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Helictite

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Downstream end of the main Blue Waterhole, Cooleman Plain, N.S.W. See page 69.

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CONTENTS

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REVIEWS

THE ARTHROPODA OF AUSTRALIAN CAVES. By E. Hamilton-Smith. J. Aust. ent. Soc., 6 (2), 1967 : 103 - 118.

This is the first attempt to bring together current knowledge of the anthropod fauna of Australian caves, and for this reason this paper is a useful contribution to the literature. However, it does not adequately cover the whole continent, and as extensive collecting was in progress in Western Australia, the Nullarbor Plain and Tasmania prior to publication of this paper, it would have been better for the author to have waited a little longer before publishing. As a result, many of his conclusions on the fauna, e.g., those on the Carabidae and the Acarina, are no longer valid, and the known fauna has been more than doubled. Nevertheless, the paper does illustrate the diversity of species in the Australian cave fauna.

What is more important is the suggested ecological classification of cavernicoles into four categories - trogloxenes, first-level troglophiles, second-level troglophiles and troglobites. Far more knowledge is required on the biology and ecology of Australian cavernicoles before one can justify the splitting of troglophiles into these two categories. The author suggests that some second-level troglophiles could be troglobites, but it could equally be argued that some proposed first-level troglophiles are trogloxenes. In conclusion, the author hypothesised that the paucity of troglobites is due to extensive secondary extinction during the Pleistocene and Holocene caused by flooding of caves followed by dehydration through changes in watertable levels and geomorphological change. These changes also led to a large number of second-level troglophiles through extinction of their surface-dwelling progenitors. This hypothesis may prove to be correct, but at the moment there is insufficient geological evidence to support or refute this suggestion. A.M.R.

TRANSFER OF NEW-BORN OFFSPRING IN THE BAT MINIOPTERUS SCHREIBERSII. By L.S. Hall and J.L. McKean. Aust. J. Sci., 30 (4), 1967 : 145.

Recent studies of the bent-winged bat, Miniopterus schreibersii, in the Wee Jasper district, New South Wales, indicated that it transferred its new-born young from Pylon Cave, where parturition occurred, to Church Cave, a traditional maternity cave five miles away. No other species of vespertilionid bats are known to do this. The wording of this brief paper introduces some confusion as to what is meant by the term "traditional maternity cave". In this case the terms "parturition cave" and "lactating cave" would seem more appropriate. A.M.R. and E.A.L.

RIVER CAVE, COOLEMAN PLAIN, KOSCIUSKO NATIONAL PARK, AND ITS HYDROLOGICAL RELATIONSHIPS

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Abstract

River Cave is a Zwischenhöhle (between-cave) in which the active river passage is reached through a former tributary stream passage from a dry valley. Now vadose in character, it is of gentle gradient, with some normally and some temporarily water-filled reaches of shallow phreatic nature. There is only a single level of development. Water tracing has confirmed previous inferences that it is mainly fed from the South Branch watersink, that its normal flow goes to the Blue Waterholes, the main rising of the Plain, and that there is flood overflow to Murray Cave, which is shown to have been formerly the normal outflow cave of the system. In the changeover from one outflow point (Vorfluter) to another, a shorter, steeper cave and longer surface course has been replaced by a longer cave of shorter gradient.

Ev's Cave, a flood inflow cave of the South Branch, may also feed River Cave and Keith's Faint Cave is inferred to be part of the link between South Branch Sink and River Cave. It has the aspect of an early stage of vadose development from phreatic conditions. Previous interpretation of Glop Pot as a true phreatic relic is maintained in the light of new facts.

Evidence is lacking with which to date the caves at all reliably. Glop Pot possibly belongs to a phase of surface planation of Tertiary age whereas the other caves are likely to be consequent on Pleistocene dissection. The tributary passage of River Cave and its associated dry valley may have lost their stream in the Holocene when Murray Cave became intermittent in action also. The Murray Cave event is due to subterranean piracy associated with rejuvenation whereas the loss of the tributary stream is probably in part due to increasing warmth and less effective precipitation.

Introduction

Virtually the whole drainage of Cooleman Plain in the Kosciusko National Park gathers to feed the Blue Waterholes, the largest limestone rising in the southeastern mainland of Australia. It is made up of a number of individual springs but there is good hydrological evidence (Jennings, in preparation) that a single underground river feeds them. As yet this major artery has not been reached by cavers. However, the largest cave stream known in the Plain, that in River Cave, is probably the largest tributary to that artery. The morphology of this cave and its drainage connections will be discussed here.

Exploration

There is no record or evidence of the cave being known prior to 1953 when V. Pickering, J. Webb and J. Cameron of the Canberra Alpine Club entered it as far as the first downstream watertrap. Webb and Pickering were among the founder members in 1954 of the Canberra Speleological Society, which in that year reached upstream to the watertrap in that direction. P. Rose of the Sydney Speleological Society was the first to get round the first downstream watertrap through the "dry bypass" and reach the second watertrap in 1961. Aqualung divers of the Highland Caving Club, supported by less amphibious members of that Club and of CSS, extended the cave by diving a short distance upstream end and more substantially downstream beyond the second watertrap in January, 1966. The great drought of 1967-68 opened up the downstream watertraps and almost dried out the cave. This enabled a Sydney University Speleological Society party led by H. Wright to reach beyond the divers' limit on 12 April 1968 and to take a low-grade, but very useful, traverse beyond the CSS survey presented here.

