WESSEX
CAVE
CLUB

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MEETS

FRIDAY NIGHT CLUB

Friday July 13th	GB
Friday July 27th	Swildons II
Friday September 7th	Swildons Shatter Passage

All meets at 7.30 p.m.

NEWS

Wookey Hole Caves has been sold to Tussaud's for £400,000.

FROM THE LOG

7th March 1973 NINE BARROWS

Rich and Dave Gordon. After a couple of bangs at the inlet in the new extension we got through into about 20ft of tight passage. We were hoping for a cross rift which might enable us to bypass the terminal choke, but no luck. The only alternative now is to attack the end choke which will mean a lot of extremely hard work.

15th March 1973 SWILDONS HOLE

Dave and Rich Gordon and Pete Moody. Abandon Hope. After taking a couple of pictures of the mud formations discovered on the 3rd we made a thorough examination of the new passage. The left hand passage chokes and doesn't look very good. The passage straight on is choked solidly to the roof and is fed by a trickle of water which makes digging fairly hopeless. The right hand passage is choked to within a few inches of the roof but digging is easy although the position is rather cramped. After about an hour we exited muddily.

10th March 1973 NANTYNWEL COLLIERY

Ian Jepson, Mike Thompson, Rich West, Phil Davies, Mike Hart, Tim Reynolds, Bob Pyke, Mike D.-York and John Jones at Wyndham Western Pit at Nantynwel. Descended 340yd shaft easy way (by lift), explored various passages one over a mile long. Excellent draughts! Various unexplored passages running off. Rummaged around amongst roof supports (chocks) and saw some coal. Rapid exit made as pubs were open. Whole system unsafe as roof and walls had to be supported. Definitely dodgy. Good transport service. Guides provided and hot or cold showers after trip. Unfortunately no smoking.

J. Jones

17th March 1973 RHINO RIFT

Alan Mills, B.W. and R.R. Object to climb traverse on first pitch. This was climbed from the first ledge by Alan free. Rope was laid across and left in cave. R.R. came across followed by B.W. Passage was 35ft long, now named "Satanic Walk". Aven above was 100ft plus. There are no passages opposite.

"Satanic"

24th March 1973 SWILDONS HOLE

Jeff Yeadon and Pete Moody. Desolation Row. We took a crowbar to the Desperation Extension to attack the hole in the floor found on 28/12/72. Unfortunately more rocks had slipped since the last visit and we were unable to clear them. A section of 5ft of passage is very unstable and digging boulders out from beneath is rather dodgy. We went on to the final choke and dug for about an hour but it remains very hard work. Removed the ladders from the big pitch on the way out leaving a rope as a hand line. Thanks to the BEC who lent us a ladder for the pitch.

P.M.

25th March 1973 SWILDONS HOLE

Pete Moody and Rich Gordon to North West Stream Passage to have a look at the end of Heaven and Hell Passage. We then went up to the extension in Abandon Hope and dug at the dig on the right of the mud formations. After an hours digging we broke through into a bedding plane that descended steeply into the main passage again. The passage continues for about 70ft then chokes.

21st and 28th March 1973 (Wednesdays) NINE BARROWS

Rich and Dave Gordon now attacking terminal choke in the extension. With very little water going down the cave the choke looks quite diggable if only you had enough room to dig, so at the moment we are enlarging the passage.

1st April 1973 SWILDONS HOLE

If you want to escape from civilisation don’t go down Swildons. Intended to do a photographic trip. Got as far as the Well. 20 people coming up. Went back to Long Dry Way met two parties. 5 people going down 8ft drop. Arrived at 20ft. 30 people waiting to go down. 2 parties coming up. Frustrated returned. Unable to photograph in main streamway due to a thick fog.

J. Jones.

1st April 1973 SWILDONS HOLE

D. & R. Gordon and I. Jepson to Abandon Hope. Flash in camera failed, so did not photograph mud formations. These wont last much longer so any photographers wishing to perform, please do so! Spent some time at the end working in what looks to be a fairly long term dig, the which, on account of the quality of its clay is hereby named "Good Stuff Dig". Buckets and an entrenching tool (head in situ) are required. Total length of new passage from "Pickford's Luck Squeeze" from old Abandon Hope to end is approx l60ft. The final section is about 70ft. Quite big 6ft high and 6-10ft wide and very reminiscent of parts of Vicarage Passage. Anyone visiting please be careful of mud formations after flat out crawl, about 40ft from "Pickford's Luck". 5½ hrs.

8th April 1973 SWILDONS HOLE

Graham, Tessa (UBSS) and Pete Moody. Down to 4 by Paradise Regained then on to 9. Inspected last bang in Thrutch Tube (Feb 72)! It had done a good deal of damage and we were able to get on another 20ft (previously accessible to midgets). After a bit of trouble with the bang wire we banged the next constriction. Out via Troubles.

P.M.

11th April 1973 NINE BARROWS

Recent attempts to enlarge the terminal choke with plaster have been rather ineffective. We have therefore commenced digging out the floor. The dig is downhill and wet, spoil having to be moved well back up the passage.

Gordons 1, 2 and 3.

14th April 1973 SWILDONS HOLE

Pat Cronin (?) and Pete Moody. A trip to Desolation Row was abandoned when Pat had trouble with his sinuses in Sump 6. We had a look at the bang effects in Thrutch Tube. The way on was open and after a short dig a few feet further on we entered a further ten feet of new passage. At the end the passage became very tight and neither of us felt like pushing it. The passage opens out again beyond the squeeze and there is a good draught. Its muddier than the Abandon Hope extensions!

P.M.

15th April 1973 GB
Dave and Pete Gordon. Oral connection made with surface from top of Gorge, after climbing a knee-deep mud river.

14th April 1973 SWILDONS HOLE

Dook and Pete Moody had a good look at St. Pauls Oxbow and then on to Abandon Hope. Stream has invaded "Good Stuff Dig" which is flooded to a depth of about 6". No Good Dig?

20th April 1973 SWILDONS HOLE

Jepson, R & D Gordon to Good Stuff Dig to be joined later by P. Andrews and P. Moody who had previously visited Vicarage Passage. Bailed out dig and reconstructed drainage channel which had been trampled in on a previous trip by one of the Gordons. No forward progress, but spent some time and much effort enlarging working space. Split one bucket, so replacement now needed. 5 hrs.

21st April 1973 SWILDONS HOLE

Julian Penge, R. Gordon and Pete Moody. Three hours of very efficient digging done in left hand branch of Fault Passage in Swildons 4. The dig is looking quite promising although a lot more work will have to be done.

28th April 1973 SWILDONS HOLE

Bob Craig, R. Gordon P. Moody. We continued the dig commenced on the 21st but we soon had problems when a large boulder began to be exposed. It was eventually released from the choke but as it weighed several hundredweight we could not get it out the hole. We managed to continue the dig but we were only able to rabbit. Still looks very promising. The hole is now about 10ft deep.

P M

2nd May (Wednesday) SWILDONS HOLE

Tessa, Tony Boycott (both UBSS) and Pete Moody. Enthusiasm for banging in 9 and a Figure 8 trip waned in Thrutch Tube. Tony's zip broke completely and with the fact that there seemed nowhere in particular to bang together with the prospect of forcing oneself back up the passage, which is similar to a very tight Blue Pencil filled with Abandon Hope type mud, if there was a misfire we decided not to bang. On the way out we put a small charge on the boulder at the bottom of the Swildons 4 dig but with the luck we had on this trip it probably failed to split the boulder but succeed in bringing down the sides of the dig. The pool at the bottom of the dig had dried up.

P.M.

EXPOSURE UNDERGROUND

Editors note.

The following paper, by Dr. J.C. Frankland of Red Rose Pothole Club, is printed by kind permission of the author.

The National Scout Caving Centre, Whernside Manor, Dent, in conjunction with the British Association of Caving Instructors held a National Cave Rescue Training Course from 18th to 23rd May last at which venue this paper was read. The course director was Harry Long of the Upper Wharfedale Fell Rescue Association.

Hypothermia and its Relevance to Cave Exploration

Hypothermia or 'exposure' describes a fall in body temperature occurring when a negative heat balance develops in the body. Appreciation of the factors affecting this balance and of the problems attached to preventing and treating hypothermic states is a neglected aspect of first aid training and indeed of the training of doctors.

Hypothermia exists as a medical problem more than is widely realised, infants and the elderly being particularly vulnerable. In wartime it claimed many lives especially amongst the ship wrecked. In our own sphere of interest - caving particularly when supervising novices - it can be ignored only at our peril and is an ever present risk when cavers are immobilised through injury.

The temperature of the blood perfusing the vital central organs of heart, lungs and brain is maintained at 98.4^{0}F or 37°C ('normal' body temperature) by a refined series of mechanisms which conserve or allow loss of heat depending on whether body temperature is below or in excess of environmental temperature. Body metabolism, whether basal (ie. at rest) or when raised by exercise, produces heat and in the normal situation a considerable energy loss as heat occurs from the body. In a cold environment heat loss is mainly by convection and the degree of this is dependent on the insulation provided by clothing. The efficiency of this varies tremendously with moisture and is considerably reduced after immersion.

