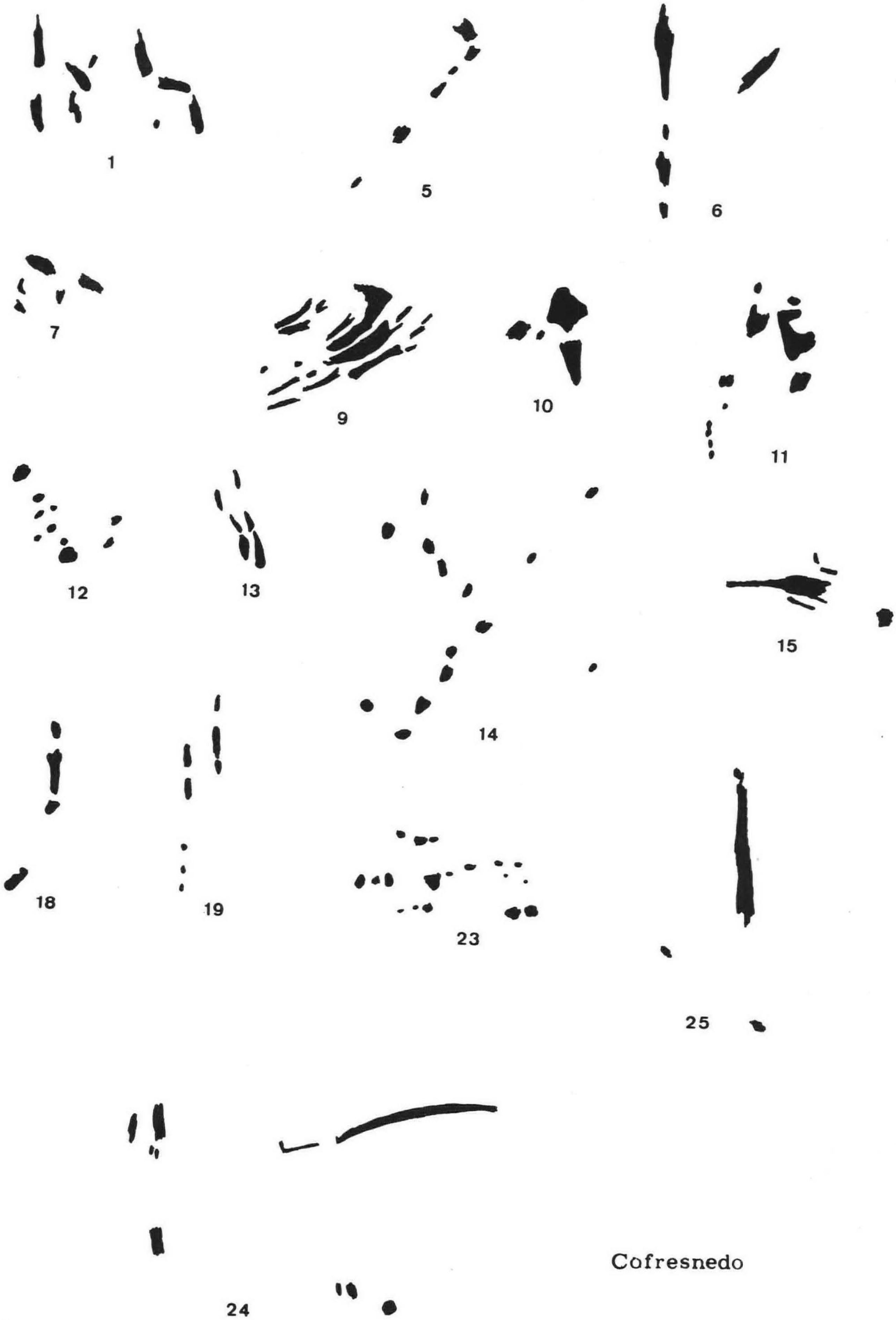


Fig.4. Some of the schematic-abstract paintings in Cofresnedo.

10. Again a single piece from the same site, it has a projection which sticks out some 13 mm.

11. A single piece from a hollow on the right of the entrance chamber. The rim of a straight-sided pot, the edge is decorated with regular fingernail impressions and the outerside with irregular "smudged" finger marks.

Human remains: During the first study of the cave, five skeletal fragments were collected (García Caraves,.1966).

Piece 36-A. Part of the lower jaw, which, from its proportions, could belong to a young person.

Piece 36-B. A large right molar and part of the upper jaw.

Piece 36-C. The orbital region of the right forehead. 36-B and 36-C could belong to the same person, with a large and thick skull. The muscular insertions suggest that he was male.

Pieces 36-D and 36-E. Fragments of ribs, probably of a young person.

Thus there appear to be at least two people buried in the cave, one young and the other an adult male.

The newly-discovered remains are limited to teeth, and have been studied by Don Luis Antonio del Olmo.

F. In an alcove to the right of the main passage, a molar (position 6, lower left).

G. In the main passage, on the right-hand side. A group of teeth with part of the jaw. Possibly of a young person.

H. Also on the right of the main passage. A molar (position 6, lower left). As it is the same tooth as "F", this means there would be a minimum of two adults in the cave.

I. On the left-hand side of the main passage. A premolar (position 4, lower right).

J. Again on the left, a total of eight teeth were found in a small gour pool. Some of them, badly conserved, could not be identified. The others are; an incisor, a premolar and two molars (positions 1, 5, 6 and 7, all upper left).

Therefore it appears that a minimum of three people was buried in the cave, two adults and one youth.

All the molars examined were noticeably abraded on their upper face. This might be through a vegetarian diet, which needs more of a grinding action, rather than meat which requires a cutting action. The abrasion was especially noticeable in the case of the piece F, perhaps of a very old person, but it was also seen in the other pieces.

The Paintings: A total of 26 figures have been located since the first discoveries in October 1981. Most of them are found on the righthand wall, once within the dark zone, although a few examples can be seen on the left wall in two different areas. All the paintings can be included in "schematic-abstract" style, which is found in the Alava-Cantabrian Coast Area. These paintings, always a charcoal black, may represent stylized human figures or entirely schematic or abstract compositions.

The first paintings in Cofresnedo are quite simple figures of dots and short lines, apart from No. 1, drawn with vertical and diagonal lines. The most interesting paintings are grouped on the end wall of the first chamber on the right of the main passage. No. 9 is a composition of diagonal, subparallel lines, which is similar to some paintings in the cave of Altamira (Breuil and Obermaier, 1935). No. 14 is a series of dots which suggest the form of an "L" or perhaps a "Y". It is possibly the most important figure in the cave in a dominating position (Fig. 4 and Photos 5 and 8).

Another group of paintings can be seen in the next chamber on the right, where the iron artifacts were found. These are mainly of short, vertical lines. Also an overhang, covered with a layer of calcite, is decorated with small dots (Photo 6).

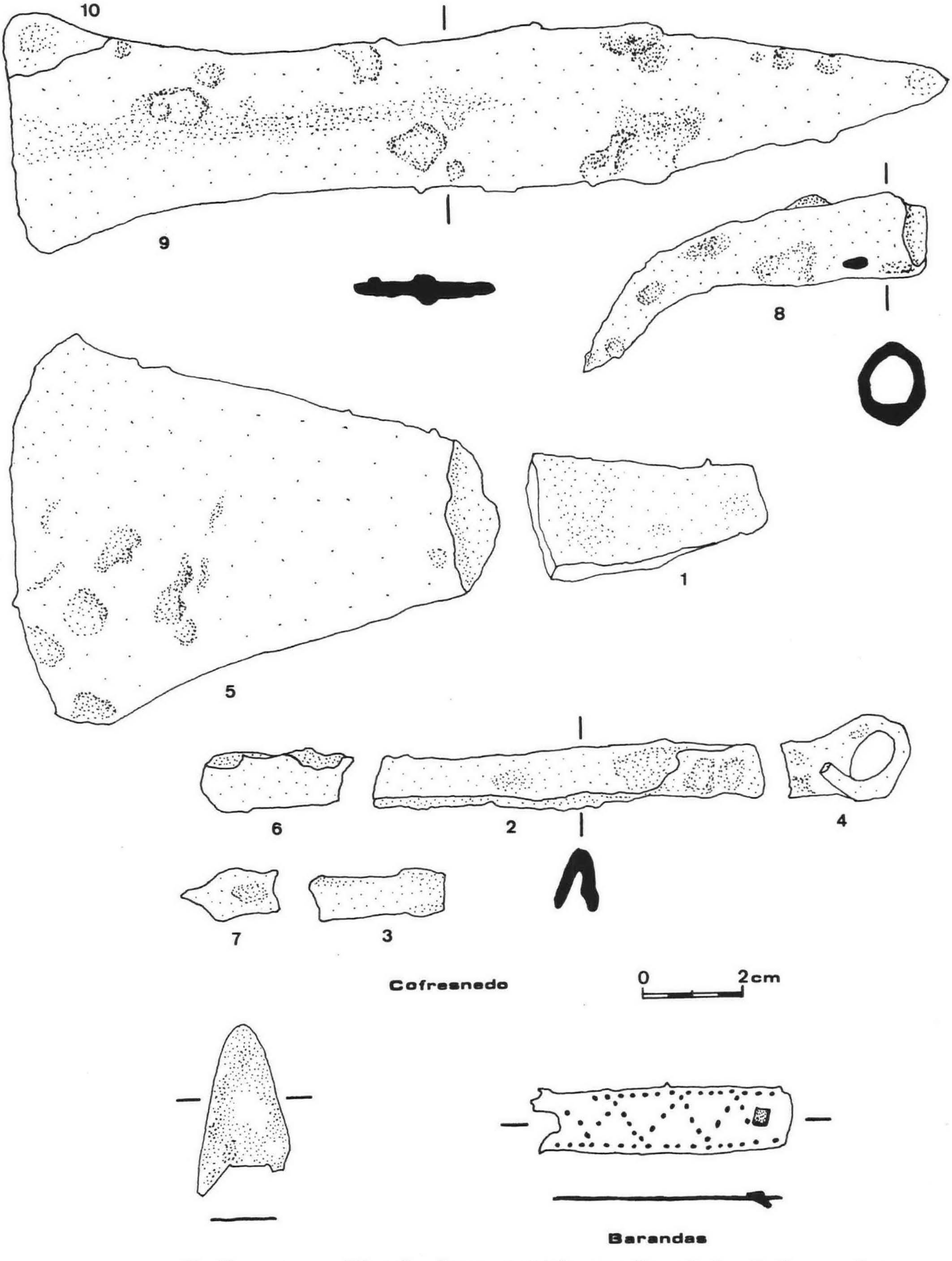
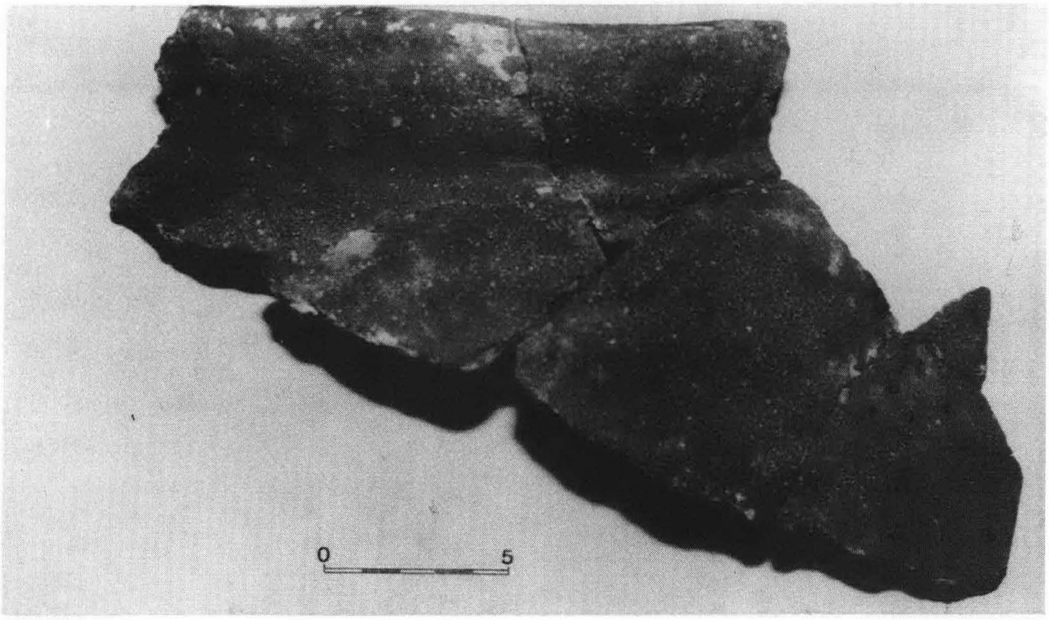
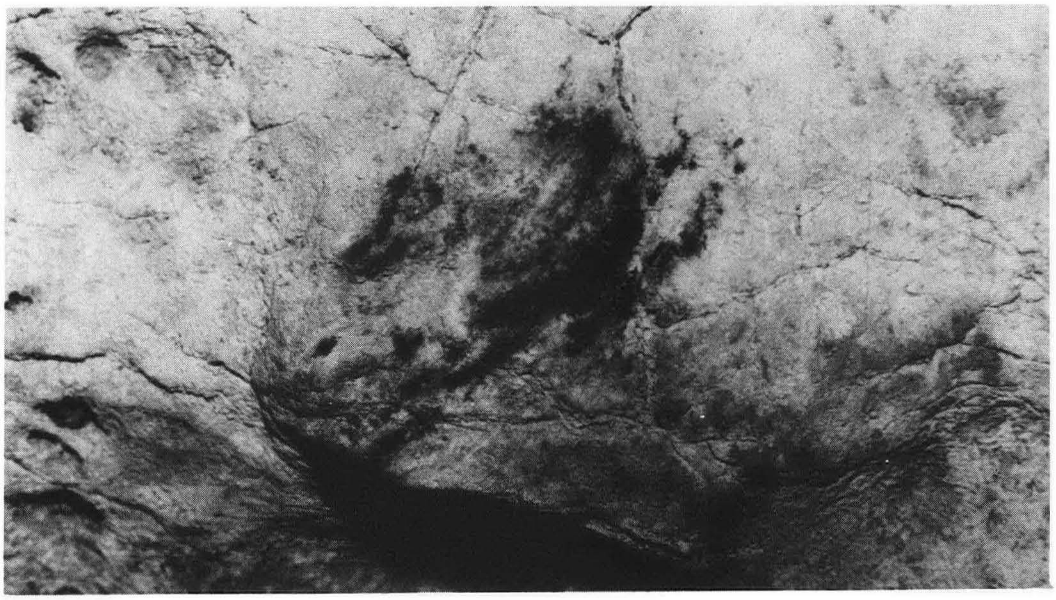


Fig.6. Iron artifacts found in Cofresnedo, and two finds in Codisera and Barandas.