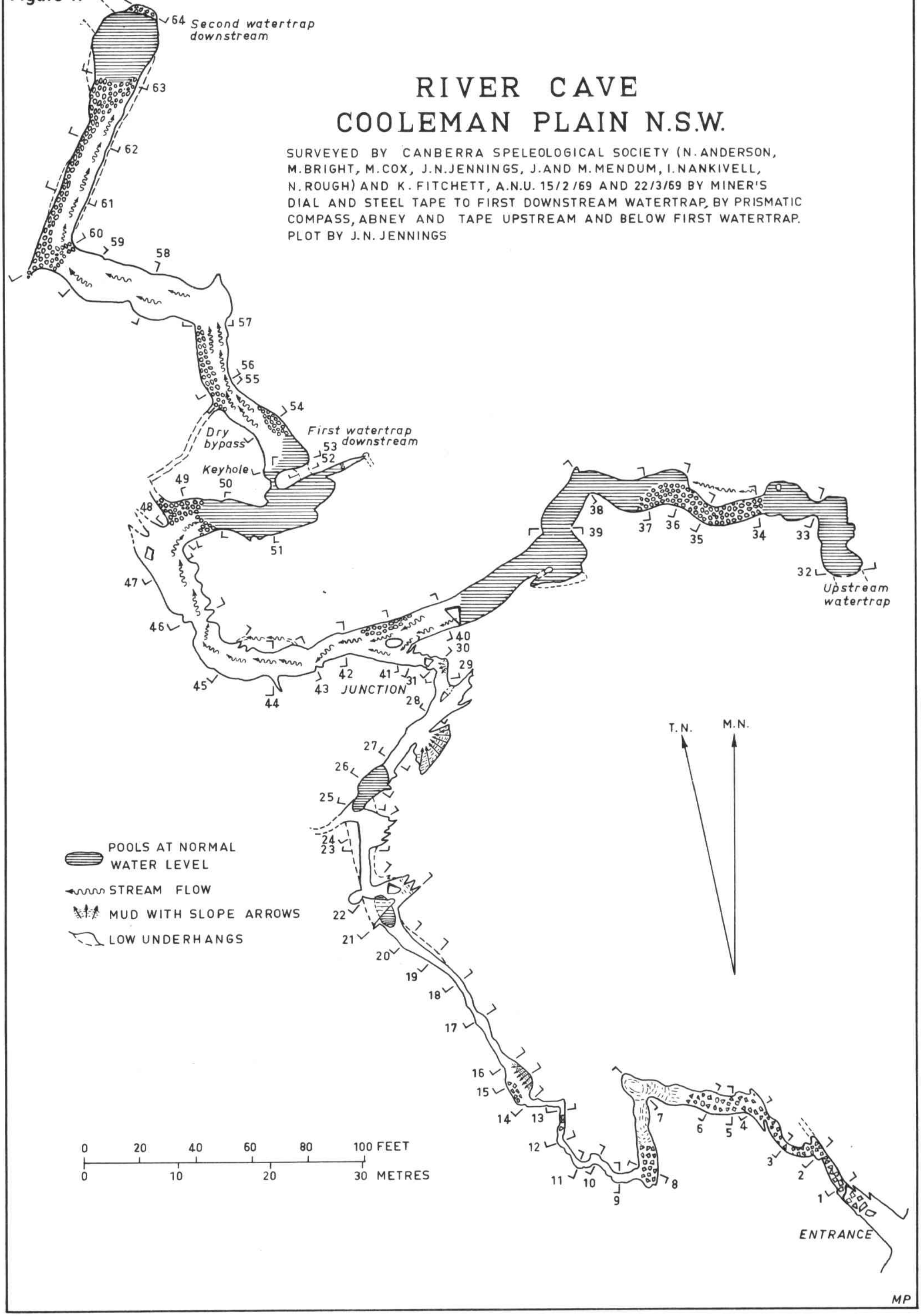
Of related caves mentioned here, Murray Cave exploration has been referred to briefly in Jennings (1966) and Jennings and others (1969). Though known from 1954 at least, Ev's Cave was so named after Evelyn Young who along with Margot Cox made the first real effort as far as CSS is concerned to get along this tight passage, whilst N. Anderson and J. Coulton of CSS are thought to have penetrated further along this in 1963. Keith's Faint Cave was discovered by R.M. Frank, J.N. Jennings and P.W. Williams on 26 May 1967, by the time-honoured method of spotting a column of steam on a cold winter's day. It was explored by the same party on 31 May after enlargement of the entrance. Glop Pot was first explored in December, 1965, and on 1 January 1966 by A. Spate, T. Evans, I. Nankivell and J.N. Jennings. On 2 January the Highland Club divers sounded its depths.

Description of River Cave

(See Figures 1 and 2.)

River Cave (CP 6) lies at 688984 (1:50,000 Sheet 8626 - IV Currango) in a dry valley running northeast to make a hanging junction with the lower dry section of the valley of the South Branch of Cave Creek. At the cave the dry valley is floored in bedrock and is about 70 feet deep with steep craggy sides. Immediately below the cave entrance there is a rock threshold across valley; a former stream has cut down about 15 feet after it began to sink into the cave and ceased to flow farther down the valley, making it blind. The Cooleman Limestone dips about 20 deg. east hereabouts.

Figure 1.



RIVER CAVE
COOLEMAN PLAIN N.S.W.

SURVEYED BY CANBERRA SPELEOLOGICAL SOCIETY (N. ANDERSON, M. BRIGHT, M. COX, J. N. JENNINGS, J. AND M. MENDUM, I. NANKIVELL, N. ROUGH) AND K. FITCHETT, A.N.U. 15/2/69 AND 22/3/69 BY MINER'S DIAL AND STEEL TAPE TO FIRST DOWNSTREAM WATERTRAP, BY PRISMATIC COMPASS, ABNEY AND TAPE UPSTREAM AND BELOW FIRST WATERTRAP. PLOT BY J. N. JENNINGS

The entrance is of fissure type (Xsct 1) at the back of a cleft in the northern valleyside. A few fallen blocks scarcely interrupt a downward gradient into the cave but there is never any surface flow into it. The passage descends about 15 feet steeply over fallen blocks so that it heightens to about 30 feet (Xsct 2). There is then a level floor over partly waterworn limestone cobbles. After very heavy rains a modest gathering of seepage water can bring about a small flow from here onwards.

The cave bends to the west into a parallel NNW trend along another nearly vertical joint. Well developed current markings reach high up the walls here, indicative of very substantial flow in the past. At another bend to the northwest, the fissure passage is abruptly replaced by a low (2 ft - 6 ft), slightly wider (5 ft - 8 ft) stretch, with a shallow dip in its middle part where water occasionally accumulates almost to the roof (Xscts 4 - 8). Smoothed wall and roof surfaces show that this length, which includes a very sharp bend back to the south, has been subject to pressure flow in the past.

The cave then returns twistily to a NNW trend as a moderately sloping and very narrow fissure passage again, as high as 30 feet in parts, with the walls showing former stream levels above the present floor (Xscts 9 - 14). There is also some secondary calcite precipitation on the lower walls here. A drop of 8 feet in the tightest part leads to a semi-permanent tiny pool on bedrock and a very sharp angle due to joint control (Xsct 13). From a widening at Xsct 15, dark silty clay begins to coat the floor and lower walls onwards. A fairly straight, narrow reach follows along the NNW trend (Xscts 15 - 18) with the roof coming down sharply. Next cross-joints of NE trend make the passage much more irregular in width, height and direction with fairly persistent pools of varying depth with time in a floor now more or less horizontal. Occasionally in winter seepage water and water backing up from the river can fill the passage to the roof at its lowest points. The Xscts 19 - 25 show the effects of lateral solution at floor level when flows were much greater than are experienced nowadays. Between Xscts 27 and 28 a small, tall, mud-banked room develops on a NE joint parallel to the passage but opening onto it. Along here to the junction with the main river passage some fallen blocks interrupt the floor level, with the roof once again reaching to heights of 30 feet and more in association with this evidence of collapse.