The insulation afforded by clothing can be assessed quantitively and is measured in aptly-named Clo units*. For the average man in a cold environment (air temperature 0°C) the following figures apply (1):

- 6-7 Clo units are necessary to maintain heat balance at rest without shivering;
- 1-2 Clo should be adequate for fairly heavy work such as carrying equipment along a cave;
- 4 or more Clo will probably be needed for light work, e.g. surveying.

For most clothing insulation depends on the thickness, and usually about 4 Clo per inch can be obtained. The traditional caving garb of layers of sweaters covered by a boiler suit probably provides about 3 Clo units when dry, which is adequate for most purposes when the wearer is moderately active. When wet this will be considerably reduced, possibly to well below 0.5 Clo units (2). With a neoprene wet-suit the insulation level - about 2.5 Clo will not fall after a wetting. The value of neoprene suits in wet caves is too obvious to need expressing scientifically; the ULSA team trapped down Lancliffe Pot for almost two days would almost certainly not have survived without them.

* Insulation, I, is calculated as (Ts – Ta) divided by H, where Ts and Ta are the mean skin and ambient temperatures (°C) and H is the non-evaporative heat loss from the body surface in Kcal/sq. Metre/hour. 1 Clo unit = 0.18 I and corresponds to the insulation afforded by ordinary business clothing.

The body's defence against heat loss is purposeful. The first reaction is a shut down of circulation to the skin, the external muscles and the limbs so that the perfusion of these with warm blood and consequent heat loss is minimised. The aim of this is to maintain the central or ‘core’ temperature - the temperature of the blood flowing through the vital organs. However, as the core temperature falls, deterioration progresses and drowsiness leads to coma and, possibly within less than one hour, death.

An individual's adaptation to cold can vary with his experience of a cold environment, this acclimatisation being well shown in parties living in Arctic regions who find the second winter much more tolerable than the first. One consequence of this is that the cave leader must not expect novices to have his own tolerance to cold and discomfort.

If total heat loss is balanced by body heat production all is well. However, the moment that the total heat loss exceeds body heat production problems begin and deterioration starts. This may be the moment the badly dressed caver leaves the surface or gets his inadequate clothing damp. From this moment hypothermia begins to develop and it is only a matter of time before its sequalae cause problems, the most disturbing of which may be the death of the patient. This sounds dramatic, but it is a necessary concept to understand in appreciating the problems of heat loss.

Obviously body heat production is very variable, depending on the degree of exertion undergone, but the cave leader must appreciate that the timid novice proceeding gingerly through a strange environment and not dashing about to ladder and lifeline pitches and carry equipment may well be producing only a fraction of his own heat energy. In consequence he is much more prone to hypothermia. When long waits for pitches are involved it is very easy for unsuspected deterioration to set in and the leader must watch his charges for this. All we experienced cavers clad safely in neoprene have known what a colourful character in my own club describes as "the bloody shaking shivers", when our energy output falls whilst waiting our turn to climb a pitch.

Fit young adults can work for some time at oxygen consumption four or five times basal (resting) values; this is up to 70% of maximum breathing capacity. Energy expenditures of this order are sufficient to prevent a fall in core temperature in wet cold conditions with mean skin temperatures as low as 20° C (3). However, groups of young people are not always well matched physically, so that less fit persons become exhausted and are unable to maintain their energy output, after which a progressive and unremitting fall in temperature occurs. With exhaustion, muscle glycogen stores become depleted and the deterioration is accelerated.

However, to be practical, how does one recognise exposure and what does one do about it? Its onset is insidious and difficult to detect unless one maintains a high degree of vigilance. The early picture is just the cold, shivering and rather inert individual, who may be less cheerful than usual and who may be returned to full normality (and full thermostatic equilibrium) by only a few minutes of strenuous exertion. Further symptoms are initially vague and can include fatigue, pallor, inertia, shivering, feeling cold, lethargy and cramps, these progressing to unreasonable behaviour, violent trembling attacks, confusion, slurring of speech, muscular weakness, lack of co-ordination, inability to walk, delirium, sleepiness and finally a state of coma and death. The sequence and progression of these features can be rapid. Individuals developing exposure can at times be awkward, aggressive, and truculent and even display short bursts of extreme, irrational and undirected activity. A smell of ketones or acetone becomes detectable on the breath. Cave leaders should be aware of the significance of these behavioural patterns. One final word of warning: if signs of hypothermia develop in one member of the party, be on the lookout for its occurrence in others.

Who is at risk? Basically everyone, but particularly the inadequately dressed, thinner, younger, least experienced and most apprehensive members of the party, i.e. the novices above all. Other factors which can never be ignored are hunger, exhaustion, recent illness and - caving being a pastime for men rather than boys - last night's beer! In flood times, when a soaking is more likely and especially when the melt water from thaws flows off the fells, be particularly wary. After an accident, the casualty is in great danger from exposure. When immobilized through injury heat production is minimized and, unless the patient is insulated, dry and rapidly rescued, hypothermia is inevitable and can never be ignored by cave rescue personnel.

What does one do if this condition develops underground? Obviously the action depends on the severity of the problem. The first and most obvious reaction is to force exercise on the patient and make him rewarm himself by this means. In the mild case this will be correct, desirable and adequate but in the serious case this decision would be profoundly and totally wrong, leading to a fatal deterioration. How does one distinguish between opposite courses of action?

The lower limit of rectal temperature compatible with continued exercise is believed to be 34 - 35° C (4). With core temperature below this, a state exists where further exercise is harmful as it necessitates opening up the circulation to muscles in the limbs. This causes cooled blood in the extremities to be returned to the core, reducing the vital core temperature and also allowing further heat loss from the body surface.

Very interesting, but what do I do underground when the lad is cold and shivering and I do not have a low-reading thermometer to shove up his rectum?

The leader has a difficult decision to take - whether to attempt to force the patient to move out of the cave under his own steam, thereby perhaps worsening his hypothermia and adding the further dangerous insult of exhaustion, or whether to delay his removal until a rescue team arrives with stretchers and blankets, which may take several hours.

The decision must rest on the leader's appraisal of the patient and his circumstances but the writer suggests the following principles for general guidance.

If you feel it is reasonable, try to get the patient to move out of the system under his own steam. Watch him closely when doing this and protect him meticulously by lifelining on even minor hazards. If the effort appears too much, or if he is deteriorating, be prepared to reverse this decision.

Wring out very wet top clothing and put on extra clothing from fitter and fatter members of the party. If he has no wet suit, putting him into one will provide extra insulation, but fit this over existing clothing to avoid chilling him further by complete undressing. Rubbing the limbs, contrary to traditional first aid teaching, has no value and is a waste of time. Reassure and encourage the patient and feed him with any nourishment (especially hot and sweet) available but give no alcohol or amphetamine-type stimulants under any circumstances, as this will further enfeeble him by expanding blood vessels near the skin and allowing more heat loss. One wonders how many people have been killed by the alpine St. Bernard's dog's brandy!

If he has been immobilised for any length of time through injury or being trapped, be cautious about his fitness to move under his own steam. His injuries may prevent this in some cases, of course.

In mountain rescue circles it is becoming well recognised that the best chances of survival when severe hypothermia supervenes is by taking shelter (5, 6) and that once final collapse has occurred the situation is extremely dangerous (4, 7).

The best guide as to whether to encourage a cold patient to move is, in the writer's opinion, probably his level of consciousness. If the patient's speech and thoughts become impaired, giving confusion or a degree of delirium, or if he has impairment of muscle function so that simple actions like movement along a cave passage become laboured and uncoordinated, then it is unwise to force exertion on him.

To summarize; if he is not too exhausted to maintain a high level of activity for long enough to warm him up then exercise him; if he is too exhausted to do this or if his general condition suggests a core temperature of below 35° C then rest and insulate him; if in doubt underground then exercise him but watch him carefully and be prepared to reverse this decision. If other than a mild case of exposure in an accessible spot develops, an early Cave Rescue Organisation call-out is mandatory - don't wait for obvious deterioration. Medical aid should be sought.

If he is not able to move out of the system the following measures are suggested, aimed at providing insulation for the patient and thereby allowing him to warm up from his own continuing body heat production.

Make him rest in the driest most sheltered spot available. Sit him in a fully curled up position with thighs to chest and calves to backs of thighs; this technique can reduce body surface available for heat loss by approximately 30%>. Put on extra clothing as mentioned above, including a wet-suit if not worn. Try to insulate the head and hands. Feed him as described above. Insulate him by having several members of the party lie with direct body-to-body contact with him; this can provide a surprising degree of heat. Further spare clothing or a bed of rope is better than sitting on cold rock. A pit dug from sand or shale can provide protection from draughts. If a polythene survival bag or a space blanket is available, wrap him in this (the space blanket should be foil inwards). Theoretically wrapping him in this with a warmer colleague would be optimal; the temperature inside a bag can be slightly raised by the expired air of the patient and/or companions.

Generally, space blankets have received an unfair press in caving circles. Undoubtedly they are less efficient than neoprene exposure bags but have the tremendous advantage of being as compact as a packet of cigarettes and can therefore be carried on all trips. One reads that first aid kits should be carried on all caving trips (especially with novices) and I would rank them as infinitely more useful than the bandages and elastoplast of first aid kits.

These measures may seem pathetically inadequate but the lowest documented case of survival from hypothermia, where the patient had a rectal temperature of 18° C (64° F) responded merely to treatment with dry insulation and no extraneous heating (8).