4. Pottery type 6 found with iron artifacts in Cofresnedo.

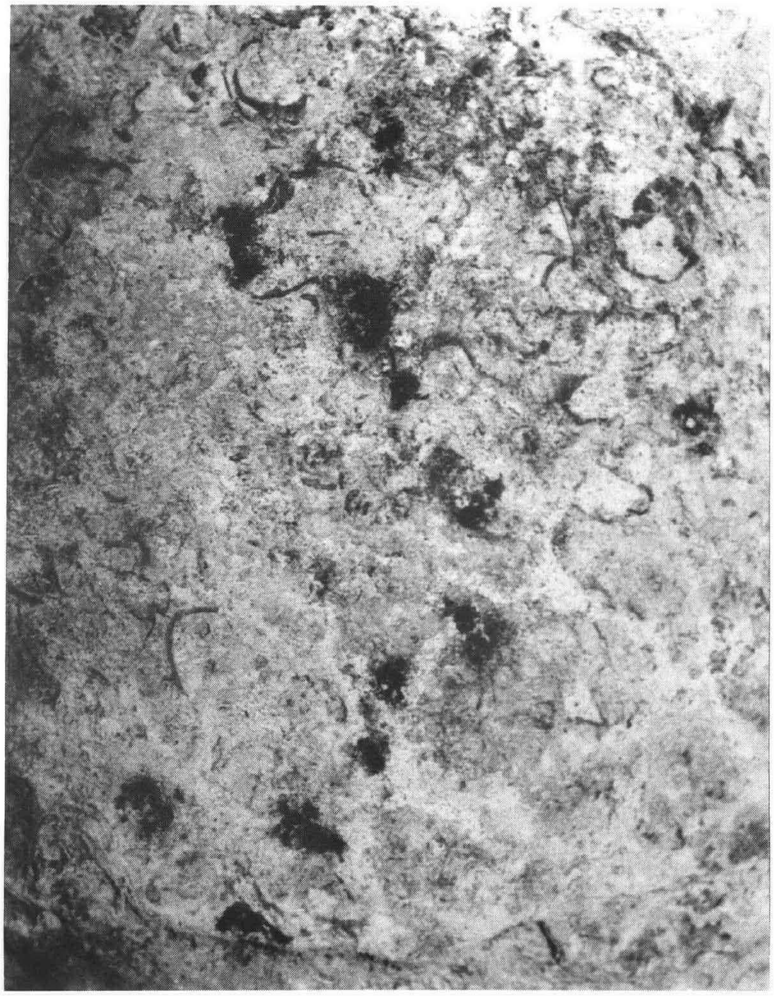


5. Painting no.9 in Cofresnedo.

6. Painting no.21 in chamber with iron artifacts in Cofresnedo.

7. Painting no.9 in Cuatribu.

9. Painting no.12 in Cuatribu.



8. Painting no.14 in Cofresnedo.

More paintings of dots are found on the left-hand wall, approximately opposite these chambers. And another chamber, on the left nearer to the entrance, contains two more paintings (No. 24 and 25). The first of these appears to have been drawn with a finer quality paint than the others.

Although it is true to say that many of these paintings are purely abstract, others could be schematic human figures, for example No. 14 or the paintings of vertical lines. Therefore Cofresnedo can be included between the second (schematic figures) and third (abstract) periods of the classification of A. Llanos (1977). It most resembles the paintings in Altamira or in the Cueva de Cudón (C.A.E.A.P., 1982).

The Metalwork: Various pieces of iron were found in the chamber at the base of the slope which ends the main passage. Ten pieces were found altogether, although these appear to belong to four objects. They were discovered separated across the chamber, and covered by the flowstone and gours of soft calcite which forms the floor in this part of the cave (Figs. 5 and 6).

Object 1: this corresponds to the pieces No. 9 and 10, and is an iron dagger. 184 mm long, it is 47 mm wide at the end, it narrows to 27 mm and widens again to 31mm. The two pieces were found together, and it seems the fracture must have occurred recently or at the time of being removed from the calcite (Photo 2).

Despite the rust, the central ridge can still be seen; however, there is no sign of rivets or any other way of fastening it to the handle, which is missing. It is similar to the dagger found in Monte Bernorio (Palencia) and on display in the Museum of Prehistory in Santander, although this has multiple ridges down the centre of the blade. It also resembles the dagger from Doroño, Condado de Treviño (Llanos, 1968).

Object 2: this appears to be the head from a spear or javelin, although it is now bent. It is 74 mm long, with a circular cross-section, hollow, and pierced with a small hole near its base. This is the piece, No. 8, which was found next to the pottery type 6.

Object 3: these are two pieces (No. 1 and 5) which, from their size, could belong to the same tool, although they do not fit together perfectly. They were discovered about four metres apart, so the break must have happened some time ago. It could be an adze, or curved axe which (piece No. 5) is 95 mm long and 77 mm wide. If No. 1 did belong to this tool, then it would form an elongation of the axe, to which the handle would be attached. A fragment of pottery was found next to this piece too (Photo 3).

Object 4: the remaining pieces of iron are grouped together, as they are all of a similar size and were found more or less close to one another. Nevertheless it is hard to say to what kind of instrument or tool they might belong. No. 2 is a long piece, 77 mm, with a "V" cross-section, while No. 4 forms a kind of ring or hook.

Other Notes: Of the four kinds of archaeological remains in the cave (pottery, human, paintings and metal) it is easiest to find a relationship between the pottery and the metal, since the pieces of iron No. 8 and 1 were discovered practically in contact with the pottery type 6 and another fragment. Therefore it is thought that the iron and the pottery, at least this particular pot, would be of the same age and even form part of the same funeral ritual.

The walls of this chamber also have some paintings, but this time the connections are not so close. Neither are they the most significant paintings in the cave.

The human remains were all found in, or adjacent to, the main passage. But they have never been found together with the pieces of pottery and charcoal, and often they are isolated in the gour pools. However, there are remains of pottery in various parts of the passage and both walls are decorated with the black paintings.

In fact, it appears that the entire cave was used for the funeral rituals, placing the pots and other objects and painting the pictures, in different but very exact points of the cave, which would have a special meaning within the rituals. Nowadays our image of this use is rather imperfect, as the studies of the 1960s and unknown intrusions have altered greatly its original state.

The Cueva de Cofresnedo is by far the richest in Matienzo in archaeological material, as if it were the cave favoured for the rituals. This is probably due not only to its impressive size and beauty, but also to its position in the centre of the depression.

CUEVA DE CUATRIBU

The entrance is hidden in the trees, to the southeast of Ozana, the most southern part of Matienzo. It faces south, and lies at 415 m above sea level. It is a dry cave, apart from a few gour pools, and the floor is mostly of clay. About 230 m long, it never reaches large dimensions, and the passage height varies between 1 and 4 metres (Fig. 7).

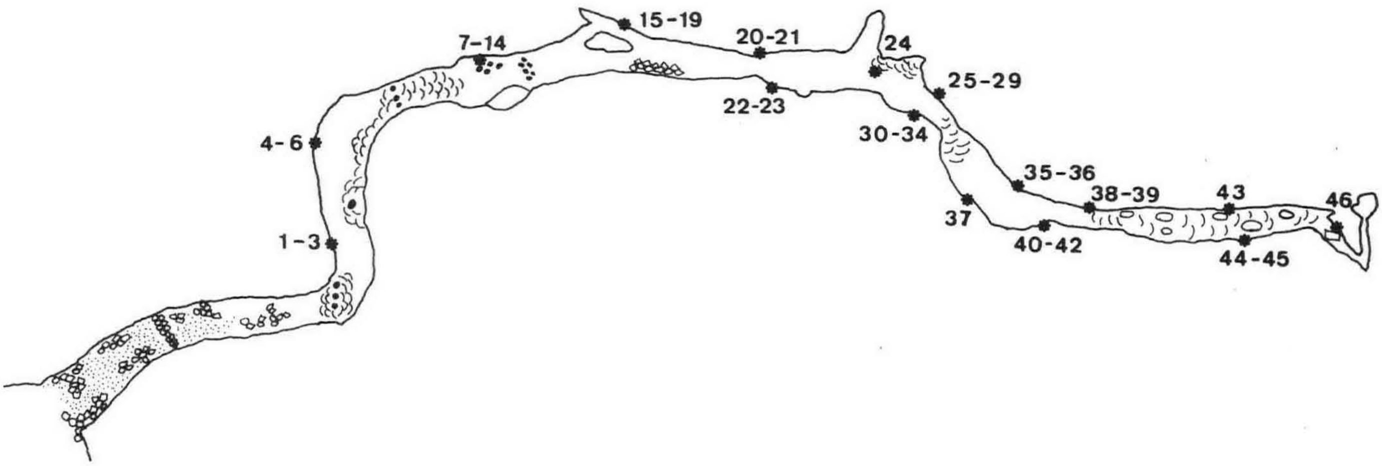


Fig.7.

Cueva de Cuatribú

topografía 1975

The cave was included in the study of the S.E.S.S., and they discovered a vase, attributed to the medieval period, and recently dated in the twelfth century (Begines, 1966; Peñil, García and Bohigas, 1982). They also noticed the large quantities of charcoal spread throughout the cave, on the floor, stalagmites and boulders. Now it is thought that this charcoal was taken to the cave, or made there, to do the paintings, which were discovered in 1982. The cave is also remarkable for the remains of bears, perhaps three or four specimens. From their size these are more likely to be brown bears, rather than cave bears.

Recently, 7th January 1983, an iron object was found in a low opening at the entrance of the cave. This is apparently part of a narrow axe, imitating the axes of the Bronze Age. It was found by a member of the Colective C.A.E.A.P. Apart from this find, out of context with the paintings, there have been no other finds of metal, pottery (except the medieval vase), or human remains.

The Paintings: These are again black, of the schematic-abstract style (Fig. 8). There are more figures than in Cueva Cofresnedo, in total 46 have been catalogued, and they are found from the start of the dark zone to the end of the cave. However, the first ones, near the entrance, and the ones near the end consist only of dots or single lines. The most interesting groups are concentrated in four zones.

Fig. 8. Some of the schematic-abstract paintings in Cuatribú.

The first of these is at the base of a flowstone slope, in a chamber with a shallow pot-hole on the right. The left-hand wall and the formations next to this wall contain several paintings. No. 9, for example, is a group of three lines which point towards another vertical line (Photo 7). No. 12 and 14 are two interesting figures painted on two stalactites (Photo 9). The floor of this chamber, as in many other parts of the cave, is covered with bones (including pieces of the skull and teeth of bear) and abundant charcoal. Also, as well as the catalogued paintings, nearly all the formations in this chamber have some or other black mark or line.

A low passage leads out of this chamber into a further passage with more paintings on the left-hand wall. No. 17 is a kind of small "L", while No. 19 is a series of dots which form an angle in a very similar way to the painting 14 in Cofresnedo.

The third zone is reached some 20 m along the passage, and this is the first time any significant paintings are seen on the right-hand wall. No. 22 is an extremely complicated figure of horizontal lines and many dots. No. 20, a group of lines pointing to another, is interesting as it resembles No. 9, but turned through 90°.

The final concentration of paintings follows on from a small chamber and again they are found on both walls. However, many of the figures are characterised by long, unconnected lines which are equally hard to describe and understand.

Notes: Just as in Cueva Cofresnedo, the majority of the paintings are purely abstract, but others could represent human figures. For example, No. 9 and No. 20 could be schematic human figures, first in a vertical position and then horizontal. Therefore Cuatribu can also be included between the second and third periods of the schematic-abstract art.

The main problem presented by Cuatribú is the lack of pottery or human remains, which are usually found in caves with this kind of art. Unless these remain undiscovered, buried in the cave floor, it is hard to see any relationship between the paintings and funeral rituals. And these are the apparent reasons for this style of painting in most caves which contain them, for example, in the caves of Solacueva (Llanos, 1961) and Los Moros (Llanos and Agorreta, 1964), both in Alava, or in Cofresnedo itself. Nevertheless, the cave of Altamira would be another example of a cave with many schematic-abstract paintings, but without any remains of the Bronze or Iron Age.