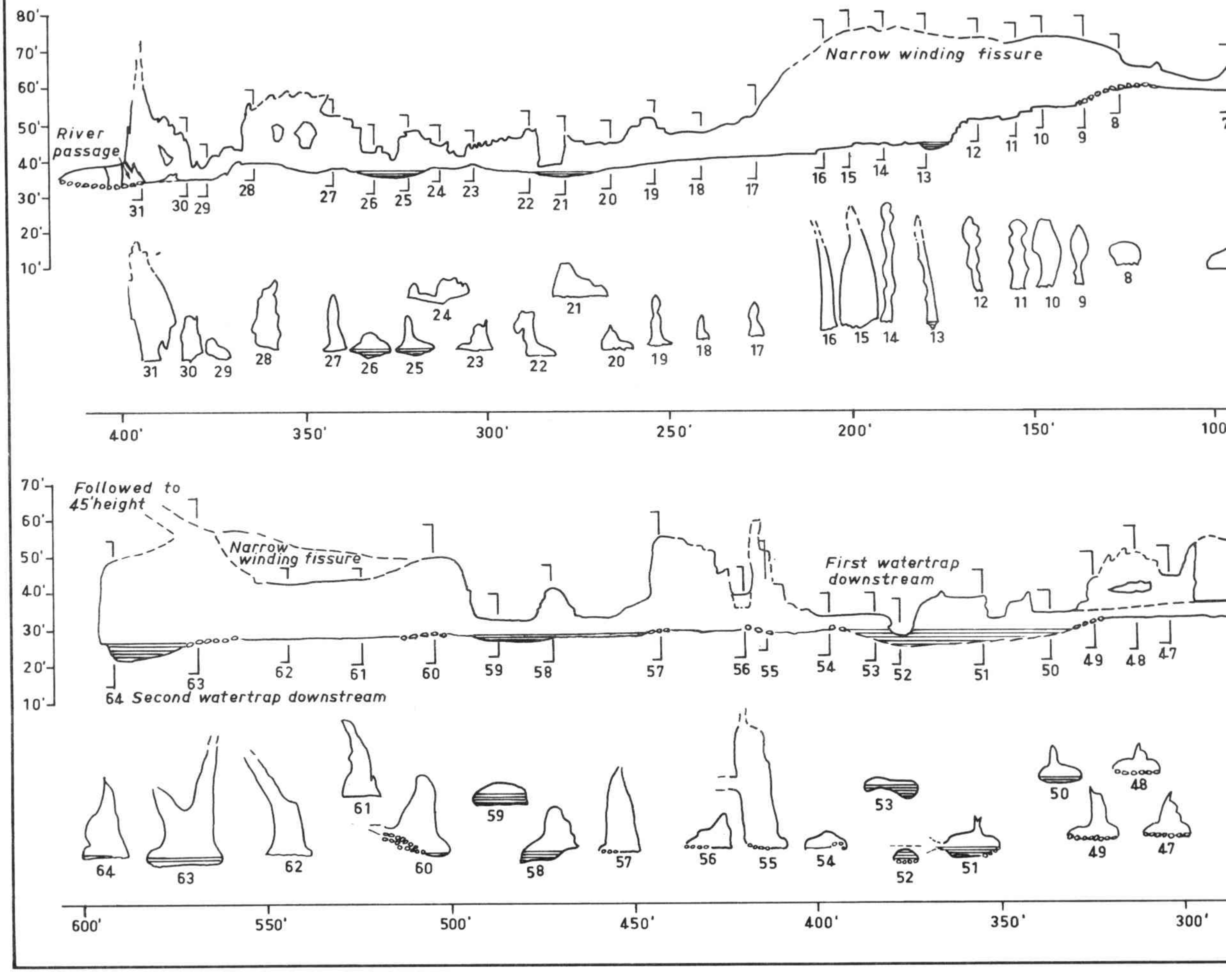
The river passage will now be described between the limits of exploration. At the upstream end a pool about 40 feet long and 6 - 12 feet wide (Xscts 32 - 33) is more than 8 feet deep where it is fed from a watertrap on the south. Diving shows that a good-sized passage continues for 50 feet several feet below water level and begins in an impenetrable horizontal fissure.

The overflow from the pool drains westwards through a low impenetrable passage, but there is easy access over collapse blocks and igneous rock

Figure 2.

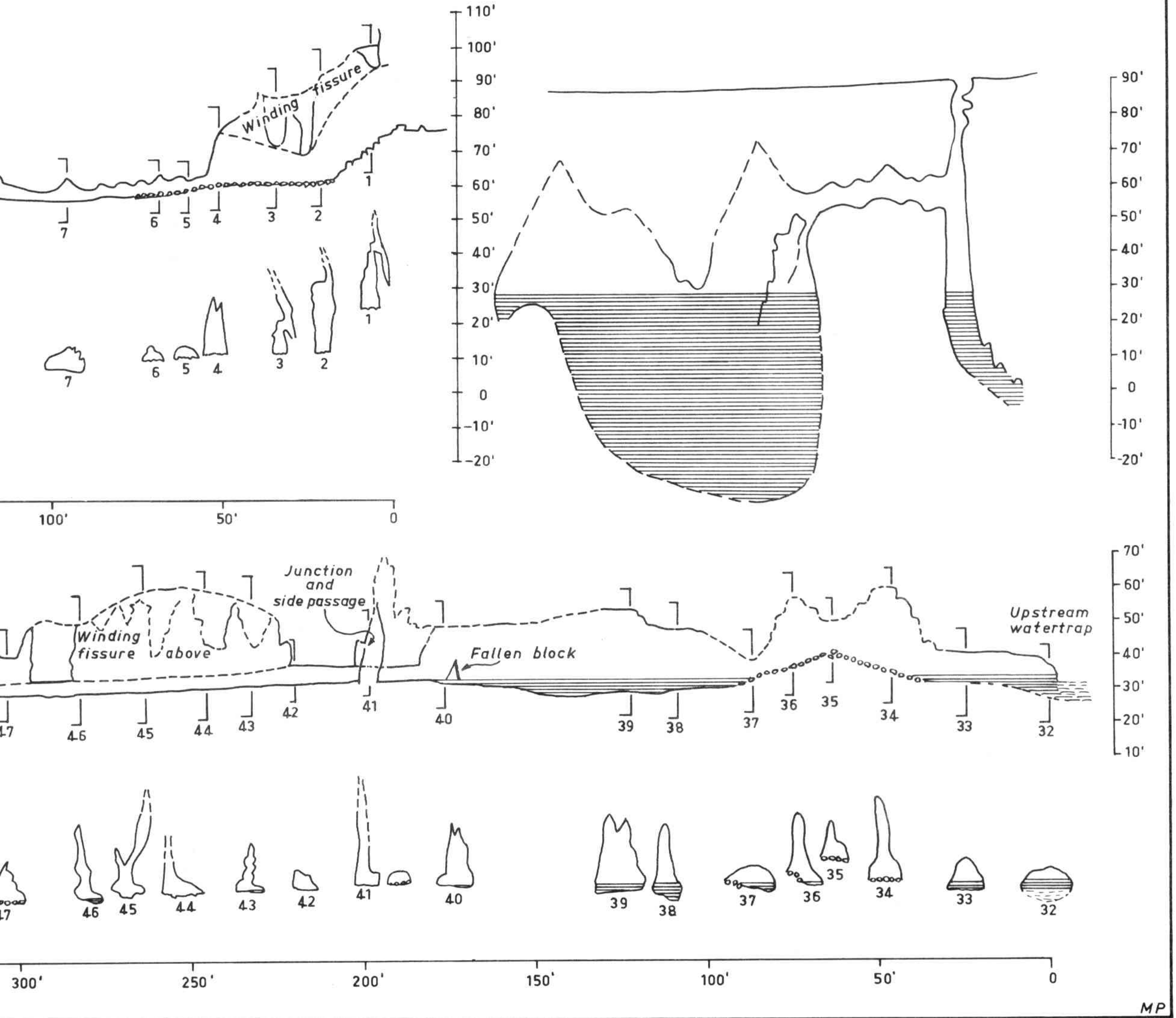
RIVER CAVE, COOLEMAN PLAIN, N.S.W.