With such measures the patient may well improve sufficiently to allow further attempts to get out of the system and warm up by his own exertions. Nevertheless, a cave rescue call should certainly be mounted so that extra help, further insulation and a stretcher are available.

What else can be done underground when the full resources of a rescue team are available? The rescue team’s arrival undoubtedly boosts the morale of the patient. The neoprene exposure bag, sleeping bag and dry clothing now available should be used to provide extra insulation. At this stage the problem arises as to whether -to strip a cold, wet caver underground to put him into an exposure bag or whether to put him in wet as he is and avoid the initial further chilling. The decision must be an individual one. In practice the clothing nearest the body will have reached skin temperature anyway and its removal may only cause further heat loss. If the way out is wet it must be unwise to remove a wet suit. Normally one would remove wet outer garments and then add extra garments, a wet suit if not worn and place the casualty in a neoprene bag. May I plead for a space blanket to be put round him <u>inside</u> the neoprene bag? May I also plead for insulation of the head to become routine on cave rescues, using a neoprene divers' hood? The head contributes 9% of the body surface area, equal to the front of the trunk, and no-one would dream of evacuating a casualty with the chest and abdomen bare, unless it was a team of doubtful moral standards rescuing a film star!

Apart from supplying warm drinks and food (but not to drowsy or unconscious patients please, as you may be pouring it straight into the lungs (7) this is at present all that can be done for hypothermia patients underground. Obviously the next priority is to get them out and quick!

Recently a technique has been described which may allow active central re-warming of hypothermic patients on the spot. Dr. E. Lloyd in Edinburgh has designed apparatus whereby warmed oxygen at up to 60° C can be administered to patients (9). Because of the enormous blood flow the lungs have an excellent capacity to take up heat and this is delivered immediately to the most vital area - the heart. The potential value of this technique for accidental hypothermia is exciting, for the apparatus is small enough to be carried to the patient even underground. We are in the process of constructing this apparatus in the Cave Rescue Organisation. It is theoretically beneficial for the very cold patient in the later stages of hypothermia to be carried slightly head down so that gravity aids the essential circulation to the brain. This is feasible within reason in carrying such a patient on the surface, but, in the writer's opinion, not an issue worth serious consideration in underground rescue as has been suggested. Underground patients have to be manipulated as the terrain allows and hauling a patient up pitches in other than the vertical head-up position carries many additional hazards.

Let us now consider the patient's arrival at the surface. Further rewarming can be done in one of two contrasting ways:-

a) slowly, by providing only dry and adequate insulation with no external heat; or
b) rapidly, by immersion in warm water, the temperature of this being maintained as it is cooled by the patient.

In (a) the heat generated by the patient's metabolism rewarms his body if heat loss is prevented. It is slow (possibly up to 48 hours) but safer for infants and the elderly and has been effective on a patient as cold as 18° C (64° F) (8).

Rewarming by immersion, (b), has become established as the method of choice in young healthy adults who do not have injuries making it inadvisable. However, it is not without hazards if badly supervised, for the following reasons. An inadequate supply of heat to the body surface will merely open up the circulation in the extremities where cold blood is pooled. This cold blood will return to the core causing a fall in core temperature. This 'after drop' in body temperature during rewarming is a real hazard and in the war many survivors from shipwrecks were lost during treatment. It was first beautifully documented by Dr. James Currie of Liverpool in 1798; he immersed conscious human volunteers (his servants!) in water 9 - 10° C and observed the continuing fall in rectal temperature after removal from cold water. Because of the 'after drop' risk the technique of immersion rewarming demands rapid heating using adequate volumes of hot water. This can supply sufficient heat to the whole body surface and ensure that the pooled blood shut off in the muscles is rewarmed as fast as it is returned to the core.

The technique is as follows: After quickly removing outer clothing (underclothing may be removed underwater) the victim is immersed to the neck in a bath of approximately 40 gallons of hot water at 45° C (112° F). A thermometer should be used to check the bath water temperature but if one is not available, use the hottest water in which an immersed elbow can be <u>kept</u>. Beware of the patient splashing violently when first immersed. With cold patients approaching loss of consciousness this can be quite dramatic, convulsion-like states developing briefly. These are helped by keeping the head fairly low, i.e. as near the water surface as is compatible with safety. Try to keep the patient immersed to the neck throughout the rewarming period. Maintain the bath water temperature at 43° to 45° C (108 - 112° F) by the continuing addition of further hot water and stir the water around the patient; this topping up to maintain bath water temperature is most important. Remove the patient from the bath when he begins to sweat visibly on the face, indicating that his body temperature has returned to normal, then keep the patient in dry clothes in a warm room until his temperature has stabilized.

This technique should be used on all hypothermia victims whenever practical. If any exposure situation develops or any underground accident occurs then rescue leaders should obtain facilities for this method of treatment at the nearest house in case it is necessary.

Don Robinson of the Upper Wharfedale Fell Rescue Association has told me of experiments he has done using himself as a 'victim' and pouring hot water directly into the sump-rescue neoprene exposure bag which most teams now possess. These surround the victims head and body, have a watertight seal around the face and have no sleeves. With hot water obtained by heating two milk churns, each half full, over a large bonfire a dramatic rise in body temperature was obtained. Although I believe this technique has not been used in earnest, I would commend it for the desperate situation where a severely hypothermic patient, in extremis, is brought out of a cave and the nearest bath is a long distance away.

To assess the level of hypothermia a subnormal or low-reading thermometer down to 75° F is essential and all rescue teams should have one available. Ideally it should be used in the rectum but obvious difficulties prevent this being done underground. The Cave Rescue Organisation has just purchased an electronic thermistor thermometer where a rectal or skin probe can be strapped in position and readings taken at intervals. At a core temperature of 35° C patients feel detached and disorientated. At 34° C there is a reluctance to communicate and loss of memory. Below 33° C irregularities of the heart develop and the patient becomes semi-conscious., By 30° C the patient is unconscious, the pupils dilated, respiration depressed and the pulse very slow and weak and at this stage many victims can be abandoned as dead (10).

It is worth digressing on how one defines and decides the point of death in hypothermic states. Experienced forensic pathologists have erroneously pronounced death in hypothermic patients who are alive and well today, much to the delight of the newspapers. The definition of death in hypothermia must be that of ‘failure to revive’ after all rescusitatory measures including rewarming, artificial ventilation of the lungs and cardiac massage. (10, 11, 12). Diagnosis of death from exposure at the site of the tragedy is often not satisfactory and Scottish mountain rescue and Service personnel are advocating immediate removal of such patients to hospital by helicopter if necessary. (11, 12).

In caving we have further difficulties in that hypothermic patients may be in very inaccessible situations and cannot be immediately resuscitated but I think it worth stressing that resuscitation on the surface should not be abandoned because the patient looks dead. Certainly medical aid should be sought.

By now the reader may be forgiven for being apprehensive to the point of panic regarding hypothermia but it must be realised that it is a common experience for all who deal with cave, mountain and fell rescue. Fortunately most cases are mild and recover promptly with simple measures but deaths do occur, some being perhaps preventable deaths as distinct from the unpredictable hazards such as falls, rock falls and equipment failures.

It is certainly the responsibility of all who take novices caving to be aware of the problem and competent to handle the situation when hypothermia develops. The aim of this article is to encourage the interest of such people in this topic.

Dr. John C. Frankland,

Red Rose Cave & Pothole Club.

REFERENCES

1.	Williams, R.M.	Manual of Caving Techniques, p.293 (Routledge & Kegan Paul, London 1949).
2.	Pugh, L.G. C.	Nature, 209, 1281, 1966. 'Clothing insulation and accidental hypothermia in youth!
3.	Pugh, L.G.C.	Brit.Med. J. 2, 333, 1967. 'Cold stress and muscular exercise, with special reference to accidental hypothermia'.
4.	Freeman, J. and Pugh, L.G.C.	Internat. Amaesthesiol. Clinics. 7, 997, 1969 'Hypothermia in mountain accidents'.
5.	Cooper, K.E. et al	Internat. Anaesthesiol. Clinics. 2, 999, 1964. 'Accidental Hypothermia'.
6.	Mountain Rescue Committee	Mountain Rescue and Cave Rescue Handbook, 1968-69 (M.R.C., 9 Milldale Avenue, Temple Meads, Buxton).
7.	Lloyd, O.C.	Bristol Medico Churgical J. 79, 291, 1964, 'Cavers dying of cold'.
8.	Laufmann, H.	J. Amer. Med. Assoc. 147, 1201, 1951 'Profound accidental hypothermia'.
9.	Lloyd, E.L1. et al	Scot. Med. J. 17, 83, 1972 'Accidental hypothermia: an apparatus for central rewarming as a first aid measure'.
10.	Golden, F. St. C.	Brit. Med. J. 3, 344, 1972 'Immersion Hypothermia'.
11.	Lloyd, E. LI.	Lancet, 2, 1367, 1971 'Treatment after exposure to cold'.
12.	Hillman, H. and Leathert, G.L.	Lancet, 2, 1257, 1971 'Treatment after exposure to cold'.

