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Helictite

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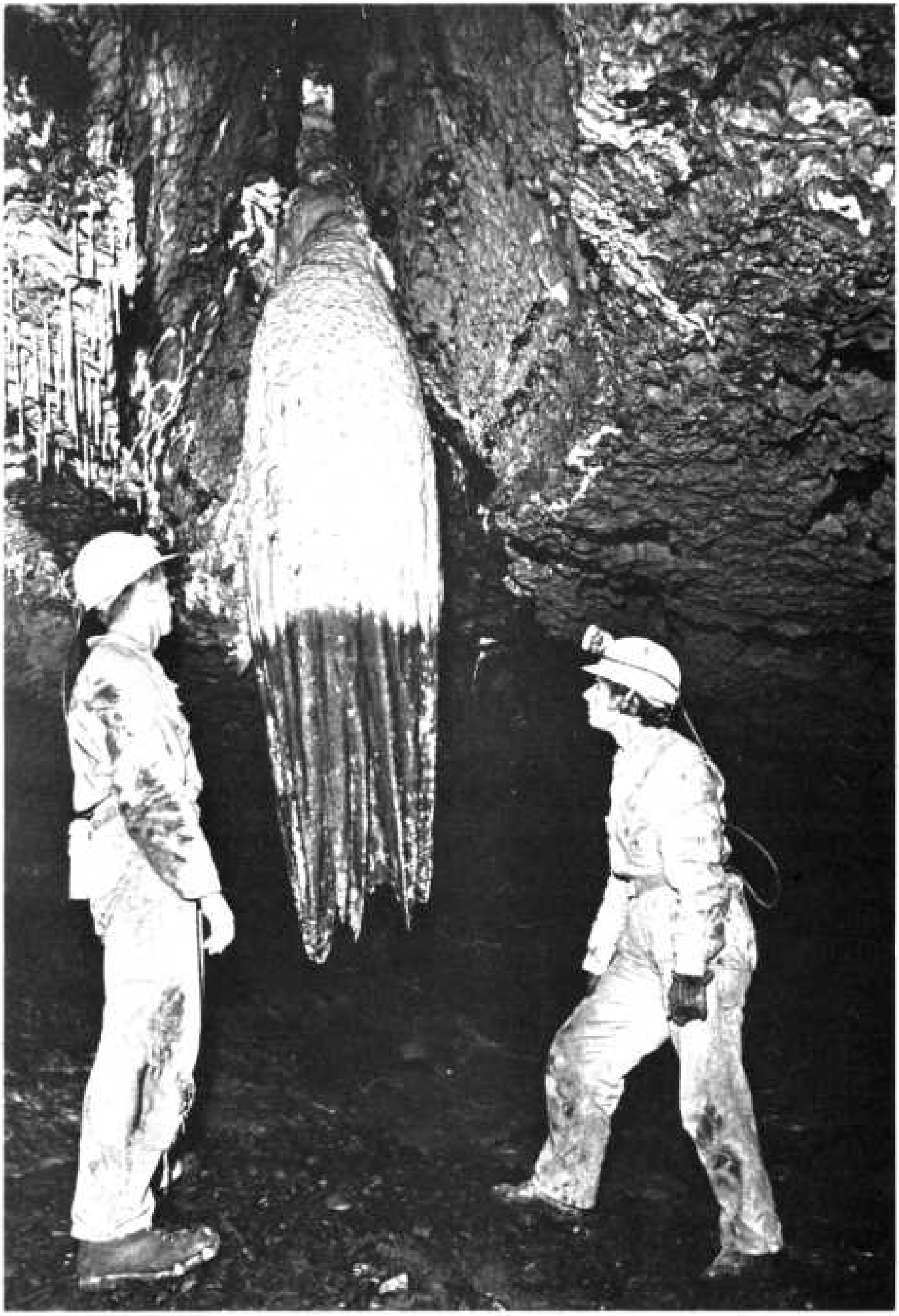

General view of the stalactite in Murray Cave extension, Cooleman Plain, N.S.W., carrying signatures of early explorers. Here the cave is elliptical except for solution widening of joint in roof in which stalactite has formed. Gravel of igneous rocks on floor. See page 23.