FOR APPROXIMATE ABSOLUTE HEIGHT ADD 4000



W.

GLOP POT


110'
100'
90'
80'
70'
60'
50'
40'
30'
20'
10'
0
-10'
-20'
Winding fissure
1
2
3
4
5
6
7
100'
50'
0
Junction and side passage
Winding fissure above
Fallen block
Upstream watertrap
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
300'
250'
200'
150'
100'
50'
0
MP

gravel in a high passage (Xscts 34 - 36) on the southern side. About 100 feet of pool, 10 - 20 feet wide, follows, westerly trending with a northward bight. At normal discharge it has a maximum depth of 6 - 7 feet, with the roof 15 - 20 feet above the water, and is at least partly sand-floored (Xscts 37 - 39).

There succeeds a shallow channel with a gentle fall over bedrock with occasional gravel patches (Xscts 40 - 49). Past the junction with the tributary passage from the entrance, the direction is westerly but two sharp bends eventually bring it round to flow east into another pool. Along this reach there is a narrow winding fissure as much as 30 feet high above a low bottom part up to 4 feet high and 10 - 20 feet wide due to lateral solution at the present gradient, e.g. Xsct 43. A small part of the flow anabranches through a rathole on the northern side for some 20 feet between Xscts 43 and 45.

The succeeding pool deepens to about 6 feet on gravel near a short watertrap or duckunder of 4 - 5 feet on the northern side (Xscts 50 - 53). Nearby is a keyhole above normal waterlevel, through which a slim person can "ease" himself. A few feet beyond the watertrap the pool changes to a riverbed between gravel banks and the roof rises once more. The trap can be avoided by a difficult joint passage at varying height across the angle of the big bend in which this pool lies; nominally the "dry bypass", it can involve a mud wallow.

The river goes along a NNW reach, a NW one and finally a northerly one before reaching another pool and watertrap (Xscts 54 - 64). This is the most spacious part of the cave with the width varying between 10 feet and 20 feet and the height between 3 feet and 30 feet. Near the pool an inclined aven reaches more than 45 feet up (Xsct 63).

From this pool there is normally an irregular short watertrap, about 12 feet down and 30 feet long according to the Highland Club divers. The 1968 SUSS party roughly mapped about 800 feet of passage beyond this. H. Wright's description (<u>in litt</u>.) does not indicate further watertraps, but refers to the whole section as about half crawling and half walking, suggesting that it is in general somewhat lower than the CSS surveyed part of the main passage. Four rockfall localities are mapped, the last one being very close to the limit of exploration which was where the river entered a narrow, earthy, crumbly passage presenting some danger. Stalactites and shawls about halfway along this section are the only noteworthy cave decorations in the whole length of the main passage. About 300 feet before the exploration limit a branch passage comes in from the west.

Downstream of the junction of the entrance passage and the river passage, flood flow will fill the cave to the roof at several additional points to those normally waterfilled. Between CSS surveyed limits the river at normal discharge drops 9 feet in 600 feet, giving a gradient of 1:65.

Neighbouring Caves and Surface Features

The largest cave nearby is Murray Cave (CP 3, 691992), an occasionally active outflow cave to the north. It has already been argued (Jennings, 1966; Jennings and others, 1969) that

(1) Murray Cave was formerly the outflow cave of a combined River - Murray Cave system prior to capture or diversion of River Cave to normal outflow at the Blue Waterholes.