"HAZARDS OF COLD WATER"

Summary of the Paul Esser Memorial Lecture,
delivered on 14th February, 1973
in the University of Bristol by

Professor W.R. Keatinge

Some of the most exciting sports are the dangerous ones, but the risk becomes quite small if the hazards are understood. Of all these, water sports take the greatest toll of human life: about 1,000 deaths in a year around Great Britain, compared with about a dozen on the mountains. Death from shipwreck results more often from cold than from drowning. Old-fashioned equipment was designed to provide flotation rather than to protect from cold, but ideally both should be provided. Since the last war much research has been devoted to studying body-cooling of volunteers, measuring core temperature by electric thermometers. These give most reliable measurements when swallowed to lie just behind the heart.

Body Cooling

Thin men cool faster than fat men, because the layer of fat insulates the body core. The cold causes the blood vessels in the fat to shut down. Channel swimmers are usually fat. The usual summer sea temperature here is about 15 C. At this temperature fat men have a distinct advantage over thin. For thin men the critical water temperature at which heat balance is possible is about 20° C, for fat it is 10° C. Below these temperatures the rate of body-cooling is uncontrollable, even by shivering. The rate of body cooling can, however, be reduced. Firstly, keep still, because exercise in water (unlike air) always accelerates body-cooling, if the water is cold enough to threaten life. Secondly, keep on as much clothing as possible, as this will slow down the rate of cooling.

The same principles apply to children, who often seem to be able to tolerate cold water better than adults. This is an illusion. They cool more rapidly, both because they are usually thinner and because they have a larger surface area of skin in relation to body weight. Girls generally cool more slowly than boys, because they are fatter. In one experiment one boy cooled as much as 3.2° C in 33 minutes. All the children who looked really cold were found to have core temperatures of less than 35° C (normal is 37° C), which is a fairly serious degree of hypothermia.

Cold Vasodilatation

At temperatures near freezing point the protective shutdown of blood vessels in skin becomes reversed due to paralysis of their muscular walls. The resulting vasodilatation accelerates cooling, particularly of the hands, from which heat pours out of the body. The practical answer to this is a wet suit with gloves. Whales and seals do not get cold vasodilatation at low temperatures, and so their blubber will always protect them from heat loss.

Sudden Sinking

Professor Keatinge quoted the case of a young athlete out sailing in the winter on a reservoir, when his boat overturned. He only had 50 yards to swim to the shore, but after he had got half way he shouted that he couldn't go on and sank. Cramp may be ruled out, as he was in good training.

Study of skin reflexes to cold shows that respiration is accelerated, and air is not expelled from the chest as fully as usual. The heart accelerates, the cardiac output doubles and the blood pressure goes up. Possibly the over breathing in choppy water might cause water to be inhaled; but a more important finding was that irregularities of heart beat occurred (ectopic ventricular beats). These occurred in 10 to 15% of subjects on being immersed in cold water. After a few minutes these irregularities ease off, because the nerve endings in the skin adapt to the cold. None of these things accounted for the sudden sinking of the lad in the reservoir, so it became necessary to design an experiment under controlled conditions, which would imitate the circumstances.

A good swimmer dressed up and got into water at 4.7° C and started to swim, but within 90 seconds he sank and had to be pulled out. We were shown a film of the next swimmer repeating the experiment. First we saw him over breathing, due to the cold water on the skin. When he began swimming he was holding his head high out of the water, which is tiring. He quickly began to get exhausted and to make small mistakes. After 7½ minutes he had to stop and be pulled out. On the bank he was utterly exhausted but within 1½ minutes was talking cheerfully. "I don't know why I couldn't", he said, "I just got exhausted; I couldn’t go on".

The explanation why cold water is more exhausting than hot is very simple and has nothing to do with hypothermia. This man had no drop in core temperature. It is that cold water is stickier (more viscous) than warm; it is like trying to swim in treacle.

Practical Advice

Always wear a life jacket when sailing. If you have to abandon ship on the open sea make sure that you are fully clothed (or wear a wet suit), don't exercise yourself but keep afloat until rescued. The natural thing to do is to swim about. This is one case where the natural thing is the wrong thing to do. If you are caught in cold water without a life jacket do not swim for shore; cling to the boat until rescued if rescue is on the way.

When a subject appears to have died from hypothermia, do not despair. Plunge him if possible into a bath of water as hot as the hand can stand. This is a life-saving measure if done early. The hot bath should not be continued after a satisfactory heart beat and respiration are restored.

Alcohol taken before immersion in cold water does not noticeably accelerate heat loss and makes the ordeal more tolerable. On the other hand, if taken after two hours of exhausting exercise, it can cause a dramatic fall in blood sugar, which eliminates the ability of the body to control temperature, and so may be lethal. So if you take a hip flask up a mountain, take some sweets as well.

WATER TRACING ON MENDIP

by W.I. Stanton

Recently the Bristol Avon River Authority traced four more Mendip swallets

In East Mendip, Hale Combe Swallet and Park Corner Swallet were traced to all three Finger Springs and to Cobby Wood Spring. The Pyranine dye from Hale Combe Swallet took 6 to 7 hours to reach the springs and the Rhodamine W.T. from Park Corner Swallet took about 14 hours. It is supposed that water from these swallets also finds its way to the group of boreholes at Oldford, near Frome, and this will be tested later in the year when the Finger and Cobby Wood Springs dry up.

In Central Mendip, Rookery Farm Swallet was traced to Wookey Hole in 102 hours, and Attborough Swallet to Cheddar Risings in 120 hours. Rhodamine W.T. was used in both cases, and the springs sampled were Wookey Hole, Rodney Stoke, Cheddar, Sherborne, Chewton Mendip, and a borehole at Pullin's Dairy between Chewton Mendip and Litton. The fact that these swallets on the north side of the Mendip plateau drain to springs on the south side recalls the way that the main dry valleys on the plateau debouch on the south flank, and in fact the underground drainage systems of Cheddar and Wookey Hole stretch even further to the north than the dry valley systems of Cheddar and Ebbor. It would not be surprising if the little streams in Lamb Leer were proved to feed Cheddar.

Pyranine dye put into Bowery Corner Swallet was not recovered at any of the springs tested during the 8-day sampling period. Tim Atkinson failed to spore-trace this swallet some years ago, and a future test will have to sample the more obscure risings like Rowpits and Honeyhurst Borehole.

An error crept into the note on water tracing in the last Journal. Finger Slocker, not Finger Farm Swallet, was the one traced to Finger and Cobby Wood Springs. Dye was put into Finger Farm Swallet but was not recovered.

LETTERS TO THE EDITOR

Dear Richard,

While I think of it, I would like to criticise Willie Stanton on his nomenclature both in the last article, and in several previous surveying notes. He writes of using an ‘Oil Filled’ compass. However the standard Ex - Army prismatic which he uses is in fact filled with Alcohol - Isopropanol to be precise. The more usual term is ‘Liquid filled’ although I agree that Oil Filled may not be strictly incorrect since the terms Oil, Fat, etc have a much wider meaning than common usage would suggest; nevertheless, I suggest that 'Oil' in this context is misleading.

Best Wishes,

Peter Cousins.

THE GEOMORPHOLOGY OF AGEN ALLWEDD

1. The Local Scenery

Agen Allwedd is a cave of some 13 miles extent and over 500 ft vertical range, entered by a relatively insignificant vadose passage (Ogof Gam.) at an altitude of 1180 ft. This entrance is perched about half-way up an enormous limestone scarp which falls from the plateau above, (Mynydd Llangattwg, Alt. 1640 ft O.D.) to a stream below at around 850 ft O.D. This stream drains to the river Usk at Crickhowell (225 ft O.D.) No significant drainage now enters the cave from the scarp face, all the streams inside the cave apparently coming directly through from the plateau.

Around the Agen Allwedd entrance the scarp faces North-East, and the limestones dip gently South/South-West from here under the South Wales coalfield. Typically for a North-East facing scarp there is a small cirque not far beyond the cave entrance with a peat 'lake' below (Waen Ddu). The outlet from this is dammed by one of two small moraines in the valley below, the lower of which was apparently breached early this century - it is shown retaining a small lake on early geological survey maps. The scarp face itself is covered in typical frost-weathered scree with limestone bluffs protruding. The bluffs incidentally provide the only habitat for the Lesser Whitebeam shrubs which were instrumental in the whole area becoming a Nature Reserve - caves are of lesser importance.

The Mynydd Llangattwg plateau is partly peat covered and often boggy. It is bounded on the North and East by the scarp slopes, and on the South by the towns of Brynmawr and Beaufort at the northern end of the coalfields. To the West, Mynydd Llangattwg merges with Mynydd Llangynidr - the practical boundary being the B4560 Beaufort/Blaen Onneu/Llangynidr road. The plateau, which is said to form part of the 'High Plateau' observable over most of Wales, is effectively unbroken until the Taf Fechan valley is reached 8 miles west of Llangattock quarries. This 'High Plateau' apparently formed under sub-aerial conditions during the Miocene period.

There are swallets on the plateau; Waen Rudd, at the head of the gully leading up from Agen Allwedd, is an impressive 80ft deep shakehole with a poorly developed catchment. Similar large-isolated shakeholes occur by the Beaufort; Llangynidr road (e.g. Pwll Coch.) but the water entering these has not been traced to the cave. In the centre of the plateau an unnamed peaty depression against low bluffs takes a dependable stream which is known to feed Cascade passage. A third known swallet - Crochan Sion-Hopkin - lies off the plateau and receives drainage off the north slope. The plateau is liberally studded with shakeholes around its edge, but the majority of these are normally dry.