Photo. G. Thomson

"HELICTITE"

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REVIEW

CAVES OF THE NULLARBOR. A REVIEW OF SPELEOLOGICAL INVESTIGATIONS IN THE NULLARBOR PLAIN, SOUTHERN AUSTRALIA. Ed. J.R. Dunkley and T.M.L. Wigley. The Speleological Research Council Ltd., Box 35, The Union, University of Sydney, 1967 : 61 pp + vii and 2 foldout maps. Price: A$1.25.

Recently various scientific disciplines have focussed their attention on the Nullarbor Plain, north of the Great Australian Bight, and a considerable amount of work is in progress. Much of this interest has been initiated by the series of speleological expeditions dating from the early 1950s. This book, published towards the end of 1967, reviews in a series of papers by various authors several aspects of the research undertaken up to that time. For this reason, "Caves of the Nullarbor" is a very welcome and valuable addition to Australian speleological literature. Papers are: "The Geographical and Historical Background" by J.R. Dunkley; "The Surface and Underground Geomorphology" by J.N. Jennings; "Meteorology of the Nullarbor Plain Caves" by T.M.L. Wigley and I.D. Wood; "Fauna of the Nullarbor Caves" by E. Hamilton-Smith; "Vertebrate Palaeontology of the Quaternary Deposits of the Nullarbor Plain" by M.R. Walter and N.S. Pledge;"The Anthropology and Archaeology of the Nullarbor Plain" by G.L. Pretty and A. Gallus; "Checklist of Caves and Related Features" by A.L. Hill. One tends to feel, however, that the value of the publication would have been enhanced had production been delayed a couple of years so as to include the great volume of work then in hand in several disciplines. Only geomorphology had reached a stage where it could be adequately reviewed and most of the other papers are of an interim nature, particularly archaeology, biology and palaeontology. Stratigraphy for some reason is ignored. One of the most useful papers to the Australian speleologist is the checklist of caves and localities. In the book, some conclusions have been drawn which are not backed by sufficient evidence. For example, the reviewers query the suggestion that the troglobitic cockroach (p. 40) provides considerable support for a suggestion - no more - by Jennings that at least some cave genesis must have occurred during the Tertiary. While proven geological events can be used to measure animal evolutionary rates and possibly determine the causes of particular trends of evolution, one is very rarely in a position to use evolutionary rates and inferred responses to environmental stimuli as evidence for the timing and nature of geological events. The cockroach cannot be used for assessing the age of the Nullarbor caves. The book was produced jointly by the Sydney University Speleological Society and the Cave Exploration Group (South Australia). It is well printed by letterpress on art paper, extensively illustrated with maps and photographs, and has an attractive two-colour cover on Kromecote. A collective acknowledgment is given on page iv for the photographs. In view of the skill and time involved in cave photography, one wonders why each photo was not acknowledged individually, the additional cost would not have been great. In conclusion, the reviewers believe that "Caves of the Nullarbor" is an important reference for both Australian and overseas speleologists. - A. M. R. and E. A. L.