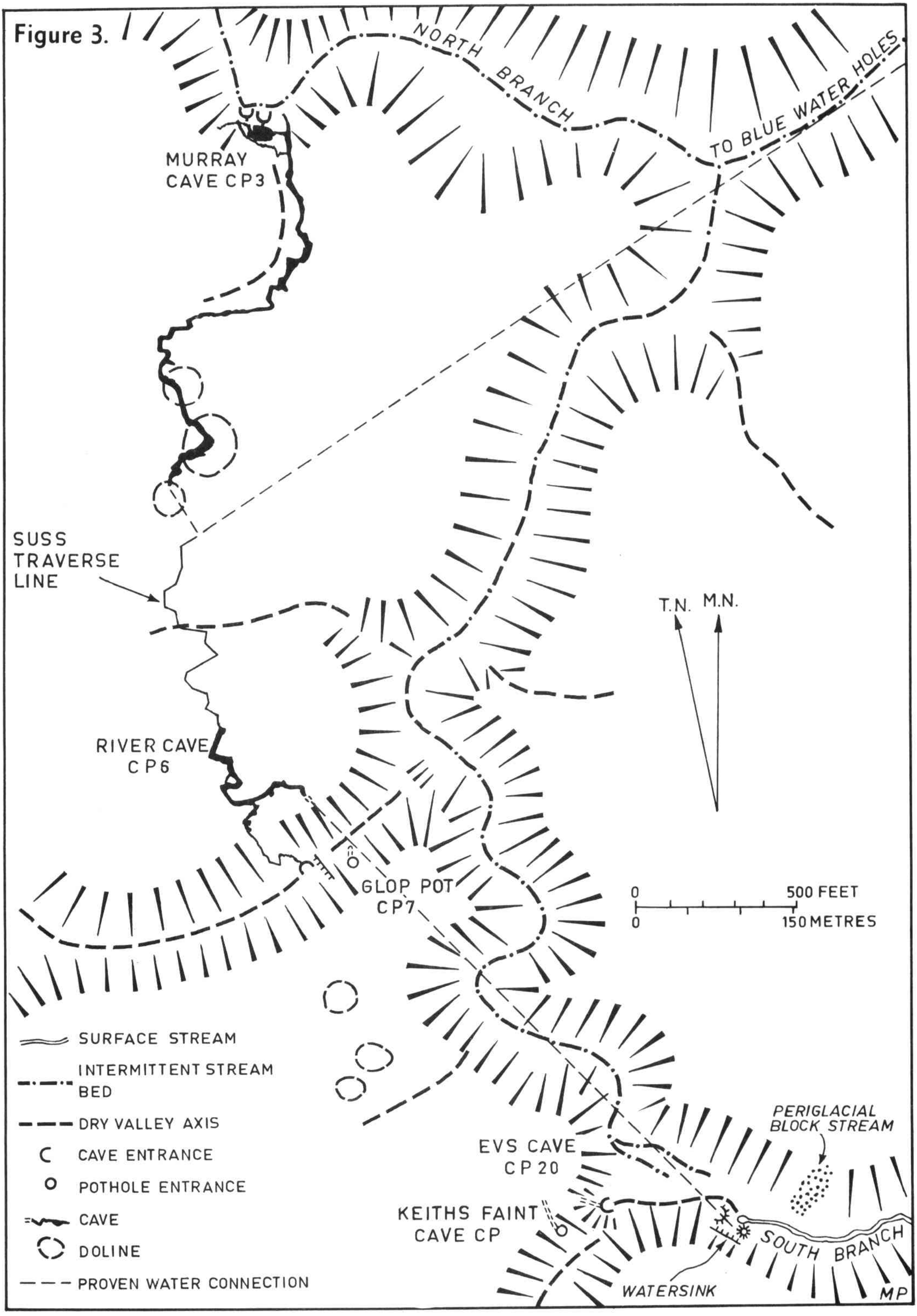
(2) When a stream does flow in Murray Cave for a few days or a few weeks more or less annually, the water is flood overflow from River Cave.

The evidence presented previously for these inferences will be reverted to only partially here.

The distance between the lower limit of the CSS survey of the River Cave and the upper limit of Murray Cave is about 800 feet (Figure 3). There is less certainty about the position of the explored limit because of the nature of the SUSS traverse. Nevertheless, the gap of about 200 feet remaining between River Cave and Murray Cave cannot be substantially in error. There is about 37 feet vertical difference between the lower limit of CSS survey and the inner end of Murray Cave. There does not appear to be an observable change in gradient along the further extension of River Cave, which therefore would make the lower limit of exploration round about 25 feet above Murray Cave. Therefore, the relative level permits the two inferences made above, though it suggests also the occurrence of some obstacle to flow into Murray Cave at normal stage, which is overtopped at flood. This might be the collapse from the doline above.

Beyond the threshold in the River Cave dry valley and only 150 feet away from that cave's entrance is Glop Pot (CP 7, 689984) (Figure 1). Its own small entrance in the valley floor leads at a steep angle into a vertical shaft with a diameter of about 8 feet at waterlevel 62 feet down. The pool filling the shaft has been dived to 25 feet, but the shaft continues to descend at a steep angle inclined away from the rest of the pot. About 37 feet down from the surface a passage leads more or less horizontally about 50 feet to a pool-filled extension about 100 feet long and up to 10 feet wide. Narrowing upwards the roof reaches close to the surface but about one third along the pool it descends close to its surface (which approximates to the level in the entrance shaft) almost to create two rooms. Near the approach end the depth was determined by diving as 57 feet, with a muddy bottom and no underwater way through to the entrance shaft pool or on from the far end of the cave was found. The waterlevel in Glop Pot is close to that at the upstream end of the River Cave, which is about 250 feet away.

Figure 3.


NORTH BRANCH
TO BLUE WATER HOLES
MURRAY CAVE CP3
SUSS TRAVERSE LINE
T.N.
M.N.
RIVER CAVE CP6
GLOP POT CP7
0
500 FEET
0
150 METRES
PERIGLACIAL BLOCK STREAM
EVS CAVE CP 20
KEITHS FAINT CAVE CP
SOUTH BRANCH
WATERSINK
SURFACE STREAM
INTERMITTENT STREAM BED
DRY VALLEY AXIS
CAVE ENTRANCE
POTHOLE ENTRANCE
CAVE
DOLINE
PROVEN WATER CONNECTION
MP

About 1,750 feet southeast by south from River Cave is the normal point of sinking (693799) of the South Branch of Cave Creek. The stream sinks in coarse gravels and bedrock clefts in a recess in the southern valleyside, formed by two cliffs nearly at right angles to one another and to a square-cut rock tower. In this recess there is much large blockfall, which digging by CSS in an effort to reach the cave entrance did not plumb at more than 10 feet below the alluvial surface. Some of the river water was traced to a small crack in the rear bedrock wall but it is likely that a somewhat larger entrance lies deeper. A former cave arch seems to have collapsed here to form the recess and this may well have been the product of frost wedging in the former cold period of which there is evidence on Cooleman Plain. Fissures in the limestone spur forming the western flank of the recess reach down some 30 feet where the noise of underground flow can be clearly heard. It has not yet proved possible to break through to the stream here.

A surface channel kept free from vegetation by occasional flood flows continues some 400 feet westwards from the recess down the valley, falling more than 10 feet below the coarse alluvial valley fill and entering Ev's Cave (CP 20, 692980) at the base of a meander cliff on the western side of the South Branch valley just beyond the hanging junction of a dry valley. This flood overflow cave is a tight, gently descending simple passage, which has been penetrated about 250 feet.

Westwards from Ev's Cave entrance is the small vertical fissure of Keith's Faint Cave (692980) which is near the top of the northern side of the dry valley just mentioned. A rift leads vertically down some 70 feet to a river with some space at the bottom created by collapse. Some 200 feet of river passage, mostly downstream of the shaft, starts and ends in bedrock holes too small to penetrate. Several small passages in anastomosing pattern, some with flow at normal discharge and some without, comprise this nearly horizontal cave. At the largest the individual passages reach 6 feet high and 4 feet wide but for the most part they are much smaller. Current marking is general, including covering the surfaces of thin blades between neighbouring passages and even on projecting spikes of rock. There is igneous gravel in the beds and mud covers parts of the floors, walls and roofs, the product of flood flow filling the whole cave. The total aspect of the cave suggests an early stage of conversion of phreatic forms into a vadose stream passage.