Some two miles south of the cave the river Clydach - a small tributary of the Usk - has cut a deep gorge back towards Brynmawr which is now also the route of the Head of the Valleys road (A465) between Gilwern and Brynmawr. It is below this road that the cave waters at present resurge, welling up in the middle of the river Clydach at 690 ft O.D.

2. The Geology of the Area

The limestones in which Agen Allwedd has formed are known as the Oolite Group and occur near the base of the Carboniferous sequence, immediately above the Lower Limestone Shales which themselves rest on the Basal Conglomerate overlying the Devonian Old Red Sandstones. Above the Oolite Group are other similar beds followed by the Seminula Limestones and a capping of Millstone Grit through which the plateau shakeholes are developed. As a result of two unconformities and the Namurian overstep the Seminula is not well developed.

The cave resurges where the river Clydach runs across the lowest beds of the Oolite Group, known locally as the Pwll y Cwm Oolite. Curiously the Clydach has cut a 30 ft deep gorge in this oolite only 150 ft downstream of the resurgence, just beneath the aptly named Devils Bridge. The Pwll y Cwm Oolite is part of a group of beds some of which are highly dolomitised. At one point in the sequence two beds, separated by 3ft, of calcite rhombs in a marl matrix occur - the marker beds; these can be traced right across the mountain. Very little geological prospecting has been done within the cave system, although the early explorers did notice that the 'marker beds' often form the roof of the system. The floor of much of the active streamways appears to follow a bed of rock which is; a) soft and crumbly, b) coloured rusty brown, c) perhaps less soluble than the limestones above it. This bed variously forms the floor of stream passages or has been incised by up to 4 ft. Does it correspond with the 'rusty weathering, sugary dolomite' described by T.N. George? It certainly is not good mountain limestone! Apart from this the dolomitised beds have not yet been clearly identified within the cave.

The most remarkable beds have been seen in the lower streamway between Fifth Choke and the Southern Stream confluence. Here a bed, perhaps 10 ft thick, outcrops at shoulder height and comprises a rock so soft that a spike can be pushed into it by hand, and it crumbles to the touch. The stream has cut from higher, solid beds right through this soft stratum into solid rock beneath. Could this soft rock type be an uncemented or 'rotten' oolite? Is it localised or does it outcrop on the surface? These are questions we cannot yet answer.

Whilst the cave is entered down dip, and the first streams met (Main Stream, and Southern Stream) continue this trend; the innermost areas of the active system are based on the strike-trending Turkey Passage which falls at an average 1 in 40 for some miles from the Remembrance series upstream to Easter passage beyond the downstream sump. Inevitably very few tributaries enter from the south of this passage since they would have to flow up dip! Only Cascade passage is known and this falls almost vertically from the plateau 600 ft above.

Just below Third Choke a short climb above the stream gives access to what appears to be a fault running parallel to the streamway. The throw has not yet been determined, but appears to be at least 8 ft. This may be part of the 65 yard fault well known in the coalfield further south. Possibly the cascade sink is on the same fault line though this has not been mapped as a fault. The Crochan Sion-Hopkin sink is on a mapped fault, again in the same general line as the 65 yard system. Thus apart from Waen Rudd all currently known swallet feeders may have developed down a fault. However there are several other underground feeders for which no surface sink is known.

3. The Llangattwg Cave System

We have to distinguish between two separate cave systems in Agen Allwedd. The older, now dry, passages of Main Chamber, Summertime etc, and the nearby cave Eglwys Faen; and the active streamways we see today. The latter are vadose passages which have cut down by 30-40 ft throughout the system after initiating near the marker beds. Originally there were sumps (phreatic loops?) in the streamway - Turkey Pool, Deep Water etc - but most of these have been breached, although Deep Water certainly still sumps in flood.

The fossil system is a network of very large, phreatic passages now predominantly filled with sterile silt. The system appears to be a series of inlets from the cliff face, all but one of which are now blocked by boulder chokes and scree outside. The exception - if such it be - is Eglwys Faen, and this is blocked beyond the second chamber by what appears to be a fault. These large passages could well have developed as a sequence of captures -1, Eglwys Faen; 2, Main Passage; 3, Summertime; 4, Sand Caverns. However there are some large gaps in the postulated network underground, and no indication of where all the water went.

There are several other caves in the area of which only Eglwys Faen appears to relate directly to Aggie. Daren Cilau, in the recently worked quarry 1 mile east of Ogof Gam has a large shattered passage running back towards the quarry face. This is in the same beds, and probably comparable to the fossil passages in Agen Allwedd. A similar passage fragment can be seen at Blaen Onneu, but this is in Seminula limestone, about 100 ft higher than the Agen Allwedd system and therefore unlikely to connect - although its formation will eventually have to be explained.

4. The Ice Age in South Wales

Any discussion of the spelaeogenesis of Agen Allwedd will inevitably be punctuated by reference to glaciers and the Ice Age since, unlike the Mendip region, South Wales was heavily glaciated. In spite of intensive study, the details of British glaciations are still rather sketchy and surrounded with conflicting opinions., However it is now becoming agreed that during only three of the six Pleistocene cold periods was Britain extensively glaciated. Unfortunately a multitude of names have previously been used for these glaciations. The Geological Society has now recommended that the thirteen periods into which the Pleistocene has been divided shall be named after localities in East Anglia in which typical deposits can be found. The last eight of these, together with some of the names used previously, and in Europe, are tabulated below. The Pleistocene started about 1.8 - 2.0 million years ago, and the dates in the table refer to about the middle of the respective periods.

CLIMATIC PERIODS IN THE MIDDLE AND LATE PLEISTOCENE

Climate	British Name(s)	NW European Name	Alpine Name	Time B,,P.
WARM	Flandrian	-	- Since -10,000 yrs.	
GLACIAL	Devensian (Smestow)	Weichselian	Wurm	25,000
WARM	Ipswichian	Eemian	-	105,000
GLACIAL	Wolstonian (Gipping)	Saalian	Riss	140,000
WARM	Hoxnian	Holstein	-	195,000
GLACIAL	Anglian (Lowestoft)	Elster	Mindel	275,000
WARM	Cromerian	-	-	325,000
COLD	Beestonian	-	Gunz	425,000 ?

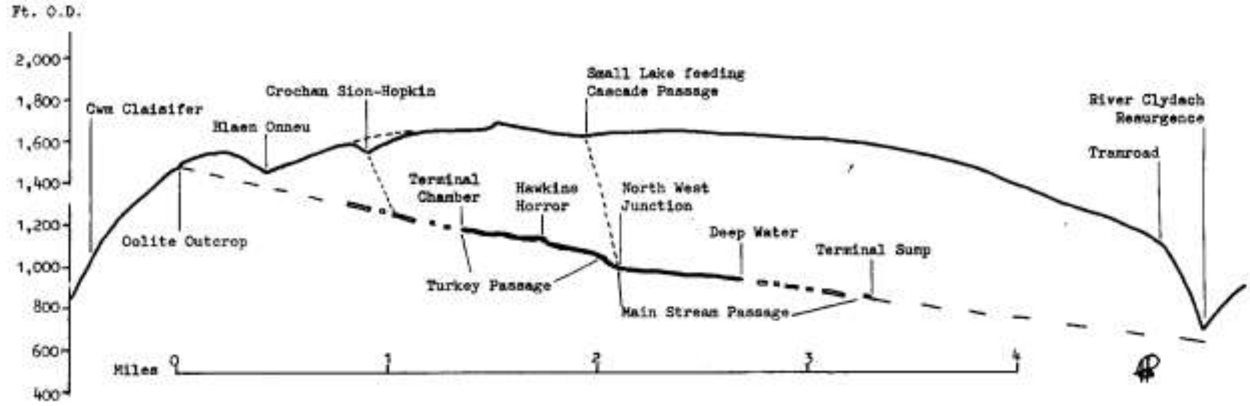
Whilst the two earlier glaciations (Anglian and Wolstonian) are believed to have been of similar severity, and to have covered all Wales; the last glaciation (Devensian) was much smaller, and left some valleys of S. Wales untouched. This is a critical point in appreciating the chronology of Llangattwg caves. There was a major glaciation in the Usk valley, during the Devensian, but this appears to have stopped near Abergavenny - 5 miles beyond Llangattock - where there is a large moraine,, Although the glacier is believed to have been 1,000 ft deep upstream of Crickhowell, it seems unlikely to have affected the Llangattwg scarp. Presumably the Waen Ddu cirque dates from this period, as do many corries in Snowdonia.

Whether the cave system was active throughout this last glaciation, or whether it partially silted up, is an open question. However in the prevailing periglacial conditions stream flow would only have occurred during the summer, probably with a much higher silt content (due to solifluxion and lack of vegetation) so partial blockage at least seems likely.

The earlier glaciations are believed to have completely covered Mynydd Llangattwg although evidence on the plateau (e.g. striated boulders) has largely disappeared. At least one active cave system (in Canada) is known which underlies a glacier, and takes a substantial flow of summer meltwater.

It is therefore conceivable that during either or both the Anglian and Wolstonian glaciations Agen Allwedd carried meltwater streams. In fact the infilling of the fossil passages very probably took place towards the end of the Wolstonian, but no dateable material has yet been retrieved.