CUEVA DE CODISERA

The cave of Codisera lies to the southwest of Ozana, at 450 m above sea level (Fig. 9). The entrance faces northeast, and it is a very large and

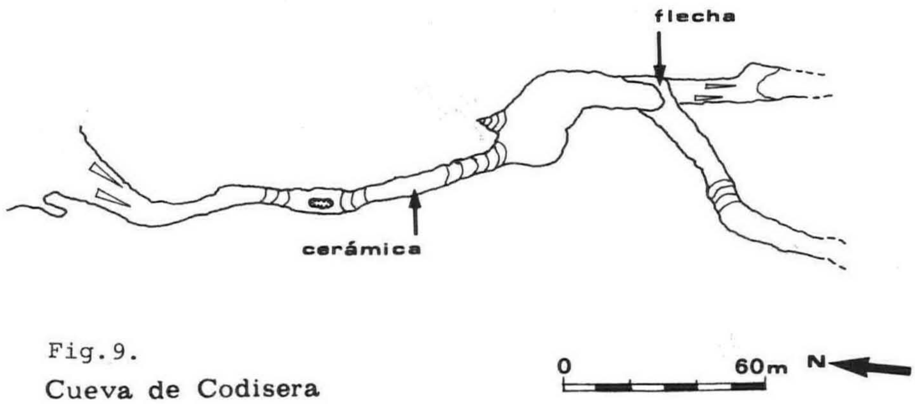


Fig.9.
Cueva de Codisera
topografía S.E.S.S.

sporting cave, almost two kilometres long. From the entrance the first passage slopes down to a pitch, which can be traversed on the left, and the passage continues through a small chamber to another larger one where a lake forms in wet weather. From here the passage slopes down again to another pitch, while a secondary passage climbs up on the left and crosses over the first.

It was completely explored by the S.E.S.S. in the 1960s, but the first archaeological discovery was made by Alfonso Pintó in 1978; he found some pottery in the chamber which follows after the first pitch.

The Pottery: This find has not been published at all, but we have been able to collect some more pieces from the same site, and this allows us to reach some conclusions about the kind of material in the cave.

The fragments all appear to belong to the same article, which is quite small with thin walls. (See appendix 1 and Fig. 3).

It is of the type with the rim turned outwards and without any decoration, therefore it is similar to the type 1 in Cofresnedo, the most abundant in the cave, and it very closely resembles the pot No. 2 in the cueva de las Barandas.

The floor of the chamber where these fragments were found is covered with many bones, of which we have been able to recognise those of cow and goat.

The Metalwork: At the start of the passage which climbs up on the left, precisely where it crosses over the first passage, a copper arrow-head was discovered. It is 35 mm long, from the tip to the end of the fin, 19 mm wide, and is very thin. It is flat, without any type of central ridge or other kind of decoration. One of the fins is missing, and also the central spike which fastens to the shaft.

Other examples of copper or bronze arrow-heads were found in the caves El Castillo and La Flecha (Puente Viesgo). Although these are rather narrower (16 and 14 mm) and longer than the one from Codisera, they are similar in being thin and flat (Aragoneses, 1953). This author dated them in the early Bronze Age, although a later dating might be preferable as the arrow-head type "Palmella", without fins, is now thought to be from the early Bronze (Apellániz, 1974).

The only other known arrow-head found in Santander has recently been published (Rincón, 1983). It was discovered in the Cueva de la Lastrilla (Castro Urdiales).

Notes: It must be remembered that the arrow-head in Codisera was found at a distance of 100 m from the pottery. Therefore there ought not to be any relationship between the two finds. Also, while the arrow-head could be dated in the late Bronze Age, the pottery appears to be of the Iron Age type.

CUEVA DE LAS BARANDAS

This cave is in the part of Matienzo called La Vega, and its small entrance lies just above a path which climbs up the northern slopes of the valley (Fig. 10). The entrance faces south, at 208 m above sea level. A slope drops down into a chamber, with another slope on the left into the main chamber, which is decorated with a tall and wide stalagmite. The main passage then continues for another 70 m, while a narrow side-passage ends in a small chamber.

We were told of the cave in summer 1982, and in our second visit we discovered the prehistoric remains.

The Pottery: Fragments of pottery have been found in two completely different parts of the cave; in the main chamber next to the big stalagmite, and in the first chamber and slope on the right. This slope has been further subdivided to help differentiate between the various fragments; two rifts against the left wall, and the left and right halves of the slope itself.

We have collected, as on other occasions, only fragments of the rims and bases, and with these we have been able to pick out four different pots, although all four are of the same type: i.e. with the rim turned outwards and without decoration. Thus they are similar to the most common types in Cofresnedo and Codisera. (Fig. 3).

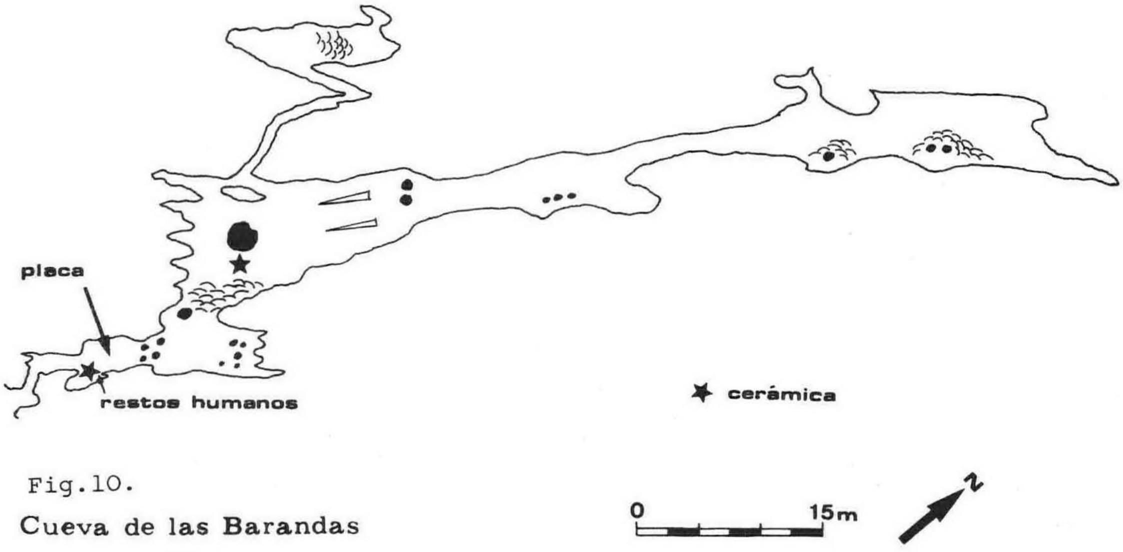


Fig.10.

Cueva de las Barandas

topografía 1982

1. The rim of a quite large pot, found in the main chamber.
2. Pieces of a small pot, very similar to the one in Codisera. Mainly from the second rift on the left of the slope.
3. The rim and base of pot very similar to No. 1, except for the reddish colour of the inside layer of the piece. From the two rifts.
4. The base and rim of a grey coloured pot with a porous texture, and a somewhat uneven surface texture, as if it had been finished off with with a spatula. From the right of the slope.

Human remains: Certain skeletal remains have been found in the first chamber and the two rifts near the entrance, and they have been studied by Dr Jose Miguel del Olmo.

A. Part of the left femur. The lower part is broken and missing, but the piece collected is 29 cm long.
B. The sacrum, possibly of a young male.
C. A possible dorsal vertebra.

The Metalwork: A small piece of copper was found in the centre of the first chamber, therefore it was in a close relationship with the pottery and the human remains. It is in the form of plaque or strip, 52 mm long by 13 mm wide, decorated with a zig-zag pattern made up of dots punched in the metal. More dots surround the border of the strip. In one end there is a small iron rivet, while the other end appears to have broken where the other rivet would have been. (Fig. 6).

It is not known what this strip would have been for, perhaps it formed part of some personal jewellery, or decorated a belt, or even a shield or sword. Nevertheless, similar strips were found in the excavation of the Iron Age hillfort of Celada Marlantes (García Guinea and Rincón, 1970). These were in bronze, and there was also one in iron. Although they did not have the same decoration of dots, they did have holes at either end, just as this new strip has the iron rivet. Finally the C.A.E.A.P. have recently found a similar plaque or strip with iron rivets in the Cueva Coventosa, in Ason, Santander (Personal communication).

Notes: Apart from these finds, we have seen in the cave a circular oxidized object which is apparently an aluminium coin. Also there was an empty bullet shell in the entrance, so these objects show a more recent use of the cave. However, it seems clear that the archaeological material belongs to the prehistoric period, and are typical of a burial cave. As the pottery is similar to most of that found in Cofresnedo, it is probable that it, too, is from the Iron Age. This theory is reinforced by the copper strip, with the iron rivet.

Also we have seen some pieces of carbonized bones in the entrance chamber. These, now half-covered with a layer of calcite, appear to be of animals, but they could indicate that cremation was practised at the time of using the cave.

CONCLUSIONS

Taking first the pottery, a noticeable uniformity is seen between the most abundant type in Cueva Cofresnedo, and all the pots in Codisera and las Barandas. This type, with the rim turned outwards and without decorations, appears to be typical of the Iron Age, very different from the Bronze Age pots, e.g. from the Cueva de A.E.R. (Ramales) conserved in the Museum of Prehistory, Santander. On the other hand it is very similar, in a more primitive form, to some of the pottery discovered in the excavations of Celada Marlantes.

The Cueva de las Barandas and also Cofresnedo, demonstrate that burials were carried out in the caves in this period. Though these were almost certainly inhumations, there are some slight signs of cremations. Thus the pottery and metal objects are seen to be grave goods.

The relationship between the archaeological material and the black paintings is not always very clear. The presence of paintings in the same chamber in Cofresnedo as the pottery type 6 and the iron objects supports the theory of a connection, as does the similarity between some paintings, especially No. 14 in Cofresnedo, and the decoration of dots on the copper strip. However, the connection between the burial caves and the paintings is not seen in the case of the Cueva de Cuatribu. Nevertheless, some of the caves in Alava with schematic-abstract paintings (second and third periods) have been dated in the Iron Age (Llanos, 1977).

The iron objects (Cofresnedo) and copper strip (Barandas) confirm this date. It appears to be a genuine Iron Age, in all its implications, which contrasts strongly with the finds in the Basque Country, where a Bronze Age culture apparently survived during a period chronologically in the Iron Age (Apellániz 1974). Thus these finds from Matienzo could be dated in the period going from 900 or 800 B.C. to the Roman conquest, with preference for the beginning of this period, whereas Celada Marlantes was dated at the end.

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Special thanks to Emilio Muñoz for reading and correcting a Spanish version of this article, and also for his help and encouragement throughout this study. Also to Javier Peñil, who has also read and corrected the article.

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M.S. Received March 1983

Peter Smith,
Calle Isaac Peral 8-C, 4ºB,
Santander,
Spain.

APPENDIX 1: THE POTTERY

The table gives the approximate sizes for the different pots, and the percentages can give an idea of the accuracy to be attached to each one.

The rim heights were measured on the inner side of the rim, from the angle with the body of the pot to the top, and all the measurements are in millimetres.

For the location of each find see the text and the relevant cave surveys.

APPENDIX 1: THE POTTERY

CAVE	COFRESNEDO						CODISERA	BARANDAS			
POTTERY TYPE	6	7	8	9	10	11		1	2	3	4
COLOUR	BROWN-BLACK	DARK BROWN	BROWN	BROWN-BLACK	BROWN	BROWN-BLACK	BLACK-BROWN	BROWN-BLACK	BLACK	BLACK-REDDISH INTERIOR	GREY-BROWN
DIAMETER MOUTH	270	300	250	250	-	210	120	240	120	210	230
HEIGHT RIM	55	43	33	34	-	-	17-19	35	22	35	33
% RIM FOUND	20	12	25	10 single piece	-	10 single piece	17	17	50	33	8
THICKNESS SIDES	5-6	5	5-7	8	7	8-9	5-6	5-7	3-4	5-7	7-8
DIAMETER BASE	-	-	230	-	-	-	90	-	90	120	165
THICKNESS BASE	-	-	8	-	-	-	4-5	-	3	9	10
% BASE FOUND	-	-	5	-	-	-	20	-	25	10	45
NOTES	Line around top of rim. Found next to iron objects	Difference between thickness of rim (15 mm) and sides. Line around top of rim	Sides decorated with fingernail impressions	Fingernail impressions on top of rim and round outside	Single small piece with projection 13 mm long	Straight-sided. Fingernail impressions on rim, finger marks outside	Irregular thickness of sides and rim				Flat-topped rim. Possible use of spatula

APPENDIX 2: THE PAINTINGS

Cueva de Cofresnedo

1. Short vertical and diagonal lines, dots.
2. Short diagonal line.
3. Dots.
4. Group of dots.
5. Dots forming diagonal line.
6. Vertical line and dots.
7. Dots.
8. Long diagonal line.
9. Diagonal, parallel and curved lines and dots.
10. Dot and larger marks.
11. Large marks and dots.
12. Group of dots.
13. Short vertical lines.
14. Series of dots making an 'L' or 'Y'.
15. Horizontal line.
16. Group of dots.
17. Vertical line and dots.
18. Vertical line.
19. Vertical lines.
20. Group of dots.
21. Group of dots.
22. Dots.
23. Group of dots.
24. Horizontal curved line and dots.
25. Vertical line and dots.
26. Diagonal lines.