DROUGHT AND MURRAY CAVE, COOLEMAN PLAIN, NEW SOUTH WALES

J.N. JENNINGS, I. NANKIVELL, C. PRATT, R. CURTIS, J. MENDUM

Canberra Speleological Society

Abstract

The drought culminating in 1967-68 opened watertraps in Murray Cave, thus permitting the re-exploration and survey in January, 1968, of a further 1,000 feet of the main passage. Previous explorations, of which oral tradition persisted, are now known to have taken place in 1902-3 and some details of the early visitors are presented. The characteristics of the extension are predominantly shallow phreatic in nature and about half of it episodically functioning in this way at the present time; the watertraps along it are inverted siphons in the strict sense and located at the sharpest changes in cave direction. The exploration limit consists of a rockfall beneath a doline, which appears, therefore, to be at least in part a collapse doline. Beneath two other dolines the cave has no sign of collapse, though tall avens reach towards the surface; these dolines are due to surface solution only. The forward part of the cave is overlain by a short, steep dry valley; the relationship between the two remains problematic but there is good reason not to regard the dry valley as the determinant of the cave's location. The evidence is now stronger for an earlier hypothesis that the cave was formerly the outflow cave of nearby River Cave, a perennially active stream cave. It also seems likely that the episodic activity of Murray Cave is due to flood overflow from River Cave.

The hydrological regime of the cave is compared with precipitation records of the nearby stations. The edisodic flow through the cave does not require an abnormally wet winter; it can follow fairly quickly after complete emptying of the watertraps and approaches an annual event. Draining of the watertraps is a much less frequent event, but whether a series of low rainfall years is necessary, or a single pronouncedly dry year is sufficient to achieve this, cannot be determined from available data. On either count, it seems probable that the cave opened up two or more times between the known occasions of 1902-3 and 1968 in the period 1909-53 when the cave was visited infrequently.

Introduction

After 14 years of frequent visiting of Murray Cave, Canberra Speleological Society had begun to wonder slightly about the story that during the great drought at the turn of the Century members of the Southwell family penetrated far beyond the watertrap blocking the inner end of the main passage (Jennings, 1966). Various efforts to pass it had failed and the water level never fell low enough to remove the obstacle. However, during a period lasting at least between January 20 and March 10, 1968, drought opened it up and also other watertraps beyond. A further 1,000 feet of cave was surveyed making a total of about 1,700 feet for the main passage.

In this paper some facts relating to the previous explorers of the extension are set out. Then the morphology of the inner part of the cave is considered in relation to that of the outer part previously discussed (Jennings, 1966) and to the surface features. Finally, the hydrology of the cave is related to the history of precipitation of the area in which it is situated.

Early Explorers

On a prominent stalactite (Plate 1) about two-thirds of the way along the extension, the following writings in pencil were found in the following arrangement:

M. Ryan
12 April 1903

Barclay S. Haley
13 April 1903

Miss E. Oldfield
Jack Southwell
M. Southwell
J. C. Moore

23.11.02

Explorers

William Gamble
Frank Sheedy
Thomas Sheedy

First Explorers

The two groups of names are each written in a single hand. At another location near the second watertrap, there is a signature "Malcolm Southwell," corresponding with the "M. Southwell" of the main group of writings, on the stalagmitic part of a column. There is a further signature, "M.E. Gifford 25.2.1903," on a shawl close by. Who were these people who took advantage of the great drought at the turn of the Century?

The story begins in 1881 when Frederick Campbell, a grandson of the famous Robert Campbell of Sydney and of "Duntroon" (in the Australian Capital Territory today), bought "Yarralumla", the present residence of the