SECTION - NW/SE across MYNYDD LLANGATTWG (showing part of Agen Allwedd)



5. Formation of the Active System

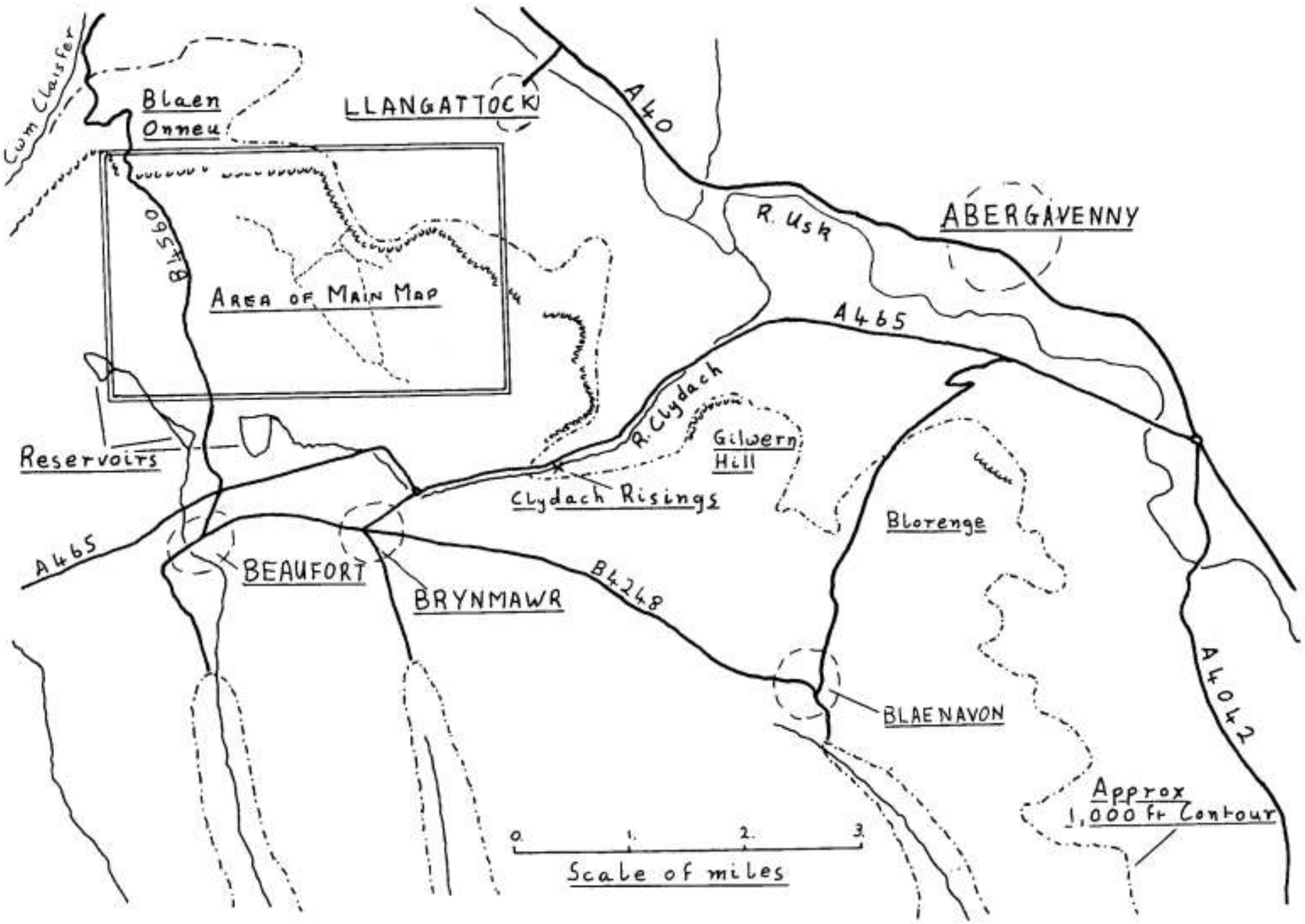
We can probably reject the present day resurgence as being an accidental capture; since the Clydach today is a young river which has eroded rapidly, cutting a deep gorge up to Brynmawr beside which the present 'Head of the Valleys' road runs. Since this gorge is undegraded, with predominantly vertical sides, it must have developed since the peri-glacial climate of the Devensian - i.e. no low level scree formation. This vigorous down cutting was probably aided by the capture of the headwaters of the Ebbw Fach stream. The cave passage appears to continue beyond the Clydach stream - some water resurges on the South Bank - so it seems unlikely that this area was the initiating resurgence for the cave.

If the general trend is continued beyond the Clydach gorge, the Avon valley is reached below Blaenavon. This valley is floored by Lower Limestone Shales at an altitude of 700 ft O.D. and therefore appears an obvious location for an earlier rising. The limestones do not apparently outcrop in any of the valleys west of the Avon, and the only other outcrops of the right altitude are around the south of Gilwern Hill and Blorenge - due east of the present resurgence. Drainage beneath the coalfield to a resurgence in the southern outcrop is ruled out in view of the shallow hydraulic gradient this implies - a distance of 20 miles!

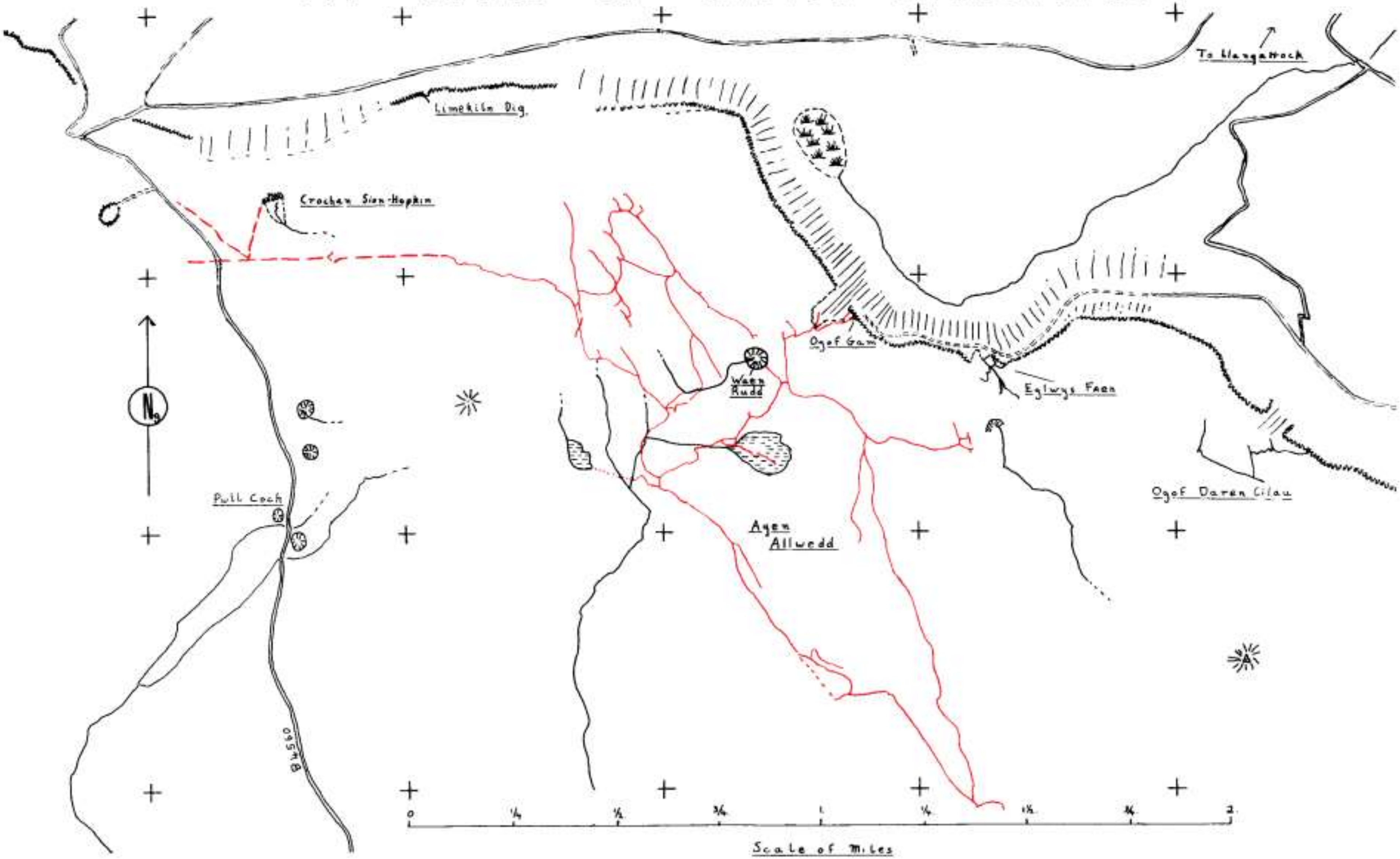
Upstream, beyond Turkey sump and into Remembrance series, the furthest known part of the cave has nearly reached Blaen Onneu; where is its source? About 1 mile further west the Claisifer valley has a small outcrop of limestone running along its east side at about 1450 ft. Since block faulting has elevated the limestone west of this valley it seems unlikely the cave ever continued further. However it is possible that more southerly passages - as yet unknown - could drain Mynydd Llangynidr.

The valley above Blaenavon, which has been postulated above as an early resurgence, was not glaciated in the Devensian period. Thus in the active system we are looking at a set of streamways which could have been, forming since Mid - Pleistocene times - after the Avon valley had been deepened by earlier glaciations. This implies a maximum age of about 120,000 years for these streamways.