Cueva de Cuatribú

1. Dots.
2. Dots forming a line.
3. Dots.
4. Dots and short vertical line.
5. Dots on stalactite.
6. Pair of dots on stal column.
7. Vertical lines on column.
8. Lines and dots on column.
9. Three lines pointing towards other vertical line.
10. Horizontal and diagonal lines, many dots.
11. Few dots on stalagmite.
12. Vertical lines and dots on stalactite.
13. Vertical lines and marks on column (badly conserved).
14. Small figure of wedge-shaped marks on stalactite.
15. Diagonal line and dots.
16. Vertical lines on calcite.
17. 'L' shaped figure.
18. Vertical line and dots on stalactite.
19. Dots making an angled figure.
20. Diagonal and other short lines.
21. Pair of parallel diagonal lines and dots.
22. Horizontal line and many dots.
23. Dots.
24. Dots on stalagmite.
25. Horizontal line.
26. Dots, horizontal and vertical lines.
27. Dots and horizontal line.
28. Pair of parallel horizontal lines and dots.
29. Dots.
30. Diagonal lines, large spot and dots.
31. Vertical line.
32. Horizontal line.
33. Dots.
34. Vertical line.
35. Dots and vertical line on stalagmite.
36. Dots.
37. Dots.
38. Vertical line.
39. Dots.
40. Dots.
41. Dots.
42. Diagonal line and dot.
43. Small lines and dots.
44. Dots.
45. Dots.
46. Vertical and diagonal lines and dot.

POSTSCRIPT Since the above article was completed we have found several objects adding to our knowledge of the period in Matienzo. These are, firstly in Cofresnedo, a flint scraper in the entrance chamber and a blue glass bead and copper ring near painting no.20. Also Juan Corrin has found a complete lower jaw and a copper or bronze nail. Found in the same alcove as molar F, this is the first time in Cofresnedo that human remains have been found with other objects. In Barandas, David Hartnup has discovered another copper strip almost identical to the one reported above and other iron objects. Barandas thus confirms even more closely the results from Cofresnedo.

CAVE SCIENCE

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TEMPERATURE OF ROCK SURFACES IN ALTAMIRA CAVE (SPAIN)

E. Villar, P.L. Fernandez, L.S. Quindos, J.R. Solana and J. Soto

Abstract

Rock surface temperatures at several points in Altamira Cave have been determined by a radiation thermometer. The origin of the temperatures in the cave has been examined and theoretical values have been deduced from equations of heat conduction through the rock. There is good agreement between theory and observation in respect of seasonal variations in temerature and their lags in the cave compared to the surface. This suggests that the temperature of the cave walls is mainly controlled by heat conduction through the rock.

INTRODUCTION

Since its discovery Altamira Cave (Spain) has attracted attention both for its profuse and beautiful Palaeolithic paintings and much research has been carried out (Breuil and Obermaier, 1935; Garcia Lorenzo et al, 1970; Cendrero et al, 1976; Somavilla et al, 1978; Villar, 1979). Nevertheless the problem of experimental determination of rock surface temperatures inside the cave and their evolution through time have not previously been studied. The rock surface temperatures may determine the air and water temperatures of the cave, which are the variables controlling the dynamic features of the ecosystem. Furthermore variations in roof temperatures together with surface moisture variations may lead to contraction and expansion of painted surfaces with resultant loosening of the surface layers and consequent risk of damage to the paintings.

In this paper measurements of rock surface temperature in different sites in the cave are presented and analyzed.

THEORETICAL CONSIDERATIONS

Rock surface temperature in the different rooms of Altamira cave may be affected fundamentally through three causes:

a) Thermal flow of heat from a terrestrial source (Geothermal heat flow)
b) Thermal flow of solar heat downwards from the land surface
c) Heat advection by water flowing through the rocks, also latent and sensible heat exchange between the walls and air flowing through the cave.

Geothermal heat flow fixes the temperature distribution in rocks at depths greater than about 40 m, which is a typical depth for the neutral level below which seasonal variations do not penetrate. At greater depths the geothermal flow alone determines the mean value of rock temperatures. The geothermal gradient is positive in relation to depth and has a mean value of $3^{o}C/100$ m (Telford, 1976).

Above the neutral level, calorific flow of solar heat leads to temperature oscillations in rock and soil around a mean value determined by the local geothermal gradient. This solar energy produces soil surface temperature oscillations following daily variations of sunshine and of air temperature, and also seasonal variations following month to month changes of air temperature and sunshine. Temperature oscillations of the exterior soil surface then give rise to the propagation of a thermal wave whose characteristics depend on the thermal conductivity and specific heat of the soil through which it propagates. If we accept that the temperature oscillation is sinusoidal then it can be shown from theory that the wave penetrates the rock at a speed

$$v = \sqrt{4 \pi D \nu}$$

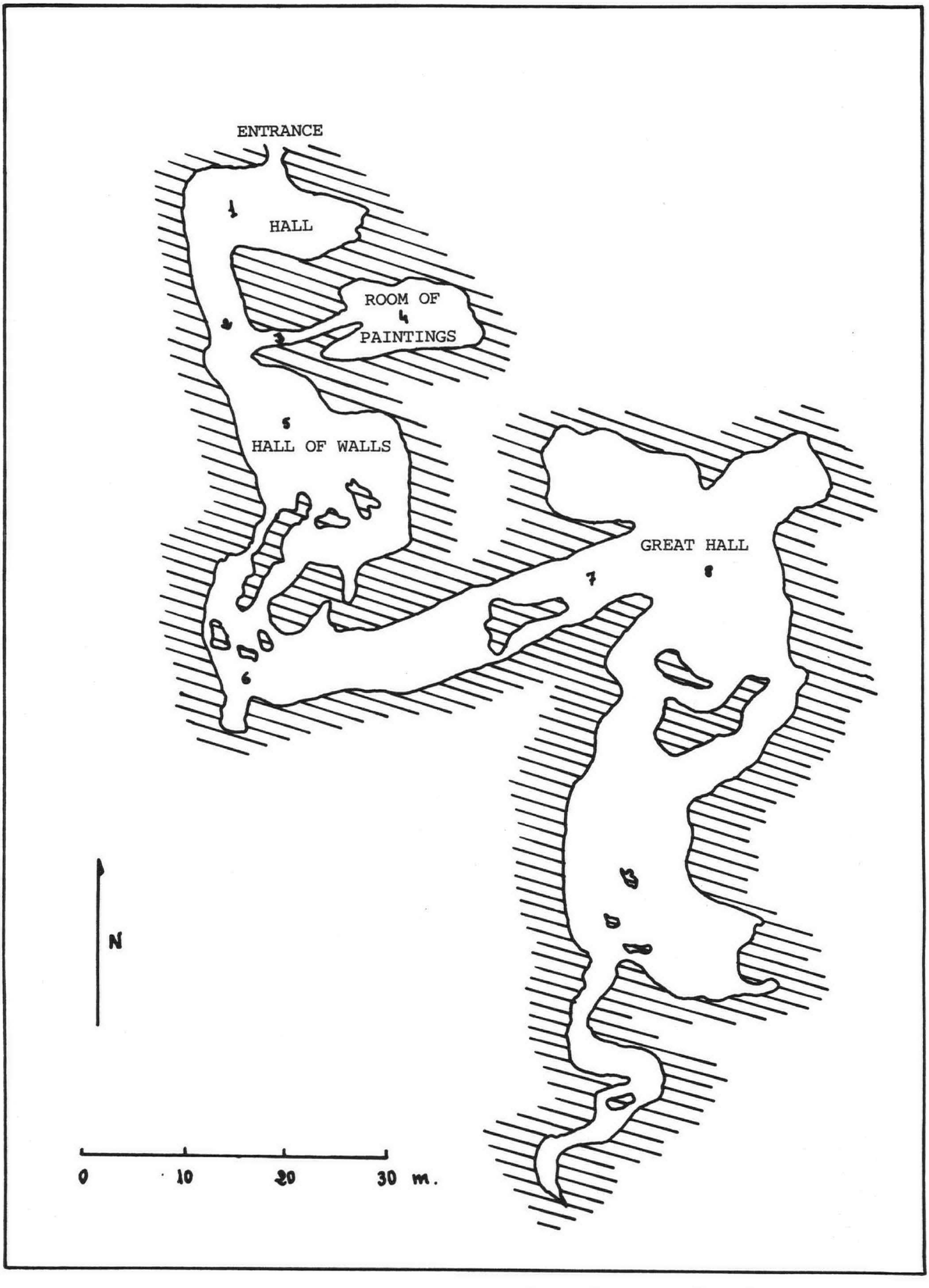

FIG. 1: Location of measurement points in Altamira Cave

with $\nu =$ the thermal oscillation frequency and D $=$ the soil thermal diffusivity (Tipler, 1976). On the other hand, the temperature oscillation amplitude in the exterior surface damps down exponentially when this thermal wave propagates downwards. If $\Delta \theta_o$ is the temperature oscillation amplitude in the soil surface, then at a depth z the thermal oscillation amplitude $\Delta \theta_z$ will be:

$$\Delta \theta_z = \Delta \theta_o \exp\{-(\pi \nu D^{-1})^{1/2} z\}$$

Note that the damping depends upon the wave frequency, so that, though the daily wave propagates at a speed 19 times faster than annual thermal wave, it is damped down more quickly and penetrates to a depth of about 2 m at most. As is pointed out in the case (c) above, caves with a single entrance, such as Altamira cave, have air flows only of convective character, and with such a low intensity that their influence has minimal effect over rock surface temperatures. On the other hand, a cave situated in a high level of the karstic zone has very weak hydrological dynamics with a minimal internal circulation and a water flow due only to direct filtration of rain-water through fissures. This fact reduces the heat advection by water flowing through the rocks contributing to a minimal effect.

EXPERIMENTAL PROCEDURE

We have carried out expermental determinations of the surface temperature of the rocks at eight points within the cave with locations as shown in Fig. 1. Measurements were made with a Barnes radiation thermometer which has a range from 0°C to 40°C and sensitivity of 0.1°C. The temperature of the overlying rock was also measured at 40 cm below the surface. In every chamber in Altamira Cave, the floor and roof are subhorizontal and temperatures are homogeneous. Twice weekly measurements were made for a period of one year from June 1980 to May 1981. This measurement frequency was decided upon after experimentally checking that daily variations of rock temperature did not occur.

RESULTS AND DISCUSSION

Figs. 2, 3, 4 and 5 show the experimental results obtained for monthly mean temperatures of the different roof and floor locations. The seasonal temperature variations of the cave surface shown in these figures correspond with external seasonal temperature changes. The thermal oscillation amplitude decreases rapidly with depth below the surface of the overlying rock, while the lag of the thermal maximum increases according to thermal wave propagation theory.

A more precise comparative study between the experimental and theoretical results was carried out. In this, the seasonal temperature variations of the different points were adjusted with a harmonical analysis of the form

$$\theta(z,t) = \theta_m(z) + \Delta\theta(z)\cos(\omega t + \varphi(z))$$

where $\theta_m(z)$, $\Delta\theta(z)$, $\varphi(z)$ represent the mean annual temperature, amplitude and lag corresponding to thermal oscillations (z) at various depths. The theoretical value of the amplitude and lag at each point were obtained by applying thermal wave propagation theory and assuming a mean diffusivity coefficient value of D= $1.1 \times 10^{-2} cm^2/s$ and taking the overlying rock surface temperature as reference.

The mean temperature and annual thermal amplitude oscillation are:

$$\theta_m(40cm) = 14.7 \pm 0.9\,°C$$

$$\Delta\theta(40cm) = 5.36 \pm 0.32\,°C$$

calculated from the experimental measurements at those depths.

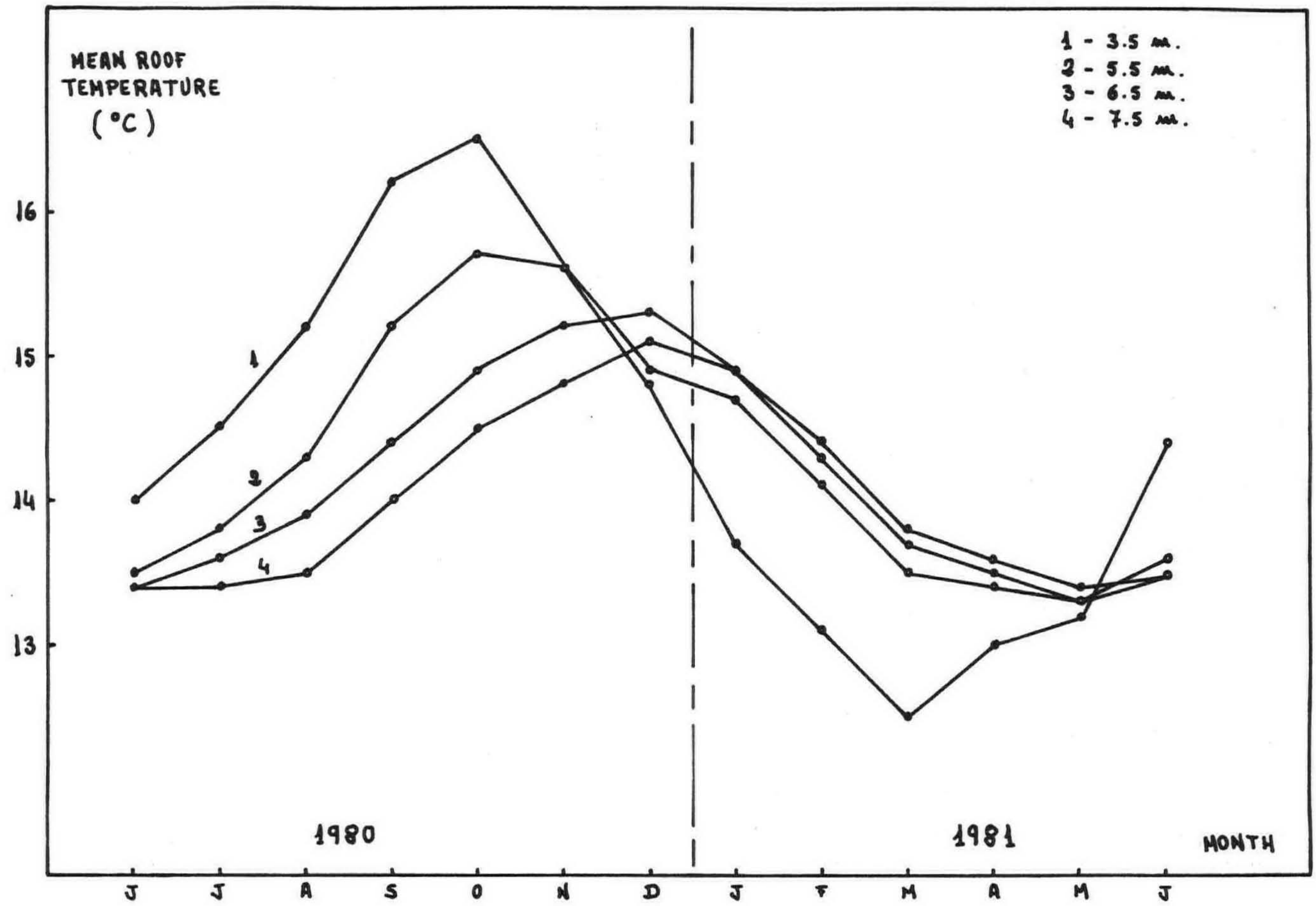

FIG. 2: Experimental monthly mean temperatures on the roofs at points 1, 2, 3 and 4