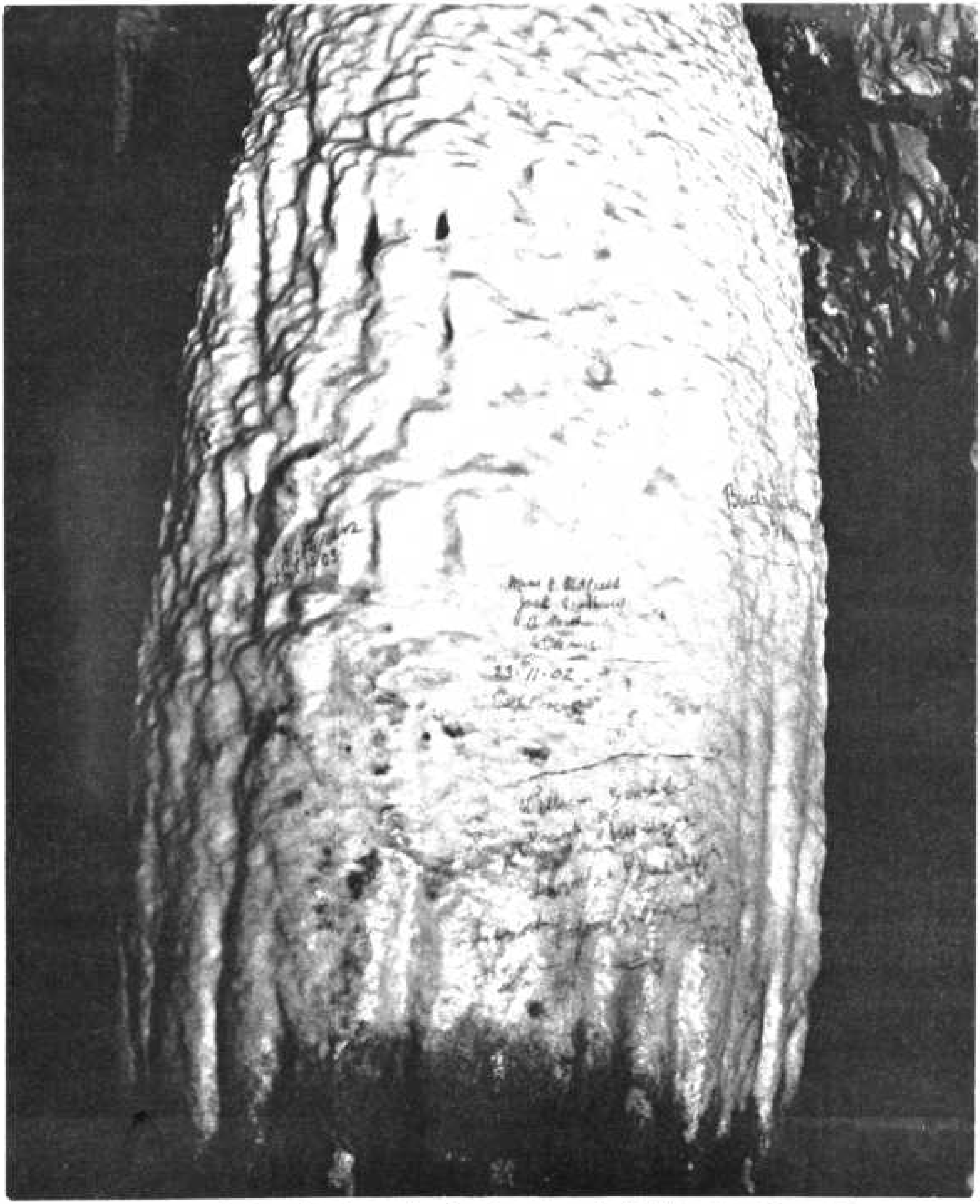


Plate 1. Stalactite towards the inner end of the extension of Murray Cave carrying signatures of the explorers during the 1902-3 drought. Mud on it reaches the level of overspill into forward part of cave. Current markings on bedrock behind stalactite indicate flow away from photographer.
Photo by G. Thomson.

Commonwealth Governor-General, and acquired land on Cooleman Plain for summer grazing of cattle and sheep. In 1882, he sent George Edward Southwell to live on Cooleman to manage it. George drove a bullock dray there, whilst his wife, Ann, rode up sidesaddle with her baby, Eleanor, not two years old at the time. Four sons and two more daughters were born to the Southwells while they lived at Cooleman. They continued to live there till 1908, though during some of the winters Mrs. Southwell and the children went down to the family property, "Rosevale", between Canberra and Sutton.