South East Breconshire



THE CAVES OF MYNYDD LLANGATTWG



6. Formation of the Fossil System

The fossil system is obviously much older than the active system; but how much older? The presence of substantial breakdown in those parts of the cave near the surface (particularly the inner parts of summertime) and the scree covering the inlets themselves, confirm the idea of a pre-glacial origin. Whether these old passages could have actually formed beneath the ice during one of the earlier glaciations, is an important question. In view of the much lower CO2 content of meltwater compared to that in soil run-off today, cave development in englacial conditions has usually been discounted. There was also not a great deal of available time since the glaciations appear to have lasted about 40,000 years with meltwater flows only during the summer thaw. In spite of these comments an englacial origin for the fossil passages of Aggie, Blaen Onneu, and Daren Cilau is possible and would imply an age of either 160,000 or 300,000 years for these parts of the Llangattwg system.

If Agen Allwedd was not formed during the early glaciations, when was it formed? To find a major river flowing at 1170 ft O.D. past (i.e. over!) Llangattock, we have to go back to the Welsh 'Middle Peneplain' - 1200 ft or thereabouts, and long before the ice ages. We can envisage the ancestral Usk flowing past the Llangattwg limestones and being captured by a series of swallets. Just as the flow of the Neath in Wales, and the Manifold in Derbyshire are diverted underground today. The sterile silt which now fills Main Passage could date from the final floods of this ancient river, or from later glacial meltwaters.

When the Middle Peneplain was forming the Usk was a large river fed, by the present headwaters of the Wye, through the valley now occupied by Llangorse Lake. This stage in the denudation of Wales was apparently reached in Mid-Pliocene times - perhaps Five Million years ago.

Whichever theory of formation is adopted for the fossil system, one question which remains to be asked is "where did this large river resurge?" The answer could be found in one of the gaps in the cliff line between Daren quarries and Brynmawr, any of which could, like the scree slides, hide a large passage.

However a tantalising possibility is that the fossil cave also crossed the Clydach valley (then non-existent) to resurge south of Gilwern Hill and Blorenge. Either way a lot of cave remains to be discovered.

7. Further Reading

Brown E.H.	'The Relief and Drainage of Wales' University of Wales Press, 1960.
George T.N.	'Pre-Seminulan Main Limestone of the Avonian Series in Breconshire', Q.J.G.S. No 439, 1955, and No 444, 1956.
Jenkins D.A.	'Notes on the Geology of Agen Allwedd and Mynydd Llangattwg' British Spelaeological Assoc. Proc. No. 1. 1963.
Leitch D.	'Agen Allwedd in Relation to Mynydd Llangattwg'. Cave Research Group, Pub No 10, 1960.
Lewis C.A. (ed)	'The Glaciations of Wales and Adjoining Regions' Longmans, 1970.
Sparks B.W. and West R.G.	'The Ice Age in Britain'. Methuen, 1972.
Warwick G.T.	'Caves and the Ice Age' Cave Research Group, Trans 13 No 2, 1971.

8. Authors Footnote

I would like to thank D.P. Drew for reading this article in draft form, and I.G. Penney (Chelsea S.S.) for assistance with map reduction.

Agen Allwedd is probably the most neglected major cave in Britain today. So little research has been done in the system that the above article is in parts highly speculative. Many of the ideas presented cannot be the last word, and better theories will no-doubt take their place one day. I sincerely hope that the future will see more ideas, and a lot more WORK done on the system.

P.R. Cousins, March 1973.

NOTES ON THE GEOLOGY AND GEOMORPHOLOGY OF THE WESTBURY BONE FISSURE

Wessex Cave Club Journal 12 (147)

W.I. Stanton

1. INTRODUCTION

This account is not based upon detailed researches at the site, but upon notes taken during some 20 visits made at irregular intervals between 1969 and May 1973. It is intended as an interim account to complement preliminary notes on the archaeology by Heal (1970) and Sutcliffe (1973).

2. THE FISSURE

The "Bone Fissure" at Westbury Quarry, Westbury-sub-Mendip (ST5080 5038) (Barrington and Stanton 1972), is a deep elongated pit with subvertical sides parallel to the roughly east-southeast strike of the enclosing Carboniferous Limestone. The length is at least 70 metres, the depth approaches 30m, and the width, which is hard to determine because of the oblique angle at which the quarry face intersects the fissure, appears to vary from 5m to as much as 25m. The floor slopes down from west to east in the western half of the pit, but in the eastern half the lowest levels have always been obscured by fallen debris.

The rock walls in the lower part of the pit show original phreatic features, as does an open cave beneath the west end as did other caves at the same level, now quarried away, about 70m further south. The upper walls of the pit show only collapse features.

There is no clear sign of a structure in the limestone, such as a major fault or thrust, that controlled the development of the fissure. Heal (1970) noted a change in the angle of dip across the fissure, but this appears to have been a local phenomenon.

3. THE DEPOSITS

Where the pit is deepest a fourfold sequence of deposits is often visible, and is probably almost always present. At the base is an accumulation of well stratified clays, silts, sands and gravels of a character largely foreign to the Mendip area. This is overlain by an irregular level of course breakdown, upon which rest the bedded layers of the main bone-bearing stratum. An upper layer of coarse breakdown brings the deposit up to ground level.

a) The basal sands and gravels

These reach a thickness of at least 10m, but their base, where they presumably rest on solid rock, has not been seen clearly exposed. They are usually well stratified, with crossbedding at various scales and parallel bedding ranging down to a fine lamination in the silts and clays, and must have been deposited in water that varied from turbulent to quiet. A gentle dip to the south or southwest is sometimes apparent. The finer-grained beds are often but not always found at the top, and in one exposure about 8m thick a regular gradation was seen from gravel upwards through sand, silt and yellowish clay into the red clay associated with the overlying breakdown layer.

The deposit is non-calcareous. It is typically of a yellow ochreous colour, indicating a high iron content. Locally, iron-bearing solutions have cemented it into a hard limonitic mass, and produced pockets and encrustations of pure iron hydroxide, sometimes in the shape of hollow shells that could be replaced limestone fragments.

A bucketful of gravelly material was washed and briefly examined. The matrix is ochreous slightly micaceous brown clay and silt. Of the sand-grade component, about one third consists of quartz grains, often well rounded, and about one quarter of round polished limonite particles, varying from a concretionary oolitic structure to a limonite skin coating a pellet of ochre or ferruginous clay. The remainder of the sand consists of broken bits of stones represented in the coarser component.

The granule/pebble component is divisible into three categories based on provenance or origins i) local rock material, ii) superficial material indicating a different climate to today's, iii) exotic rock material, from rocks not now present locally.

i) The local rock material is mainly composed of chert, which occurs in large broken lumps some of which probably fell from the fissure walls. There are also a few silicified fossils, and platy pieces of thin quartz veins. All this material is insoluble residue from the local Carboniferous Limestone, and shows no signs of rounding by transport from a distance.

Small rounded pebbles and granules of vein quartz are not uncommon, and could derive from the Old Red Sandstone, as could the occasional small rounded pebbles of sandstone. Other origins are however possible, as discussed in section iii below.

ii) The superficial material consists of limonite pisoliths like those of the sand component but larger, limonite-coated pellets of clay and ochre, lumps of more or less sandy clay in all stages of impregnation by limonite and/or ochre, and fragments of limonite encrustations, slabs and nodules. Most of the fragments are well rounded by long transport. It is all of lateritic origin, indicating that the climate was humid and warmer than that of today, probably with marked wet and dry seasons. Lateritic soils are now common in humid tropical and warm temperate countries.

Animal bones and teeth, often iron-impregnated and well rolled, occur in the deposit and fall into this category. The largest specimens are usually found in the coarsest beds of gravel.

iii) The exotic material forms a large proportion, not far short of one half, of the gravels, and consists of well-rolled granules and pebbles of siliceous rock. A brown weathered fine-grained chert, not unlike cherts in the Harptree Beds, is common, as is a harder fresher white chert of unknown provenance, with a vuggy or porous internal structure. Also common are pebbles of a remarkable off-white relatively soft rock, usually very well rounded and noticeably light in weight. This is due to the rock being honeycombed with microscopic tubes which twist and curve about and appear to be lined with chalcedonic silica. It is not clear whether the rock is in its original state, or whether it was once a material such as chalk that was burrowed and silicified during erosion; in support of the latter hypothesis is the fact that similar microscopic tubes occur very sparingly in the cherts, but against it is the apparent absence of flint from the gravels.

A few small rounded pebbles of Carboniferous Limestone chert occur, their well-rolled shape suggesting that they have come from a great distance. Alternatively, they could have derived from local conglomerates now eroded away. The same applies to the small rounded pebbles of vein quartz mentioned in i above; similar pebbles are common in, for example, the Lias conglomerate near Shepton Mallet,

b) The lower breakdown zone

This is of variable thickness up to about 5m, and is usually but not always present separating the gravels from the overlying bone-rich beds. It is an unremarkable accumulation of coarse limestone blocks up to several metres across, with the spaces usually filled with red-brown more or less silty clay.

c) The bone beds

This bedded sequence from 2 to 10 metres thick extends apparently without a break along the full length of the fissure. Individual beds are persistent and usually 0.3m to 2m in thickness, ranging from fairly stony clay through pebble-beds with a clayey matrix to pebble-beds with empty gaps between the stones. Contacts are not sharp, and the beds are clearly not water-laid. Near the fissure walls the stratification is less or not distinct, and the material is often cemented to a hard breccia by infiltrating stalagmite.