Water Tracing

In 1958, attempts to trace the destination of water from the South Branch Sink and of the River Cave stream by visual use of fluorescein proved abortive through insufficient dye or too short a watch (2½ days) or a combination of both.

In 1969, these questions were tackled again using the Dunn method of absorbing fluorescein on activated charcoal detectors (Dunn, 1957; Haas, 1959; White, 1967; Zotter, 1963).

At 1540 hours on 14 February 1969, 3 lb of fluorescein was put into the South Branch Sink. The quantity was calculated on the basis of the distance to the Blue Waterholes and the discharge there. Detectors were inserted at the junction in River Cave and in the Cliff Foot Rising at the Blue Waterholes shortly afterwards. At 0840 on 15 February 1969, charcoal gave a negative result on elutriation with alkali in agreement with visual results and visually the water was still colourless at 1230 the same day. A party entered Glop Pot at 1415 and, although there was no colour in the entrance shaft pool, the inner pool was a strong green to the eyes. When River Cave was left at 1715 that day its water was still clear. On 16 February 1969, a strong green colour was apparent from 0900 to 1045, the colour still being strong when the party left. Charcoal collected at 0900 gave a strong green also on addition of alkali. On this day visual negatives were obtained at 0900 and 1200 hours at the Blue Waterholes and a charcoal test at 1700 hours was negative also. On 21 February 1969, collection at 1015 hours gave a charcoal negative, visual watch from 1015 to 1315 giving the same result. On 2 March 1969, a positive charcoal reading was obtained at 0850 hours. All the charcoal results mentioned were confirmed in UV light in Canberra.

These observations permit the following conclusions.

(a) South Branch Sink water communicates with the larger pool of Glop Pot at least. Less than 22 hrs 35 mins was taken on this occasion of normal spring discharge at the Blue Waterholes (12 cusecs).

(b) The water also flows to River Cave stream passage and took between 25 hrs 35 mins and 41 hrs 20 mins.

(c) The water took between 12 days 21 hrs 35 mins and 15 days 17 hrs 10 mins to reach the Blue Waterholes.

Because water volumes in the South Branch River Cave are usually similar to those in River Cave, there is no need to think that there is direct connection between the Sink and the Rising. The fact that on occasion, e.g. on 25 April 1960, River Cave is observably greater in volume than the amount sinking at the South Branch, is compatible with this, whilst the incompatible converse situation has not been encountered.

On 16 April 1969 after a long period of steady, heavy rain, Murray Cave was found to have a substantial river up to 3 - 4 feet in depth, occupying its full floor but for some rock benches. Although the entrance chamber was full to the brim, overflow had ceased and outflow was at the moment by way of the Lower Branch and the short cave immediately west of the cave entrance. The Lower Branch was largely water-filled. A charcoal detector was mounted in the deep pool which had developed by the first watertrap in the main passage. Water levels nearly to the roof in the lower part of the way down to the river passage of River Cave prevented effective dyeing of the main stream there. Therefore the South Branch Sink was dyed with 5 lb of fluorescein at 1740 hrs. A detector was also inserted in the Blue Waterholes shortly afterwards.

Charcoal was recovered from the Blue Waterhole at 0900 on 19 April 1969 and from Murray Cave at 1020 the same day when the river had already ceased to flow along the main passage of that cave, though there was still strong outflow from the small nearby cave. Both samples gave strong positive results with and without UV light, but Murray Cave water was much more strongly coloured than the Blue Waterholes.

Thus it can be concluded that -

(a) With flood flow South Branch Sink provides the water for the infrequent activity of Murray Cave. The likelihood that this connection is not via River Cave is very small. The time taken must have been considerably less than 3 days 17 hrs 20 mins making allowance for the cessation of flow in Murray Cave.

(b) The South Branch water travelled to the Blue Waterholes in less than 3 days 17 hrs 20 mins. The discharge of the springs at the Blue Waterholes was 30 cusecs, a high stage.

These experiments confirm that the Dunn elaboration of fluorescein water tracing is a very useful development of this technique.

Water Analyses

Table 1 presents temperature, pH, calcium hardness and total hardness determinations at stations along the system under discussion, taken more or less simultaneously in pairs or larger combinations. The samples are too few for much to be derived from them. Those from the Blue Waterholes form part of a much larger sample with associated flow gaugings, which will be analysed elsewhere (Jennings, in preparation).

The samples are all from summer and autumn. Because of this, the temperature of the South Branch Sink are higher than the vadose and phreatic water from the other stations, which reflect the conservative effect of the body of limestone. Also the pH of the surface water is consistently greater than those of equivalent collections in time from the other stations.

Chief interest resides in how much limestone has been taken into solution and whether the waters are capable of further solution or are liable to precipitate calcite.

TABLE 1

DATE	SOUTH BRANCH (At watersink)				RIVER CAVE (Main stream at junction)				MURRAY CAVE (At first watertrap)				BLUE WATERHOLES (At Cliff Foot Rising)			
	T°C	pH	calcium hardness	total hardness	T°C	pH	calcium hardness	total hardness	T°C	pH	calcium hardness	total hardness	T°C	pH	calcium hardness	total hardness
15.2.58					11.4	7.35	88	99	10.0	7.4	75	78	10.6	7.3	83	91
1.10.59	8.9	8.2	53	57									8.9	7.5	70	85
9.11.60	18.9	8.6	82	88	12.2	7.6	96	108	10.3	7.9	81	87	10.8	7.6	82	93
13.1.60	17.2	8.7	63	75												
14.1.60													11.0	7.5	88	98
23.4.60									10.0	8.2	118	126	10.8	7.6	92	96
25.4.60	10.3	8.4	74	74	11.4	7.6	80	86								
30.12.61	18.3	8.2	72	84	8.6	7.8	43	10 *	11.4	7.4	84	97				
31.12.61													11.1	7.4	74	86
15.12.68									11.0	7.3	120	126	12.2	7.6	80	86
13.1.69									12.0	7.5	117	129	11.0	7.7	81	91
14.2.69									11.2	7.4	120	128	12.2	7.6	86	95
16.2.69	21.5	8.4	69	81	12	7.6	92	103								
$\bar{X}$				76.5				99.0				110.1				91.2
σ				10.0				8.2				20.4				4.5

Notes: 1. pH determined colorimetrically. 2. Calcium and total hardness in mg/l by EDTA (Schwarzenbach method).