The eldest son of the family, John Alexander, born in 1884 and dying in 1944, was the Jack Southwell of the cave signatures. Largely self-taught, he nevertheless left Cooleman to become qualified as a school teacher. The life of the land recalled him, however, to the family properties of "Rosevale" and "Fernhill" on the northeastern border of the A.C.T. Malcolm McIntosh Southwell, born in 1888, was the second son of the family and became a ganger in the A.C.T. on the Mt. Stromlo pine plantation. "Mac" volunteered for the Army in the 1914-18 War and served in France where he was killed in 1916.

James Courtney Moore was the son of William Moore who selected about 1900 at Tantangara a little south of Cooleman Plain. During the summer of 1902, J.C. Moore was on this property alone, caring for the stock, and spent his 21st birthday there. However, he wasn't far from the large family of the Southwells. A bush ballad survives, written by one "Bunty" Morris, an old stockhand, in August, 1903, and called "The Coolamon Ball." This tells how pleasant it was "to dance all night till break of day on the edge of the limestone plain." No doubt young Moore shared in the Southwells' dances as well as in the caving activities of the family.

The Miss E. Oldfield of the caving group seems to be Mrs. Elizabeth McInnes of Queanbeyan. She was the youngest of them at the age of 13 and today is the only survivor. She is now 80 and rather infirm. She cannot recall this cave trip nor the circumstances of her being with the party up there, only memories of later visits to Yarrangobilly Caves.

There is a slightly peeved air about the other party's "First Explorers" though their chagrin did not lead them to give the date of their prior visit, unfortunately. It may have been a little earlier in 1902 or even in the year or two previously. By the close of the Century, Cooleman had come to be managed as part of a larger enterprise than before. In 1898 Frederick Campbell and his cousin, Colonel Selwyn Campbell, bought "Cuppacumbalong" on the eastern side of what are now the A.C.T. Ranges. This property was managed for them by George Circuitt, who was also given a share in the ownership. Annually after shearing, the sheep were taken up from Cuppacumbalong across the mountains to Cooleman Plain for the period October to March. Amongst the men engaged in this at the time were the three "First Explorers" and one other of the signatories at least.

"Bill" (William) Gamble originated from Sutton and was bullock driver for Cuppacumbalong. He took the stores and gear up to the Plain for the summer's stay. "Frank" (Francis) and Thomas Sheedy, both in their twenties at the time, were two of four brothers who were all stockmen for George Circuitt. They were sons of John Sheedy, storekeeper of Tharwa, and remained on the land in the Tharwa area the rest of their lives. Martin Ryan of the Ginninderra neighbourhood and later postmaster at Michelago, was another of the stockmen going up for the summer to what later became "Snow Leases" after Government resumption. Once they had their flocks up there, they would have had a good deal of time on their hands, leaving them fairly free to explore caves.

"M.E. Gifford" has not yet been positively identified, but there have been many Giffords in the Queanbeyan district. "Barclay S. Haley" is thought to be a member of a family which also had flocks in this area around 1902-3. Today the name is a prominent one amongst grazing families in the Blayney district farther north in New South Wales.

Two generations ago people living and working in the bush had to fashion their own amusement to a degree hard to envisage in these days of radio, television and quick transport to town. To this we owe our knowledge that Murray Cave was open during what was one of the greatest droughts in Australia since white settlement began.