The stones consist almost exclusively of limestone with a small proportion of chert, all derived, presumably, from the immediate vicinity of the fissure. Bones and bone fragments are present, often in large numbers, in most or all of the beds, and in general show little or no sign of rolling, though some fragments have rounded edges. In contrast, many of the limestone pebbles and cobbles are sub-rounded in shape, a feature so pronounced in some beds that the deposit calls to mind a pebble beach, but the associated chert fragments, like the bones, seldom show any rounding, and there are other indications, such as edge-rounding of the boulder-sized rocks, that the phenomenon may result from the action of solution on limestone fragments set in a clayey matrix. Some of the cobbles have what appear to be concentric shells formed by spheroidal weathering.

At the west end of the fissure the stratification dipped gently to the northeast, but further east a gentle southerly dip was usual.

d) The Upper breakdown zone

This deposit is up to 5m thick, beneath less than a metre of almost stone-free reddish soil. It was thinnest, possibly even absent, at the west end of the fissure. It consists of angular breakdown of all sizes, with a matrix of reddish earthy clay. Very large detached rock masses, 5m or more across, were occasionally present in it, and, except at the west end of the fissure, the remains of a cave roof have been exposed at the top of the north-facing wall, showing various degrees of collapse and passing northwards into the breakdown layer. The roof appears to thicken and become less fragmented eastwards.

4. DISCUSSION

The fissure seems to have originated as a large cave passage or chamber, formed, together with adjacent smaller caves, under phreatic conditions when the water table stood higher than 800' (240m) A.O.D. Its roof, and at least the western part of its floor, sloped down gently to the southeast. At a late stage in its development, or possibly long after development ceased, conditions became such that gravel, sand and clay were washed into it from the ground surface above. These materials accumulated under water until the lower half of the chamber was full.

The nature of the gravels suggests that at this period the Mendips had not begun to emerge as a range of hills. The area was probably a wide relatively featureless plain crossed by meandering streams that, even when in flood, did not transport pebbles more than about 5cm in diameter. The climate was warm, with wet and dry seasons, and as a result the soil was deeply leached and lateritized. Eroded lateritic crusts, impregnations and pisoliths formed an important part of the stream gravels. There is no evidence that fresh outcrops of the older Mendip rocks (Old Red Sandstone, Carboniferous Limestone, Millstone Grit, Dolomitic Conglomerate) existed in the district, and the source of the gravels may have been insoluble residual stones in the subsoil. Indeed, there is no evidence that much of the area was not covered by later, Cretaceous or Tertiary, strata at the time. The quartz sand in the gravels, for example, is more like the Upper Greensand than the Old Red Sandstone or Millstone Grit. The ground surface over the cave may have been as much as 100m (350') higher than its present level of 800' A.O.D. (see later in this discussion).

There ensued a very long interval during which the water table dropped from well above 800' to below 750' A.O.D. Much of the lower breakdown zone may have formed when water drained out of the cave, withdrawing its hydrostatic support. The ground surface above the cave was lowered, perhaps by a variety of means but ultimately by solutional removal of limestone from the soil/rock interface, until an important breach of the roof occurred. The cave became accessible to animals, and the bone beds accumulated until it was largely filled. Unlike the underlying gravels, the stony component of the bone beds consists entirely of local limestone and chert, with the exception of the occasional fragments of completely weathered flint discovered by the archaeologists. The fact that this tool-making rock is the only exotic one present in the bone beds strongly suggests that it was introduced by man.

Deposition ceased when the cave, or its entrance, was full. The deposits lay buried, but the ground surface above the cave was slowly lowered by limestone solution. As the roof became thinner and weaker it tended to fracture and subside, aided, perhaps, by deep frost action in cold phases of the later Ice Age, until it was eventually converted into the upper breakdown zone.

Some idea of the altitude of the ground surface over the cave during its history may be obtained by considering rates of solutional lowering of limestone surfaces in conjunction with ancient sea levels. Atkinson (1971) has summarized recent estimates of present European surface lowering rates; a figure of 50-80mm in 1000 years seems appropriate to the Mendip plateau. Extrapolating such a rate into the past is full of hazards, but the round lower figure is here selected in view of the importance of colder climates in the Pleistocene.

Current archaeological opinion appears to place the bone beds in the First or Second (Cromerian or Hoxnian) Interglacial, respectively 320,000 or 210,000 years ago. The cave roof at these periods would have been 16m (53') or 10.5m (35') thicker, a substantial amount. (By the same argument, the upper breakdown zone would vanish entirely in 100,000 years, when the deposits would seem to be a pit-filling.) Sea level is thought to have been at about 250' A.O.D. in the Cromerian and about 130' A.O.D. in the Hoxnian (Ford and Stanton 1949), so the cave entrance would have been some 600' or 700' above the sea.

Turning to the gravels, a much greater age is demanded by the assumption that they derived from a plain with sluggish rivers not far above the sea level of the time. A sea level of 850' A.O.D. minimum would date back into the misty regions of the Early Pleistocene or Late Pliocene, more than one million years ago. But in the passage of a million years the ground surface would be lowered by some 50m (165') thus base level would have been in the region of 950' A.O.D. To attain this one must look still further back in time. Another factor to be considered is the warm humid climate of "gravel" times, which is often thought to have been charateristic of the Tertiary era. To avoid further speculation at this stage it is suggested that the gravels date from the Late Pliocene, when base level was around 1000'-1100' A.O.D., corresponding to the existing Old Red Sandstone summits. More positive evidence on this problem might be obtained by searching the associated clays and silts for microfossils.

The apparent absence of Chalk flint from the gravels is made significant by an assemblage of pebbles from a fissure in the Great Oolite plateau above Bath, at Hampton Rocks, collected by Mr. R.J. Whitaker. They are all well rounded, and mainly consist of heavily weathered flint. Small pebbles of vein quartz are also present, as at Westbury, and there are two small pebbles of the soft lightweight tube rock that is so common in the Westbury gravels. The Bath gravels occur at about 650' A.O.D., possibly an erosion surface at this level, and it may be that with the fall in sea level, there had become exposed large areas of Chalk, whereas the tube rock was becoming relatively scarce. Other explanations are of course possible.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Atkinson, T.C. 1971. (Unpublished) "Hydrology and Erosion in a Limestone Terrain". Ph.D. Thesis, University of Bristol.

Barrington, N. and Stanton, W. 1972. "The Complete Caves of Mendip". Cheddar.

Ford, D.C. and Stanton, W.I. 1969. "The Geomorphology of the South-Central Mendip Hills". Proc. Geol. Assoc., 79, 401-427.

Heal, G.J. 1970. "A New Pleistocene Mammal Site, Mendip Hills, Somerset". Proc. Univ. Bristol Speleo. Soc., 12, 135-136.

Sutcliffe, A.J. 1973. "Some Observations on the Westbury Bone Fissure". U.K.

REVIEW

Role of Vertical Shafts in the Movement of Ground Water in Carbonate Aquifers, by R.W. BRUCKER, J.W. HESS and W.B. WHITE, Groundwater, 10(6), Nov/Dec 1972, pp 5-13.

Shafts are ubiquitous in all carbonate aquifers with overlying catchment areas in non-carbonate rocks; they play a primary role in the transmission of water from perched aquifers or surface catchment areas. Thrailkill distinguishes between vadose seeps and vadose flows. The former move slowly through the soil profile and then through small fractures or other porosity in the carbonate rock; the latter are less aggressive but what aggressiveness they have is not diminished close to the entry of the limestone by solutional erosion. Shuster and White have pointed to conduit and diffuse systems of phreatic water too. There are photographs of shafts viewed vertically in the Flint Ridge System, showing the characteristic fluting of the walls. Shafts are seldom isolated but occur in complexes. There is a map of the central Kentucky karst showing the distribution of shafts, closely following the edge of the clastic caprock. Appalachian shafts are recalled.

If one thinks of groundwater flow in electric analogue terms the shaft is a short circuit, the most effective element in the transmission path. It is therefore interesting to see how the horizontal cave passages into which they drain can handle the quick provision of runoff which they allow. In some cases the passage has kept pace with the shaft, forming high narrow canyons.

The shaft waters are found to be highly undersaturated and are therefore actively cutting back the shaft walls. Measurements at the top and bottom of a shaft in Swago Pit, West Virginia reveal an increase in Ca^{2+} concentration from 14-15 ppm and in bicarbonate from 42-56 ppm in the course of 54 feet of vertical flow. Water usually moves down the walls of shafts as films or sheets, rarely as falls and exhibits a rare flow form in nature - supercritical laminar flow, depths being very low but velocity high - 1 - 5 ft/sec as measured with dyes.

Malcolm Newson

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Some late news

International Congress The Royal Society considers the proposal (that Britain should hold the Congress in 1977) on July 4th. So please let's have a merger in time to phone them!

Birthday Honour if you read the small print in the Times you may have seen in the M.B.E. list, ‘R. Hainsworth, for services to cave rescue’. Many congratulations to a hitherto overlooked service.

M.D.N.