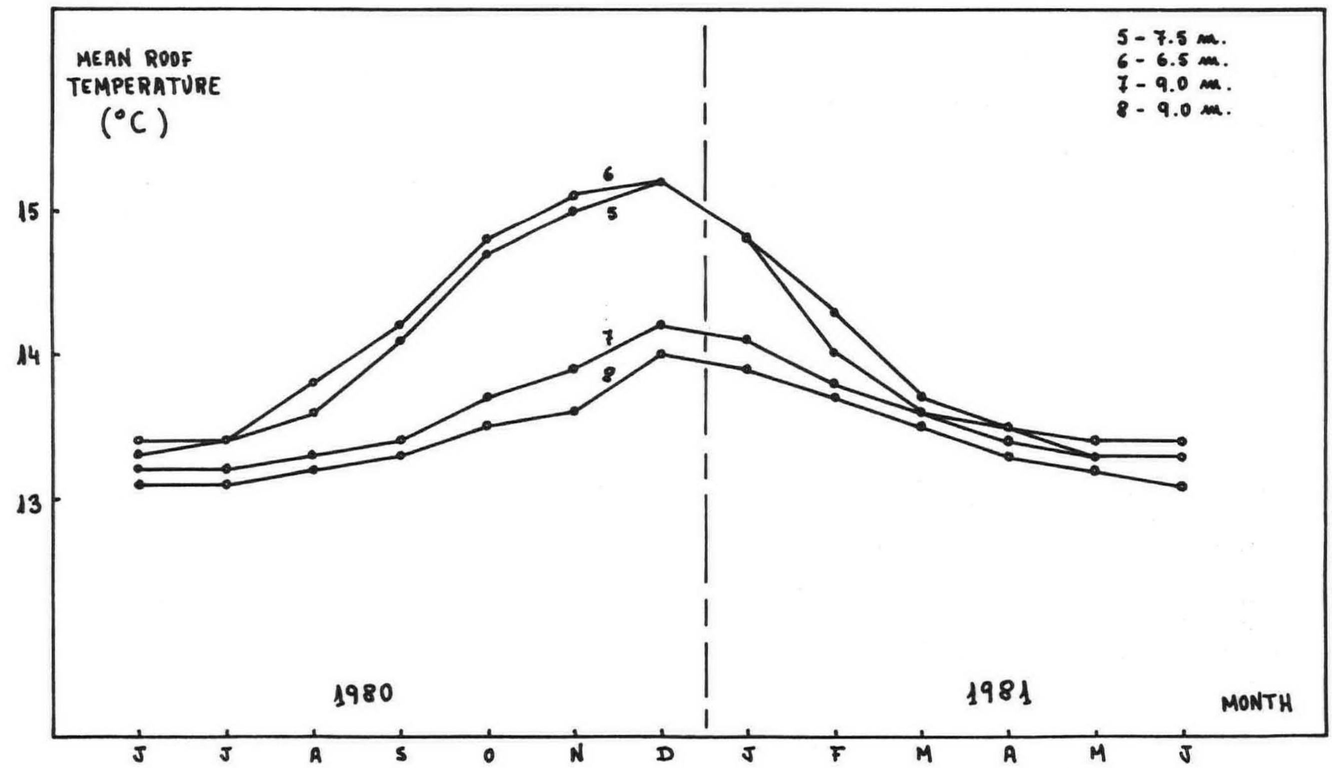

FIG. 3: Experimental monthly mean temperatures on the roofs at points 5, 6, 7 and 8.

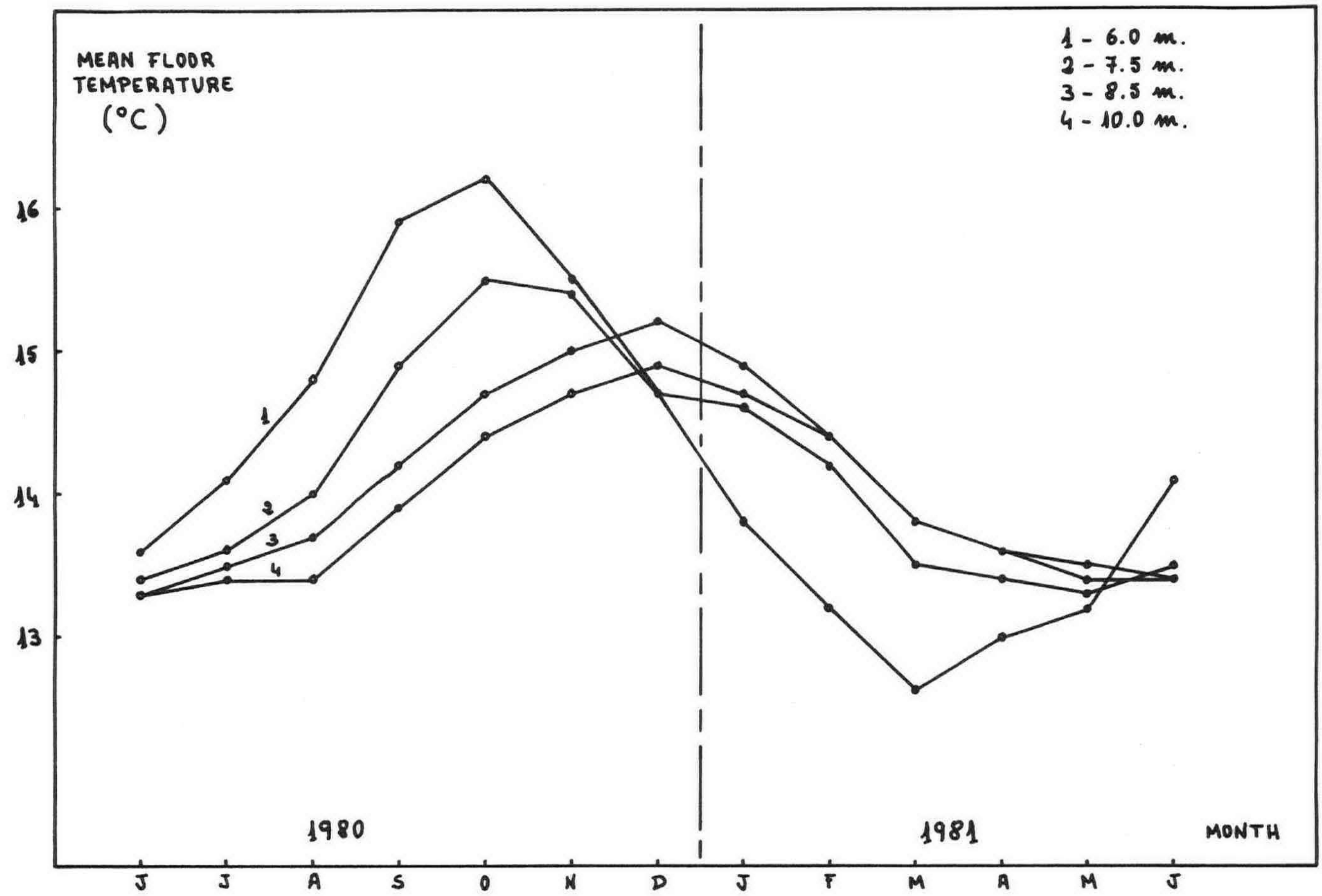

FIG. 4: Experimental monthly mean temperatures on the floors at points 1, 2, 3 and 4

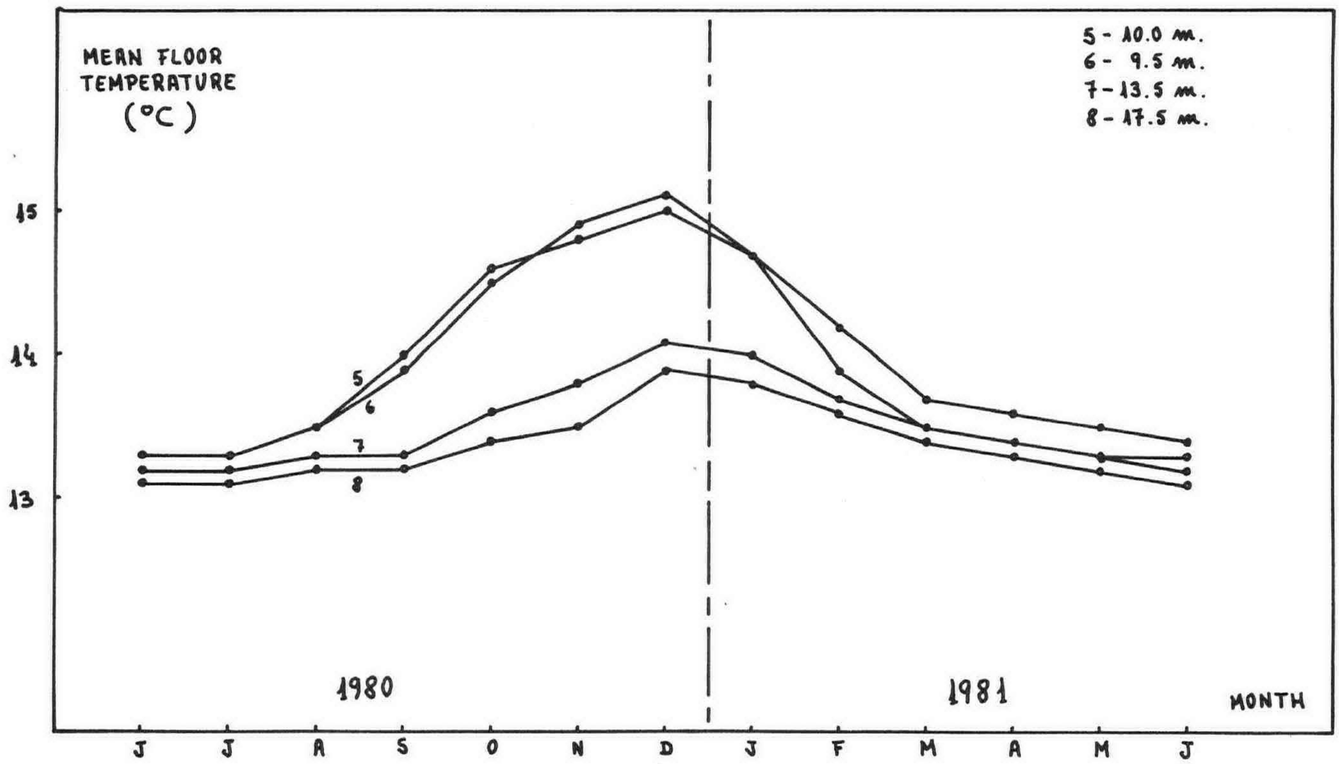

FIG. 5: Experimental monthly mean temperatures on the floors at points 5, 6, 7 and 8

TABLE I: Theoretical and experimental values of amplitude and delays of temperature oscillations on the roofs at different points in Altamira Cave.

POINT NO.	1	2	3	4	5	6	7	8
THEORETICAL DELAY (DAYS)	71±8	106±8	123±8	140±8	140±8	123±8	166±8	166±8
EXPERIMENTAL DELAY (DAYS)	69±4	107±4	127±4	147±5	139±5	130±4	165±4	168±5
THEORETICAL AMPLITUDE °C	2.10±0.30	1.16±0.16	0.86±0.12	0.64±0.09	0.64±0.09	0.86±0.12	0.41±0.06	0.41±0.06
EXPERIMENTAL AMPLITUDE °C	1.93±0.17	1.15±0.09	1.01±0.07	0.73±0.06	0.79±0.06	1.00±0.07	0.48±0.05	0.40±0.05

Table 1 gives experimental and theoretical results of amplitudes and phases of temperature oscillations of the roofs at the differents points. We found a good agreement between theory and experiment. However, this concordance does not occur for the floor of the cave. The lag between surface and cave floor temperatures is slightly bigger than in corresponding roof sites but not so large as would be expected from the depths of the floors below the surface. On the other hand, the amplitude of temperature oscillations is equal in both roofs and floors. These results may be explained by supposing that heat interchanges by radiation through the air in every chamber, which would tend to equalize roof and floor temperatures. However, the experimental data show that this temperature equalization does not occur completely and that the temperature differences between roofs and floors follow an annual variation.