Survey

On January 24 and 27, 1968, a survey of the extension by miner's dial and steel tape was made by I. Nankivell, R. Curtis, N. Anderson, J. and M. Mendum. On January 24, six points in the cave were fixed on the surface by C. and P. Pratt with radiolocation equipment loaned by the Highland Caving Club. The Pratts then carried out a miner's dial and steel tape traverse of the surface features and radiolocation points and tied them to the cave survey. When the new surveys were assembled by J.N. Jennings with the old survey of the outer part of the cave, using an IBM 360 computer program, it was apparent that there was a gross error somewhere. Resurvey in October of the outer cave traverse stations by R. Curtis, W. and M. Crowle, and of the surface stations using a Wild RDS tacheometer by J.N. Jennings and J. Coulton, eliminated the error which had occurred in the original cave survey at the handover from one instrumental observer to another and as a result also of inadequate checking by the survey leader. The radiolocation points still do not lie precisely above the cave but the discrepancies now lie within the probable errors of the method. The intervening limestone is 160-175 feet thick; the transmitter has no bubble for setting the antenna precisely vertical and a 5^0 error in visual setting, by no means unlikely in cave conditions, subtends 15 feet at 175 feet. Observation in the third watertrap was difficult at the time of survey and the bearing and angle of sight were observed in one direction only. But for this, the survey would fall in CRG Grade 6sD (Butcher and Railton, 1966).

The co-ordinates of the cave plan (Figure 1) have an arbitrary origin of 10000,10000 for station A. It was thought better to do this than to give a spuriously accurate national grid origin for it. The approximate grid reference of station A is 691992 1/50000 Sheet 8626-IV Currango; this reference has, of course, an accuracy of + or - 300 feet.

The Morphology of the Cave and its Relation to Surface Features

The most important feature of the extension of Murray Cave is that it retains essentially the horizontality of the forward part of the main passage. The innermost 100 feet, which is the roomiest part of the whole cave with the exception of the entrance chamber, is also at the same altitude as the latter. There are, however, three watertraps which interrupt this horizontality. The first one, moving inwards, is the deepest, the roof and floor descending 20 feet; it acts as an inverted siphon when the cave stream is functioning. The second and third watertraps are only 100 feet apart, the roof descending about 15 feet, the floor 10 feet; they must be considered as a single hydraulic unit since they act together as an inverted siphon also when there is flow through the cave. When there is overspill from the first watertrap into the forward part of the cave, 600-700 feet of the extension is filled to the roof, disregarding any development of hydrostatic head. The mud coating of the lower part of the stalactite in Plate 1 confirms this inference from the survey data.

It is clear, then, that we have here what Swinnerton (1932) termed a watertable stream, and the former phase of shallow phreatic solution (White, 1960) inferred for the forward part of the cave (Jennings, 1966) is still episodically recurrent in much of the extension. The circularity or ellipticity characteristic of rapid flow in waterfilled passages is clearly recognisable in few of the cross-sections, however (B2, L2, M3). Sometimes joints give rise to an ogival roof (M2, G3/H3) or a floor slot (F2). A more common departure is a very flat floor in bedrock with current markings, sometimes accompanied by banks of allogenic pebbles. This is particularly so behind the third watertrap. In the watertraps and behind them, mud and gravel cover the lower part of the passage more generally, though there is some rock floor with current markings between F2 and G2. The presence of these tools for mechanical action and the occurrence of intervening phases of vadose flow in parts can be expected to cause divergence from forms developed by shallow phreatic solution on its own.

Rock shelves due to shallow vadose incision consequent on a slight rejuvenation occur in the forward part of the main passage but are not found in the inner part of the cave; such effects would not develop upstream of a siphon in a system. Solution of a joint slot in the floor between E2 and F2 gives rise to shelves of a different kind closed off on the downstream side.

In plan, the inner part of the cave resembles the outer in that it reflects joint control with some modification due to meandering. The longest straight stretch of the cave occurs immediately upstream of the first watertrap, with the W-E joint responsible being also expressed in roof and floor features. The watertraps occur where the changes in direction of the cave under joint control are most abrupt and close-set; since this is also true of Dogleg Cave at Wee Jasper, there may be a genetic cause for the association.