* Water from large pool in tributary passage.

T-tests show that the surface samples from South Branch are significantly different at the 1% confidence level from the samples from each of the other three stations in total hardness. (Calcium hardness values have the same pattern since the magnesium component is small.) This is to be expected and the surprising fact is the comparatively small increase in carbonate content in passing through the limestone. The increase in mean total hardnesses between the South Branch Sink and River Cave is 29% only. There are no significant differences between River Cave waters and those of Murray Cave and the Blue Waterholes. Thus the bulk of the solution has gone on prior to cave entry. The differences between River Cave and the Blue Waterholes, and between River and Murray Cave are not statistically significant; not a great deal of further limestone solution seems to be going on in these two sections of the cave system. There is a significant difference at the 5% confidence level between Murray Cave and the Blue Waterholes waters. Flood waters from River Cave are likely to be less carbonated than normal flows, so the higher value in the stagnant watertrap of Murray Cave must be due either to accessions or more concentrated seepage water to the standing water or to long contact of the latter with bedrock. Both are compatible with the higher standard deviation of this sample here compared with those from the other stations. The second explanation is feasible since only one out of the seven samples from Murray Cave was saturated on the basis of temperature, pH and carbonate content applied to a Trombe graph (Trombe, 1952).

Three out of six samples of the South Branch Sink waters were saturated and a Chi-squared test shows that there is probably a significant difference in this respect between the surface water samples and the remainder considered as a group ($\chi^2 = 4.92$, significant at the 5% level). This decrease in the incidence of saturated waters whilst there is a take-up of limestone in solution could be due to (a) fall in temperature increasing saturation equilibrium for carbonates, (b) a higher carbon dioxide concentration in the cave air than in the outside atmosphere, leading to increased carbon dioxide content in the water and increased solutional capacity. The data are inadequate to determine the relative roles of these different mechanisms.

One sample was collected from the largest pool in the tributary entrance passage of River Cave. It has the lowest calcium and total hardnesses of all the samples recorded in Table 1 and this suggests that on this occasion the pool was filled by backing up from flood flow in the main passage rather than from seepage water downwards into the pool. No determinations of drip water have been made in River Cave but in Murray Cave seepage waters are significantly harder than the trap water in that cave (Jennings and others, 1969) and the Murray Cave trap has the highest mean total hardness of all the stations discussed here.

Discussion

River Cave is in German terminology a Zwischenhöhle, literally a between-cave, signifying a stream cave which is entered along its course from above or laterally and can be followed upstream and downstream though not to the surface in either direction. In the cave in question the entry is laterally by means of a former tributary's passage, which is partly vadose, partly shallow phreatic in character. There is a descent of 41 feet from the dry valley to the main river cave bringing that to 110 - 135 feet below the general surface of Cooleman Plain.

The river passage is mostly vadose in nature, with much igneous gravel for mechanical action. There are, however, short water-filled reaches, which are added to at high stage; they are shallow or epi-phreatic in origin and still so functioning temporarily or newly permanently.

There is practically no evidence for different levels of cave development except in the part of the tributary passage following the low pressure passage reach where there are indications of successive river levels in the walls. The presence of one level of development only is true in the main for Murray Cave as well, now proved by water tracing to be the former outflow of the system. Three different outflow levels into the North Branch gorge differ by only 12 feet and no effects of this lowering can be discerned farther than 550 feet inwards. Murray Cave lies 160 - 170 feet below the surface of the plain.

Water tracing has proved that the South Branch Sink drains to River Cave. The river is about 50 feet below plain level here but it is apparent that it formerly entered the rock at least 10 feet lower down prior to a phase of alluviation.

Ev's Cave and Keith's Faint Cave have not been proven by water tracing to form part of the linkage between the South Branch and River Cave. There is, however, reason to think that they do form part of the drainage system since they lie on the line between the two and the depth of the South Branch Valley, together with its fill, makes it very likely that underground connections of these smaller caves must lie to its west. Ev's Cave lies about 70 feet and Keith's Faint Cave about 80 feet below general level of the plain.

These various facts show that the South Branch Sink - River Cave - Murray Cave system developed when the present degree of dissection of Cooleman Plain had virtually been achieved.

Actual river gradients for South Branch Sink to Ev's Cave (1/25), along River Cave (1/65, CSS surveyed part) and along Murray Cave (1/251) point to a normal profile concavity. Theoretical gradients for the whole system using straight line distances can be calculated between the various points along it but little can be argued from them as can be seen from the difference in sinuosity ratio (actual stream length / straight line distance) between River Cave (1.86) and Murray Cave (1.45). However, the straight line gradient from South Branch Sink to River Cave (allowing for a minimal 10 feet descent before bedrock entry at the former) is 1/43 and so gentler than the highly meandering River Cave's straight line gradient of 1/36. This is not very promising for penetration of the cave between the two since a gentler gradient is likely to be associated with more water filling of the passage.

Today River Cave flows to the Blue Waterholes. This was known by inference from the fact that this rising is the only one large enough below the cave within the igneous intrusive cage of the Plain, though the water tracing does confirm it. (The significance of the times taken on different occasions will not be discussed here.) Thus there has been capture or diversion of River Cave from its Murray Cave course. The loss of altitude between the lower limit of River Cave and Murray Cave mouth on the one hand and the Blue Waterholes on the other, are respectively 30 feet (in part surveyed and in part estimated) and 95 feet (estimated from 1/50,000 Sheet). These give straight line gradients of 1/42 and 1/64 respectively. Thus it seems likely that a more gently falling cave has displaced a steeper one; the geomorphological explanation of this unusual relationship is that the surface stream course between Murray Cave and the Blue Waterholes is more gently sloping still. These facts are not very promising for the condition of the River Cave - Blue Waterholes link in terms of human exploration, though there are sure to be variations in gradient along it. Perhaps the most favourable part will be close to the point of deflection from the Murray Cave route.

Glop Pot fits with difficulty into the system so far established. On the grounds of its apparent isolation (possibly extending to a barrier between its two component parts), its great vertical development in relation to known horizontal extension and especially the great depth to which it reaches below water level compared with the shallow horizontality of the River Cave stream, it has already been suggested that Pot may be a little modified relic from a phase of deep or true phreatic development during the period when the plain represented by the interfluves of Cooleman Plain was formed and prior to its dissection (Jennings, 1967). Two new facts have been established since that view was published. The normal level of water in Glop Pot approximates to that of the surveyed upstream limit of River Cave not far away. Fluorescein reached into the larger pool in the Pot before arriving at River Cave; how much sooner is not known but it is not likely that it was more than 15 - 20 hours at the extreme.