In conclusion, the good correlation between the experimental and theoretical values demonstrate that in Altamira cave the temperature in the cave walls is mainly controlled by heat conduction through the rock.

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E.Villar, P.L.Fernandez, L.S.Quindos, J.R.Solana, J.Soto,
Departamento de Fisica Fundamental, Facultad de Ciencias
Universidad de Santander, Espana.

Correspondence to L.S.Quindos please.

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SANDY HOLE, ISLE OF PORTLAND

by N. Graham and P. F. Ryder

Abstract

Sandy Hole, a cave system on the Isle of Portland, was explored some years ago but has only recently been fully surveyed. The cave contains a variety of passage types showing evidence of phreatic solution, vadose downcutting and tectonic movement. Sandy Hole appears to be a section of the same fossil streamway seen in Blacknor Hole half a mile to the north. Both provide significant evidence on the Pleistocene evolution of the Isle of Portland.

LOCATION

The main entrance to the Sandy Hole System is located near the foot of the Westcliff of the Isle of Portland, c.120 ft (40 m) above sea level. The small elliptical cave entrance is situated 4 ft (1.2 m) above the actual base of the vertical cliff, here c.100 ft (30 m) high. Below the cliff is the undercliff, a steep slope partly grassed and partly boulder scree, falling to sea level.

Access to the cave is gained by following the cliff-top footpath south from the disused fort above Blacknor Hole (Portland's best known cave) to where it drops down an easy 12 ft (4 m) climb into the abandoned Sharbutt's Quarry, which is cut into the cliff top. At the foot of the climb is the small entrance into Sharbutt's Rift (an alternative and more difficult entrance into Sandy Hole) and a few yards away to the right is the larger entrance to Sharbutt's Rift 2. The footpath continues south through a small opening into the "wall" of massive blocks which encloses the quarry on the seaward side, to a second short rock-climb down onto the undercliff. A small footpath runs north from here, descending across a grassy debris cone to the obvious entrance to Sandy Hole, which lies directly below the north end of the quarry wall capping the cliff.

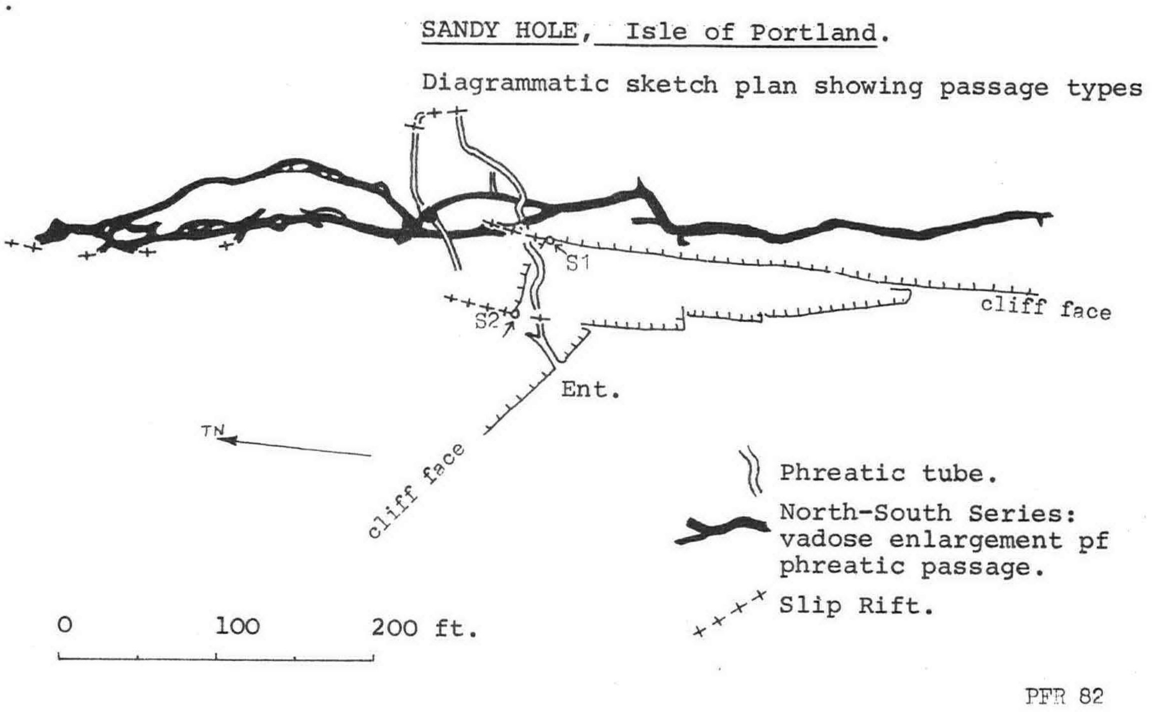
HISTORY OF EXPLORATION

Sandy Hole 'started' as a short crawl to a choke. Local Wessex Cave Club members dug here unsuccessfully, and then in November 1969 the work was resumed by two Herrison Hospital (near Dorchester) staff members who broke through into Prize Day Passage. A third member joined them, and the end of Prize Day Passage was passed into the Inkwell.

About this time various local cavers, including two Border Caving Group members, started learning of each other's existence and, in 1971, the Dorset Caving Group was formed. By this time much of Sandy Hole had been opened up by the embryo club and their colleagues. At the inaugural meeting of the DCG it was decided to commence a survey of the cave, and to make further contacts with other local cavers including Weymouth Venture Scouts and a group at Hardye's Grammar School, Dorchester, who worked alongside DCG in the explorations of Sandy Hole and Blacknor Hole.

Most Portland cave research since this date has been chronicled in the DCG Journal. Sandy Hole, as a club project, was recorded in the early journals under the generic title 'Sandy Saga continued'. Work in the cave ceased around 1972/3 with the abandonment of the Ammonite and North Passage digs, and the system has more recently been overshadowed by Blacknor Hole (MacTavish 1975). The original survey of Sandy Hole was never completed. The present survey was largely carried out when Moldywarps Speleo Group members visited Portland in August 1981, and completed by the DCG later in the year (Fig. 1). Although this work is the first in the system for several years, there is still potential for yet more chapters in the continuing Sandy saga.

Fig.1.


SANDY HOLE, Isle of Portland.
Diagrammatic sketch plan showing passage types
S1
S2
cliff face
Ent.
TN
cliff face
Phreatic tube.
North-South Series: vadose enlargement pf phreatic passage.
Slip Rift.
0
100
200 ft.
PFR 82

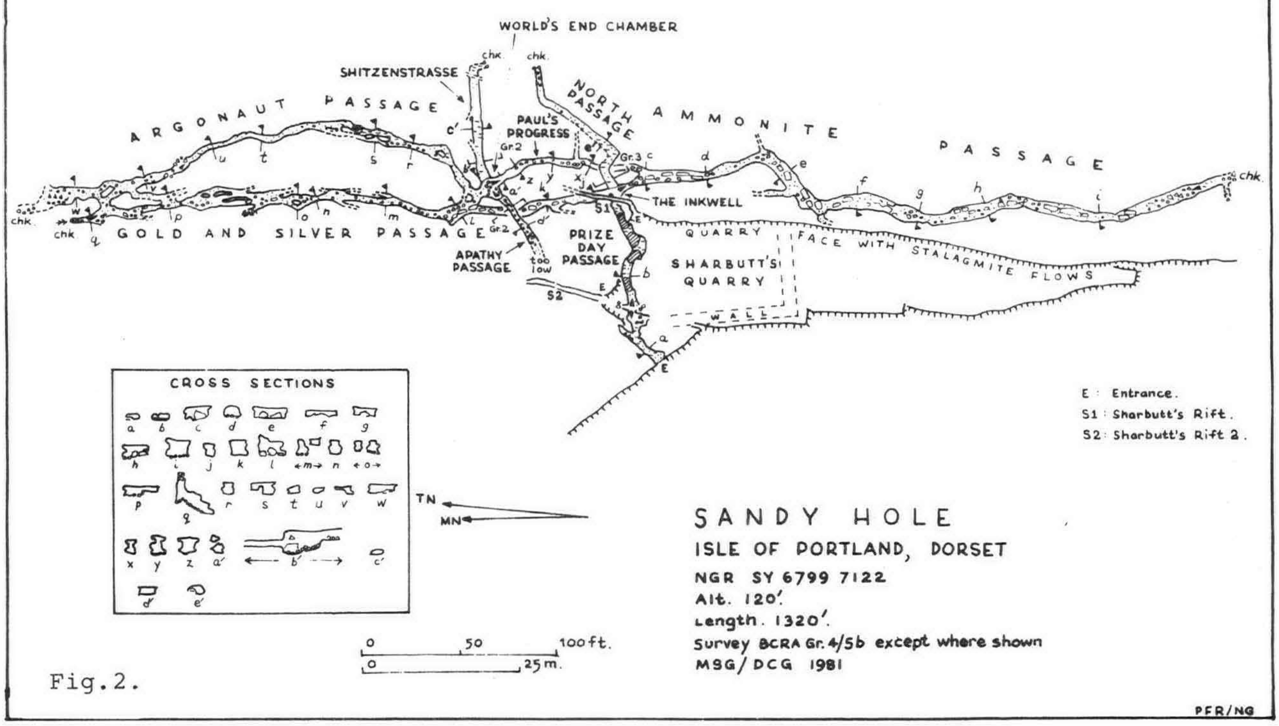

WORLD'S END CHAMBER
SHITZENSTRASSE
ARGONAUT PASSAGE
PAUL'S PROGRESS
NORTH PASSAGE
AMMONITE PASSAGE
THE INKWELL
GOLD AND SILVER PASSAGE
APATHY PASSAGE
PRIZE DAY PASSAGE
QUARRY FACE WITH STALAGMITE FLOWS
SHARBUTT'S QUARRY
WALL
CROSS SECTIONS
TN
MN
E : Entrance.
S1 : Sharbutt's Rift.
S2 : Sharbutt's Rift 2.
SANDY HOLE
ISLE OF PORTLAND, DORSET
NGR SY 6799 7122
Alt. 120'.
Length. 1320'.
Survey BCRA Gr. 4/5b except where shown
MSG/DCG 1981
0
50
100 ft.
0
25 m.
PFR/NG

Fig.2.

DESCRIPTION OF SANDY HOLE

The main entrance to the Sandy Hole system is an elliptical opening 4 ft (1.2 m) wide and 2 ft (0.6 m) wide, 4 ft (1.2 m) above the base of a vertical cliff c.90 ft (27 m) in height, below which the steeply sloping undercliff drops another 120 ft (36 m) to the sea. Immediately to the south of the cave entrance the upper part of the cliff face has been cut back by the disused Sharbutt's Quarry, its floor forming a shelf 70 ft (21 m) above cave entrance level. On the north side of the quarry are the entrances to two land-slip rift caves, Sharbutt's Rift (which provides a second, more difficult, entrance into the Sandy Hole system) and, nearer the cliff, Sharbutt's Rift II, 50 ft (15 m) long and 25 ft (8 m) deep.

The Sandy Hole cave system contains three quite distinct passage types. The greater part of the passage length is accounted for by a north-south series of passages running roughly parallel to the cliff face, and showing evidence of former vadose activity. Access to these is gained by Prize Day Passage, a phreatic tube running east-west, and a little further north another east-west tube intersects the north-south series. Sections of the third passage type, the slip rift formed by the seaward movement of large blocks of limestone, are found in several parts of the system.

Prize Day Passage / North Passage

The passage from the entrance to its intersection with the north-south series maintains relatively constant dimensions, 3 - 4 ft wide (0.9 m - 1.2 m) and c.1½ ft (0.46 m) high. A short choked branch on the left 18 ft (5.5 m) from the entrance probably connects with Apathy Passage (see below). The main tube veers right here and after a further 15 ft (4.6 m) enters an area of collapse, with an excavated hole through a calcited boulder ruckle. This ruckle marks the infill of the first of the series of land-slip rifts which intersect the cave - Sharbutt's Rift II is part of the same displacement, although there is no passable connection.

Prize Day Passage continues as a low crawl with shallow pools, until after another 'window' through calcited boulders (on the line of Sharbutt's Rift) the floor drops away to the Inkwell , 100 ft (30 m) from the entrance. Here the floor of the tube has dropped into Gold and Silver Passage, part of the north-south series. Beyond the Ink Well the tube continues as North Passage, a low crawl ending after a further 90 ft (27 m) in a choke, probably on the line of another slip rift.

Gold and Silver Passage

This is the western of the two parallel branches into which the main north-south passage divides at a junction 18 ft (5.5 m) to the south of the Ink Well. The eastern branch is the Paul's Progress/Argonaut Passage route, and the single passage continuing south from the junction is Ammonite Passage.

Descending the Ink Well and turning left (i.e. north), after 15 ft (4.6 m) a heavily calcited cross-rift cuts the passage. A tight and difficult climb here leads into Sharbutt's Rift (not surveyed). The main passage continues as a comfortable crawl 4 ft (1.2 m) high and wide, the cross section showing evidence of vadose downcutting from a small bedding passage. After a further 60 ft (18 m) one enters a section of passage showing some collapse modification, and a low bedding on the right connects with World's End chamber and Argonaut Passage. Gold and Silver Passage continues as an easy crawl with several small oxbows at roof level. After passing two side passages on the left, both infilled slip rifts running nearly parallel to the main passage, the final choke is reached where the passage bends left to end on the line of the same rift, blocked by boulders above a mound of rubble fill. 20 ft (6.1 m) before the choke is a bedding opening on the right into the further reaches of Argonaut Passage, as does a tighter crawl 35 ft (11 m) further back down the passage.

Paul's Progress / Argonaut Passage

The eastern branch of the north-south series is best described, for the sake of clarity, working northwards from the junction with Gold and Silver Passage just below the Inkwell .

The initial section of passage, Paul's Progress, shows little collapse modification, and has a cross section which clearly demonstrates vadose down-cutting from an elliptical roof tube. After 90 ft (27 m) a debris slope rises into World's End, a chamber on a rather larger scale than the Inkwell but formed in precisely the same manner, by the collapse of a section of the floor of a phreatic tube running eastwest above the main passage. It is just possible to stand up here. Passing the two side passages formed by the phreatic tube (see below), the floor drops away to a junction. On the left is the first link with Gold and Silver Passage, on the right Argonaut Passage. In general morphology this is very similar to Gold and Silver Passage, although a little smaller in cross section. A section of fairly tight crawl has to be passed before a wider bedding area is reached, where the two further connections with the far reaches of Gold and Silver Passage come in on the left. Just beyond these, passing an impressive ammonite (the usual *Titanites giganteus*) projecting from the left wall like a fossilized tractor tyre, the bedding swings left to end in a choke on the line of the same slip rift which terminates Gold and Silver Passage 30 ft (9 m) further south.

Ammonite Passage

From the Gold and Silver Passage / Paul's Progress junction, Ammonite Passage runs south for 320 ft (97 m) to its terminal choke. The passage maintains a relatively constant form, with a slightly inclined bedding roof above irregular infill of boulders. There appears to be rather more collapse modification of the initial passage form here (phreatic with vadose downcutting) than is seen further 'upstream'. Ammonite Passage is generally a roomy crawl, with one low section over fallen boulders - a route alongside the right wall is easiest here. There are a few small tubular side passages, none large enough to follow for more than a few feet.

The Northern Phreatic Tube - Side Passages from World's End.

What is probably a northern branch of the entrance tube is intersected by the Paul's Progress / Argonaut Passage route at World's End. The branch running west from World's End, Apathy Passage, is roofed by the same chert bed which forms the chamber roof, and enters c. 6 ft (1.8 m) above the floor level of the north-south passage. Apathy Passage is a crawl ending too low after only 30 ft (9 m). The tube drops 3 ft (0.9 m) in level as it crosses the chamber, the eastern branch (Shitzenstrasse) being only 3 ft (0.9 m) above floor level, and consisting of a flat out muddy crawl for 60 ft (18 m) to an impassable rift and a choke only 30 ft (9 m) from and on the same north-south line as that which terminates North Passage (the entrance tube), suggesting that the terminations of both tubes lie on the same slip rift. Shitzenstrasse shows fine fossils.

THE GEOLOGY OF PORTLAND: A SUMMARY

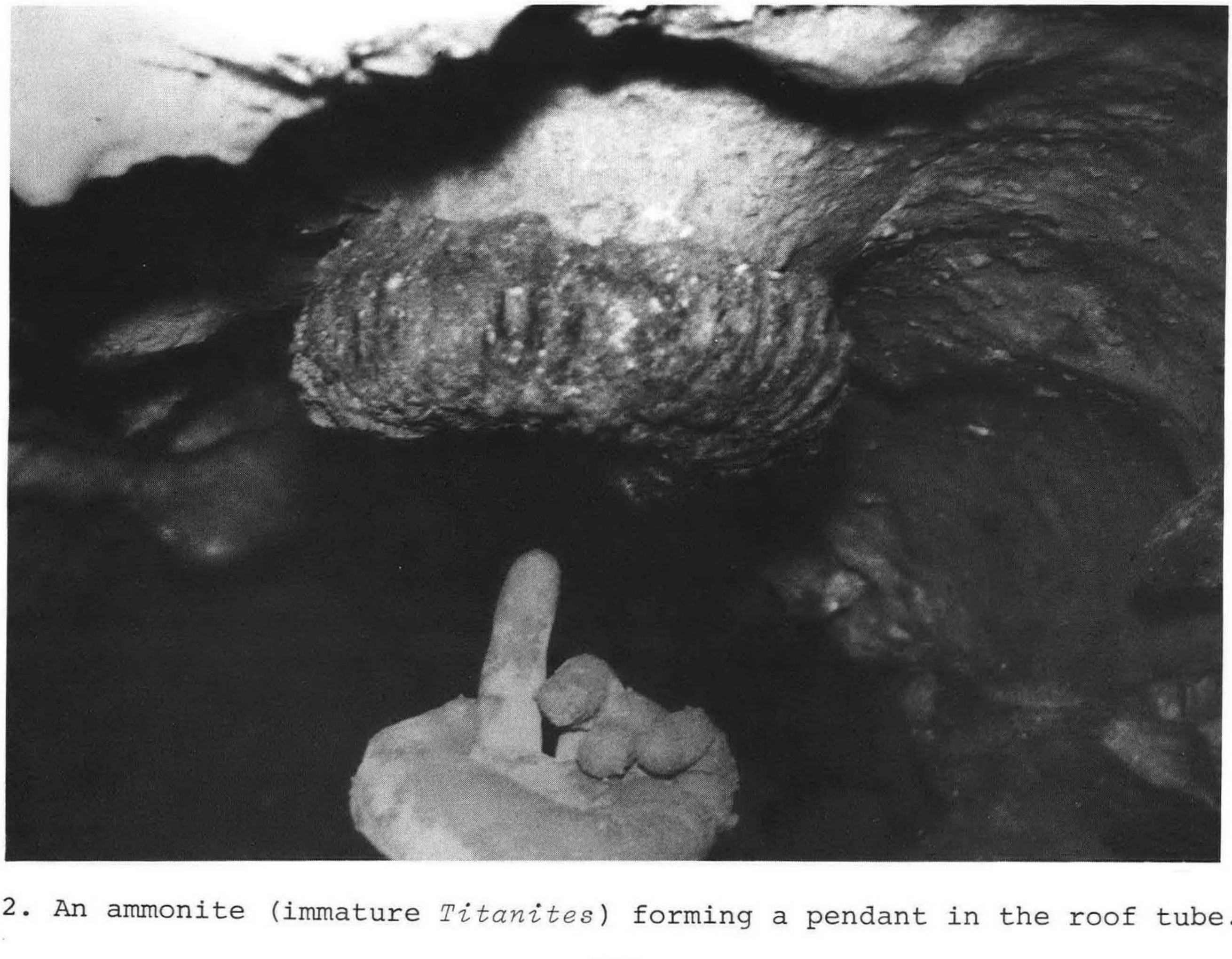
The geology and geomorphology of Portland have been outlined by Ford and Hooper (1964) and the following notes are only a brief summary.

The 'Isle' of Portland is a remnant of the southern limb of the Weymouth Anticline, a mid-Tertiary structure largely destroyed by erosion with the Isle of Portland as a residual mass on the south flank. The northern limb is steep and heavily faulted to the north of Weymouth, but the southern limb of both this fold and the related Purbeck Anticline (East Dorset) show a steady southerly dip of 1^{o}-2^{o}, with no major faults. The limestones of Portland are not faulted, but are heavily jointed, many of the joints guiding cave development.

The structure of Portland, as far as this account is concerned, is relatively straightforward. The thick Kimmeridge Clay is overlain by the marine Portlandian limestones, topped by freshwater limestones and clays of the Purbeck Group. All the strata lie conformably with few major partings between the limestones. The Purbeck Group - noted for its fossil trees - contains two thin bands of fossil soil, the Dirt Beds, the lower of which divides the Purbeck from the Portland beds. The characteristic fossil of the Portland limestone is the large ammonite *Titanites giganteus* . The Portlandian strata are of Upper Jurassic date, but the upper part of the Purbeck sequence is now regarded as of Lower Cretaceous age.

The Portland limestones comprise, from the base upwards, the Basal Shell Bed, the thick Cherty Series, the high quality 'Portland Stone' and then the sponge-like Roach, full of empty moulds of fossil shells. These limestones frequently pass from one variety to its successor with no parting: Blacknor Hole contains excellent examples of this. The Cherty Series is the thickest bed among the limestones and contains great quantities of both nodular and bedded chert. A chert band about 4 inches (0.1 m) thick has had a very important influence

1.Paul's Progress - showing roof tube and vadose downcutting.



2. An ammonite (immature *Titanites*) forming a pendant in the roof tube.

on phreatic cave development in the area.

The rift caves of Portland extend through the whole thickness of the limestones, being roofed by the clays and flaggy limestones of the lower Purbeck beds. These rifts are of tectonic origin, and the Westcliff area shows cambering at all stages from narrow fissures to fallen 'slices' of cliff.

The water-worn caves all lie in the Portlandian limestones, the Purbeck beds apparently not being favourable for cave formation, though the "Broken Beds" seen in the group at Lulworth are regarded as a massive collapse breccia due to the solutional removal of gypsum.

CAVE DEVELOPMENT

A brief general account of the caves of Portland shows Sandy Hole in perspective relationship to other caves (Ford and Hooper, 1964; Churcher et al, 1970). The phreatic and vadose systems are referred to as 'caves', the tectonic fissures as'rifts'.

The caves now accessible are either truncated by marine erosion (Sandy Hole and Blacknor Hole) or dissected by quarrying. The original relationship of most of the surviving fragments is difficult to interpret. A number of cave fragments can be entered from quarries in the central and eastern parts of Portland, but these appear to have developed separately from the Westcliff Caves - Sandy Hole and Blacknor Hole - which appear to be parts of the same system. The latter are entered through truncated passages now hanging in the Westcliff face, and extend under a large tract of quarry-free land (Fig. 3).

No traces of swallets or associated surface features are now known, although some may have been quarried away or built over. The inlets for the central area caves are also now lost. The upstream parts of Blacknor Hole and Prize Day Passage in Sandy Hole have vanished along with the land occupying what is now West Bay. The downstream limit of Blacknor Hole has been found by digging to be a junction of the two former watercourses in the system, at a point where the cave is heading south. Although much work remains to be done, this observation strengthens the theory that a vadose stream once flowed south, dropping a further 50 ft (15 m) to enter Argonaut / Gold and Silver passages in Sandy Hole. The gradient of Blacknor Hole steepens in its further reaches, suggesting that not far beyond the present terminal choke it drops rapidly (perhaps vertically). Sandy Hole's north-south series maintains the same gentle gradient throughout, conforming to the dip.

The original function of the east-west tubes in Sandy Hole is more obscure. The tubes show no vadose features, unlike the well-sculpted north-south series and are thus of phreatic origin. Prize Day Passage may have already been fossil when its floor collapsed into the underlying Gold and Silver Passage to form the Inkwell. If a stream had been flowing along the tube after the formation of the Inkwell, one would have expected to find some evidence of vadose downcutting in its floor. A distinct mark visible on the tube walls at the Inkwell and elsewhere may be a standing water line, resulting from static water perhaps backing up through the Inkwell.

The influence of the chert beds on cave development has been mentioned above. A continuous chert band high in the Cherty Series forms the roof of a considerable amount of Portland's cave passage. The limestone above can be inspected where the brittle chert has fallen away into the passage, and may be seen to be entirely free from major solutional effects. Beneath the chert, however, are very extensive areas of anastomoses, particularly well demonstrated in Blacknor Hole, where the tubes may link the roof levels of the two main passages. Such features are absent in much of Sandy Hole, developed in much purer limestone. Apathy Passage (the tube running west from World's End) is an exception, its roof being formed in a thin chert band which may be of no great areal extent.

The roof bedding of most of the north-south series in Sandy Hole is limestone to limestone, perhaps with a very thin clay parting. Roof tubes exist, but are widely scattered. Most occur towards the north (upstream) end of the cave, and others part way along Ammonite Passage. In the latter region, they are large enough to have been discrete inlets, or oxbows.