This means that hydrologically Glop Pot is part of the South Branch Sink - River Cave system, even though the nature of the connection is still obscure. However, this does not involve rejection of the previous interpretation of this cave's geomorphology, since it is the common fate of phreatic systems to be progressively incorporated in vadose systems.

The hypothesis of true phreatic origin beneath the plain stage of Cooleman Plain's evolution would make Glop Pot of an older generation than the other caves here, though this does not preclude minor preparation of the limestone for later development of other caves. Only Clown Cave, a cave with some characteristics similar to those of Glop Pot but without water in it (a fact consonant with its location in a more deeply dissected part of the Plain) seems to be a congener. It is difficult, however, to give a date for their formation. According to David and Browne (1950), Cooleman Plain and other upland plains below a postulated summit plain of the New South Wales high ranges were formed in the Pliocene. In large measure this view rests on regarding the Kosciusko Uplift, an epeirogeny affecting the whole of the Eastern Highlands, as late Pliocene-Pleistocene in age. However, Gill and Sharp (1956) have argued from palynological and other evidence from lacustrine sediments beneath basalt at Kiandra that these epeirogenic movements go well back into the lower Tertiary. As the upland plains such as Cooleman Plain could well be the product of planation following the earliest of these movements, there is the possibility that they are much older than Pliocene. Tertiary palynological data are, however, under revision and resolution of the problem may come from radiometric dating of lavas extruded on the plains.

Dating the nearly horizontal cave systems discussed hinges also on the course of the Kosciusko Uplift since they are clearly later than the dissection of Cooleman Plain and this in turn is consequent on further progress in the epeirogeny. However, since the Plain has remained sensibly horizontal and therefore tilting is not involved, rejuvenation has proceeded headwards up the Goodradigbee River system to these innermost limits and this must have taken a long time after the uplift which set this phase of headward recession into motion from the coast. The Pleistocene would seem to be indicated therefore for these caves. The association of the second level of outflow of Murray Cave with an aggradational terrace of very coarse alluvium and the presence of angular limestone gravel in its entrance chamber younger than this second level and probably due to frost shattering have led to the suggestion that part of the cave's history goes back into the Pleistocene (Jennings, 1966). Now that South Branch Sink to Murray Cave has been established as one system and the inflow cave apparently originated prior to the coarse alluvial fill of the South Branch valley, which also is to be interpreted as of periglacial-fluvial nature, this proposition is reinforced, though more positive dating is needed.

The development of the 15 foot threshold in the River Cave dry valley must be concomitant with the development of the tributary stream passage of that cave. Farther up the dry valley there is an angular gravel fill which very likely belongs to a periglacial phase of low evaporation and increased meltwater runoff. The relations between this fill and the threshold are not certain. In the next dry valley to the south investigations in progress have shown that a similar rock threshold has been buried by a similar fill. Together with the substantial time interval that the cutting down of the bedrock 15 feet would seem to require, these facts suggest that the tributary passage developed in the Pleistocene rather than in the Holocene.

The cessation of surface flow along the dry valleys and down the tributary passage could be due solely to the normal course of progressive engulfment of surface drainage in a karst area. However, association with the gravel fills which seem to be of periglacial-fluvial nature suggests that a Holocene climatic change is partially contributory at least. That change would be one of increasing warmth and reduced effective precipitation. What happened to absolute precipitation is, of course, a different question.

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ABSTRACTS

NUSA BARUNG, EGY TRÓPUSI KARSZTZIGET (NUSA BURUNG). By D. Balázs. *Karszt és Barlang*, II, 1966 : 55 - 60.

Off Java's southeast coast the island of Nusa Barung rises from the Indian Ocean. Its area is 80 km^3, the greatest length W-E 17.3 km, the N-S width 4 - 6 km. It is uninhabited under a primary tropical rainforest. The island is made of a relatively hard, dense Miocene limestone, which easily becomes karst. The limestone beds dip 4 - 6 degrees southwards; and the island rises highest on its northern edge, about 250 - 300 m. The average annual rainfall is about 1,300 mm, the average annual temperature at sea level is 26.4 degrees C, the relative humidity 80 - 85%.

The geographical and climatic conditions lead to the development of special tropical karst landforms. On the island there is a close-set system of only periodically active valleys (dry valleys). The underground hydrographic net is poorly developed; large fissure springs and caves are unknown. Between the angular dry valleys, which are however chiefly aligned NE-SW, there are lines of karst hills. The relative relief of about 450 eminences is between 50 and 100 m. These projections are chiefly rounded irregular cones, some of which are not yet properly isolated from one another. So the karst of Nusa Barung consists of much younger forms than the classical, so-called "conekarst" of Gunung Sewu of Lehman. The differentiation of the net of dry valleys and of the hills which fall into different levels must be attributed to the intensity of the precipitation (frequent heavy falls. Karst denudation here chiefly consists of the areal reduction of the surface.

On the basis of T. Soujoso's results, the author describes the most important plants and animals on the island as well as the different mosses on the basis of T. Póc's work. - Author's abstract, translated from German by J.N. Jennings. Original paper in Hungarian.

INDONÉZIA KARSZTBARLANGJAIŔL (KARST CAVES OF INDONESIA). By D. Balázs.
Karszt és Barlang, I - II, 1967 : 7 - 10.

During his journey in Indonesia in 1964 and 1965, the author investigated many karst caves. The article sets out his observations, especially on the genetic characteristics of the karst caves. Special attention is given to the so-called exogenic waters from the non-karst regions, which play an important role in cave enlargement. The most important mean physical and chemical determinations from the cave waters (standing, flowing and dripping waters) are presented. In morphological characterisation of the caves it must be noted that the dripstone decorations have a weak, porous structure as a result of the tropical climatic conditions. An account is given of microclimatic measurements in the caves, of the fauna and flora of the caves, and of their economic and tourist utilisation.- Author's abstract, translated from German by J.N. Jennings. Original paper in Hungarian.

A BLIND MYGALOMORPH SPIDER FROM A NULLARBOR PLAIN CAVE. By Barbara Y. Main.
J. Roy. Soc. W. Aust., 52 (1), 1969 : 9 - 11.

Fragments of a blind troglobitic mygalomorph spider (Dipluridae : Diplurinae) have been collected from Roaches Rest Cave, Nullarbor Plain, and are described as a new genus and species Troglodiplura lowryi Main. No living material has been discovered. This is the first record of a cavernicolous Mygalomorph in Australia. Reference is made to two other undescribed species of troglobitic spiders from the Nullarbor caves.-A.M.R.

END OF VOLUME 7