An important aspect of Portland's caves is their silt deposits. The bulk of the cave sediments are floor deposits and passage chokes, both of inwashed Tertiary material. Gingery-brown and sandy with a clay binding, these sediments seem to correspond with the massive alluvial deposits common in S.E. Dorset, though not found on the surface of Portland. The cave deposits are often stratified, the lowest horizon being rich in chert granules presumably derived

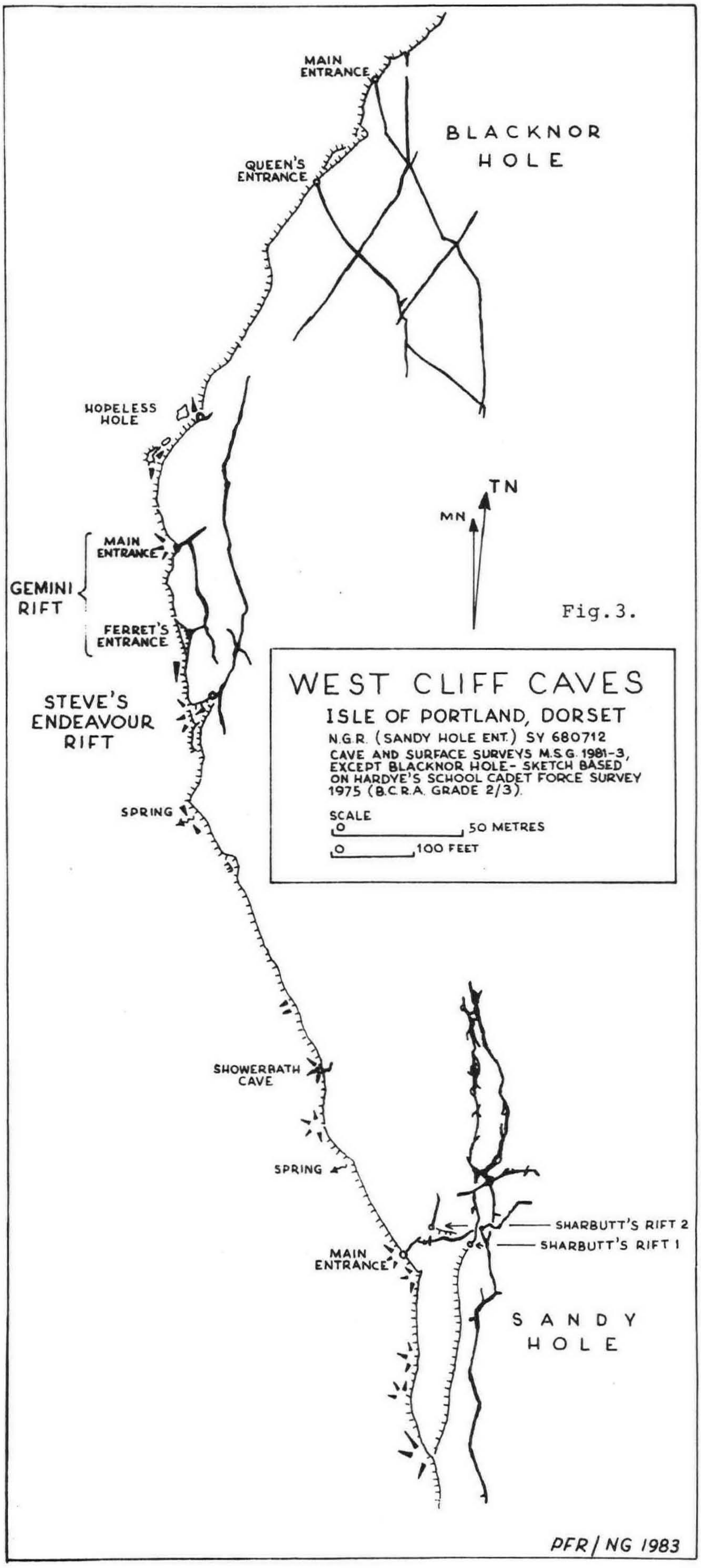

MAIN
ENTRANCE
BLACKNOR
HOLE
QUEEN'S
ENTRANCE
HOPELESS
HOLE
TN
MN
MAIN
ENTRANCE
GEMINI
RIFT
FERRET'S
ENTRANCE
STEVE'S
ENDEAVOUR
RIFT
WEST CLIFF CAVES
ISLE OF PORTLAND, DORSET
N.G.R. (SANDY HOLE ENT.) SY 680712
CAVE AND SURFACE SURVEYS M.S.G. 1981-3,
EXCEPT BLACKNOR HOLE - SKETCH BASED
ON HARDYE'S SCHOOL CADET FORCE SURVEY
1975 (B.C.R.A. GRADE 2/3).
SCALE
0 50 METRES
0 100 FEET
SPRING
SHOWERBATH
CAVE
SPRING
SHARBUTT'S RIFT 2
SHARBUTT'S RIFT 1
MAIN
ENTRANCE
SANDY
HOLE
PFR/NG 1983

Fig.3.

from the limestone itself. A fine deposit showing this patter is to be seen in World's End, in a roof cavity above the entrance to Argonaut Passage. The complete silt choke at the present limit of Ammonite Passage, coupled with the lack of similar material elsewhere except in roof cavities such as that in World's End suggests that the cave may have been filled to the roof with the deposit and then 'flushed out'. In Blacknor Hole the dig has revealed an abandoned chert-roofed passage continuing beyond the steepening downcutting of its successor: the older passage is clean, the later has a thin sediment layer on its floor. The large quantities of sediment in the caves suggest swallet feeders: it is possible that a sizeable river once occupied a valley close to the west side of the present Isle, and that the cave streams were fed from this. Fortuneswell, on the N W slopes of Portland, may lie in a valley remnant, and Weymouth is bounded by two drowned valleys. The nearest of these to Portland is now The Fleet, behind Chesil Beach, and on the south flank of the anticlinal axis.

A surface stream channel filled with similar deposits was found and quarried away in the 19th century, somewhere in the Verne area. This may have been a feeder for caves on the north of the Isle, some of which are silted.

The rifts all post-date the waterworn caves, as is obvious by inspection. Although they have been cited as solution-enlarged joints, most are of tectonic origin, joints widened by cambering. The major rifts are aligned NNE - SSW, and most occur close to the sea cliffs. There are a number of rifts close to the centre of the Isle - these may be solutionally enlarged, although there is little evidence for this. The evidence against solutional activity is the lack of fluting or similar features, and the profiles of the walls, which tend to show the 'fit features' normally associated with slip rifts. A common feature of the rifts is the constant width throughout the passage height at any given point: rifts narrow to one end, but not vertically, with the exception of the largest rifts on Westcliff where huge masses of rock are moving away by 'capsizing'.

Rift development affects some parts of Sandy Hole. Sharbutt's Rift provides a tricky top entrance, entering Gold and Silver Passage close to the Inkwell. This rift is generally of constant width. The choke in Prize Day Passage broken through in 1969 is on the line of another rift, and others are met at the end of Gold and Silver Passage. The terminal choke in Ammonite Passage beyond the silt choke dig is a boulder fall which may indicate a rift: the same applies to the end of the North Passage tube, a choke which draughts outwards when strong east winds are blowing.

Stalactite formations are fairly uncommon on Portland, Sandy Hole being no exception. There is a stalagmite bank under the aven where Sharbutt's Rift enters the cave, and various patches of small stalactites scattered around the rest of the system, generally out of the way of blundering helmets! Unlike the attractive shades of orange, red and brown seen in formations in other Portland caves (notably Blacknor Hole), the Sandy Hole deposits are creamy white in colour.

The 'glitter' deposits responsible for the name of Gold and Silver Passage have apparently been identified as ancient pollen, but no documentation for this analysis can now be traced. A peculiar transparent colourless gel found in percolation water in Ammonite Passage (collecting in an old bucket) was recently tested and found to be non-calcareous and inorganic. Its identity and source have yet to be established; it may have come from the surface, an open meadow 90 ft (27 m) above the cave.

The origin of the Portland caves was considered by Ford and Hooper (1964) to be either tectonic or phreatic. No vadose features were recognised then. A series of phases of solution, firstly of the aragonitic fossils in the Roach Bed followed, secondly, by a series of phases related to a progressively falling water-table were suggested as having been largely completed by early Pleistocene times, when the Isle was separated from the mainland by the erosion of the Weymouth lowland (Sparks, 1952). The recognition herein of vadose trenching into the floor of phreatic tubes throws new light on the sequence of events and a more extended sequence is now presented.

Although initiated in the Eocene the Weymouth anticline is mainly of Miocene age, say 10 million years old; at that time of upfolding the Portland-Purbeck strata were covered by a large part of the Cretaceous and Lower Tertiary strata, probably totalling between 1000 and 1500 metres in thickness. These have been subsequently removed by erosion from the crest of the anticline but are still preserved in the complementary syncline to the north of Purbeck. It can thus be deduced that, at some stage in the late Tertiary, the Purbeck-Portland rocks became exposed in the crestal regions, so that a hydrological regime could be established with sufficient head to initiate flow (probably very slow) developing phreatic tubes and widening tectonic fissures by solution. At that time the water-table must have been above the altitude of the summit of Portland, i.e. at over 150 m O.D. As erosion progressed the breach in the crest of the anticline was widened and circumdenudation of the southern flank of the anticline commenced. A hypothetical Solent River, with its headstreams in the Weymouth area, was proposed by Reid (1902) and the concept has recently been supported by Jones (1980, p.92), Small (1980, p.66) and by Melville & Freshney (1982). Drainage into this hypothetical valley system could have been partly subterranean, through the Portland Limestones, and, once the water-table had fallen far enough, vadose trenching could commence in the caves. Drainage into the Solent river system would have been northwards whereas the caves show evidence of southward flow, presumably into the proto-Channel lying to the south of the Solent system. Finally, breaching of the southern flank of the anticline isolated Portland, leaving the caves with no catchment for influent streams, and as sea level fell they were progressively drained.

Establishing a Pleistocene chronology for the above sequence of events has so far proved impossible. Sparks (1952) thought that the Isle had been separated from the mainland by the time of the 430 ft platform in the late Pliocene or early Pleistocene. Following Reid's (1902) concept of the Solent River, Melville & Freshney (1982) tentatively suggested that the hypothetical river system was "disrupted" by the Hoxnian interglacial, in the Middle Pleistocene, but they think that there may have been more than one phase of dismemberment and re-establishment of the river system at progressively lower altitudes as sea level rose and fell in relation to glacial and interglacial episodes. The application in the future of radio-active dating methods to speleothems and of palaeomagnetic methods to the sediments in the caves may throw some light on not only the caves' history but also that of the surrounding area.

ACKNOWLEDGMENTS

Thanks are due to the many Portland cavers who helped in this project and to Dr Ford for useful discussion of the geomorphological significance.

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M.S. Received 15th March. 1983.

N.Graham,
60 Williams Ave.,
Wyke Regis,
Weymouth, Dorset.
DT4 9BP

P.F.Ryder,
27 Melbourn Road,
Sheffield,
S10 1NR

Since the above was written Roger Cooper has published a note on "Fissures in the interior of the Isle of Portland" in the William Pengelly Cave Studies Trust Newsletter No.42, June, 1983.

APPENDIX 1.

Blacknor Hole consists of two dry passages truncated by the retreat of Westcliff; entry is by abseiling about 35 ft down the 100 ft face and swinging into the northern passage (the other is under a deep overhang). Both passages are similar in style and eventually meet in an area heavily choked by collapse in a large tectonic rift which has cut across the junction(or confluence?). Starting from the entrances both passages continue as low crawls for about 130 ft after which they both start to deepen very gradually and acquire the appearance of vadose canyons. At the junction they are 5 to 6 feet high, though the floor is now obscured by collapse and debris from the dig through the choke.

The passage cross-sections are generally rectangular with well-sculpted walls. A network of anastomoses is visible, particularly in the further reaches of the cave, where the tubes may link the two passages. The roof throughout the system is controlled by one uniform tabular chert seam about 3 - 4 inches thick. Where this has collapsed into the passage the limestone above is seen to be uneroded containing only slight spongework.

At the junction of the two stream passages, a boulder choke was dug to find the trench a apparently ending (or it may lie under the rest of the choke) at the entrance to a much smaller roof-level passage. This eventually becomes too tight, but just inside a cross-joint has been excavated to become a narrow pot linked to the main passage floor by a small tube. The walls of the pot are smooth and the outer lip has been notched as if by a small waterfall. The nature of this pot remains uncertain as its floor is choked. The main passage is thought to lie beyond the undug section of the choke, split longitudinally by its guiding joint having opened to form a large rift. This theory is reinforced by the amount of silt present.

Sediments occur throught the cave, as a shallow layer on the floors of the water-worn tunnels, with the exception of the roof-level tube in clean rock. The nature of the present terminal choke, a mass of loose rock and earth from the Dirt Beds, renders close inspection difficult, but the floor just before the pot has its share of sediments. The current belief is that much more passage lies beyond the choke, possibly dropping to a lower level and it may be the upstream continuation of Sandy Hole.

In Sandy Hole, the sediments appear to be similar to those on Blacknor, Devil's and Engineer's Holes and in solution pockets in the wall of Guano Rift (SY 703723). Material from Engineer's Hole (noted as "red clay" by Churcher et al, 1970) has been analyzed by E.D.K.Coombe (see Appendix 2). The results indicate Tertiary (?) materials including ironstone, similar to those noted in a surface channel by J.Prestwich (1874) and later quarried away. The analyses suggest the existence of at least one swallet in the northern part of the Isle. Extending this concept to land now lost to the west and north of the present cliffs , higher on the Weymouth anticline, it may be suggested that a stream once flowed south not far west of the Westcliff At least some of this water formed a swallet large enough to take some sediment underground through Blacknor Hole and possibly in to Sandy Hole.

Reference: Prestwich, J. 1874. Notes on the phenomena of the Quaternary period in the Isle of Portland and around Weymouth. *Quart Journal Geol. Soc. London.* vol. 31.

APPENDIX 2

CAVE SEDIMENT SAMPLES FROM ENGINEER'S HOLE analyzed by E.D.K.Coombe for his thesis "Some aspects of coastal landslips and cliff falls at Portland", B.A.thesis, Worcester College, University of Oxford. Table V:

Comparison of deposits found in a relict water-course on Portland by J. Prestwich (1874) and those found by the Dorset Caving Group in Engineer's Hole

Prestwich's description	Origin?	D.C.G. Samples A,B,C & D treated and sieved by E.Coombe. Present in :-
Small round flint pebbles	Tertiary	A, B, C, D
Rolled and subangular pieces of irontsone grit	Tertiary	A, B, C, D
Imperfectly rounded ditto	Tertiary	A
Small angular fragments of flint	Chalk	A, B, C, D
Well-rounded chert pebbles	Upper Greensand	A, C
Subangular chert fragments	Upper Greensand	A, B, C, D
Quartz pebbles	Old gravel?	A

Summary of ignition tests on cave samples % weight loss:

Sample A	not tested
Sample B	5.79
Sample C	2.49
Sample D	5.69

Fossil soil samples from Silklake Quarry (SY 6974 7163):

Sample X	6.71
Sample Y	11.88

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