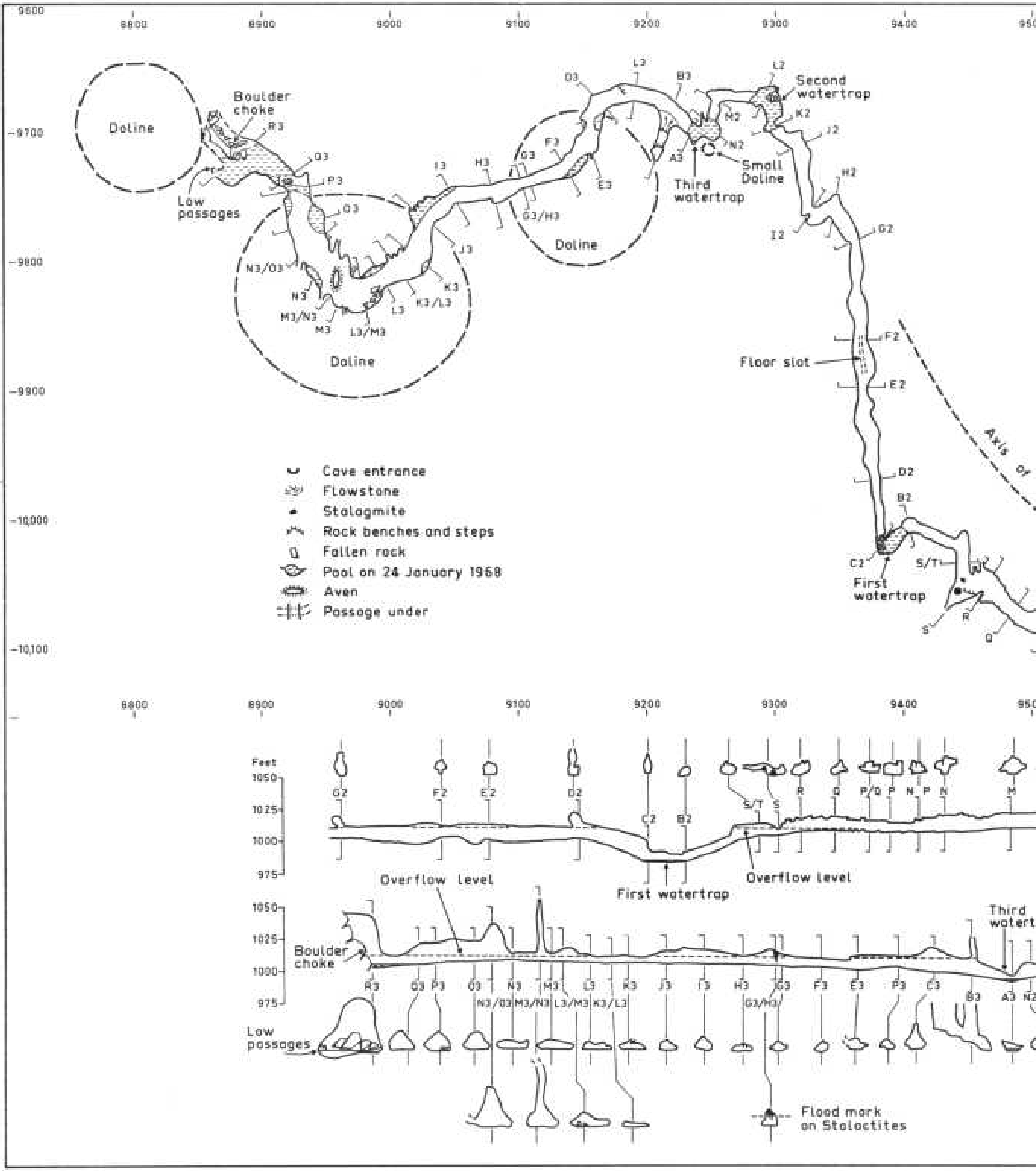
It has been suggested already (Jennings, 1966) that the line of any extension of Murray Cave might be indicated by three dolines, larger than the common size for Cooleman Plain, in the flat interfluve between the North Branch Gorge and the River Cave dry valley. The survey of the extension has justified this prediction, but the relations between the cave and these dolines are not all of the same type.

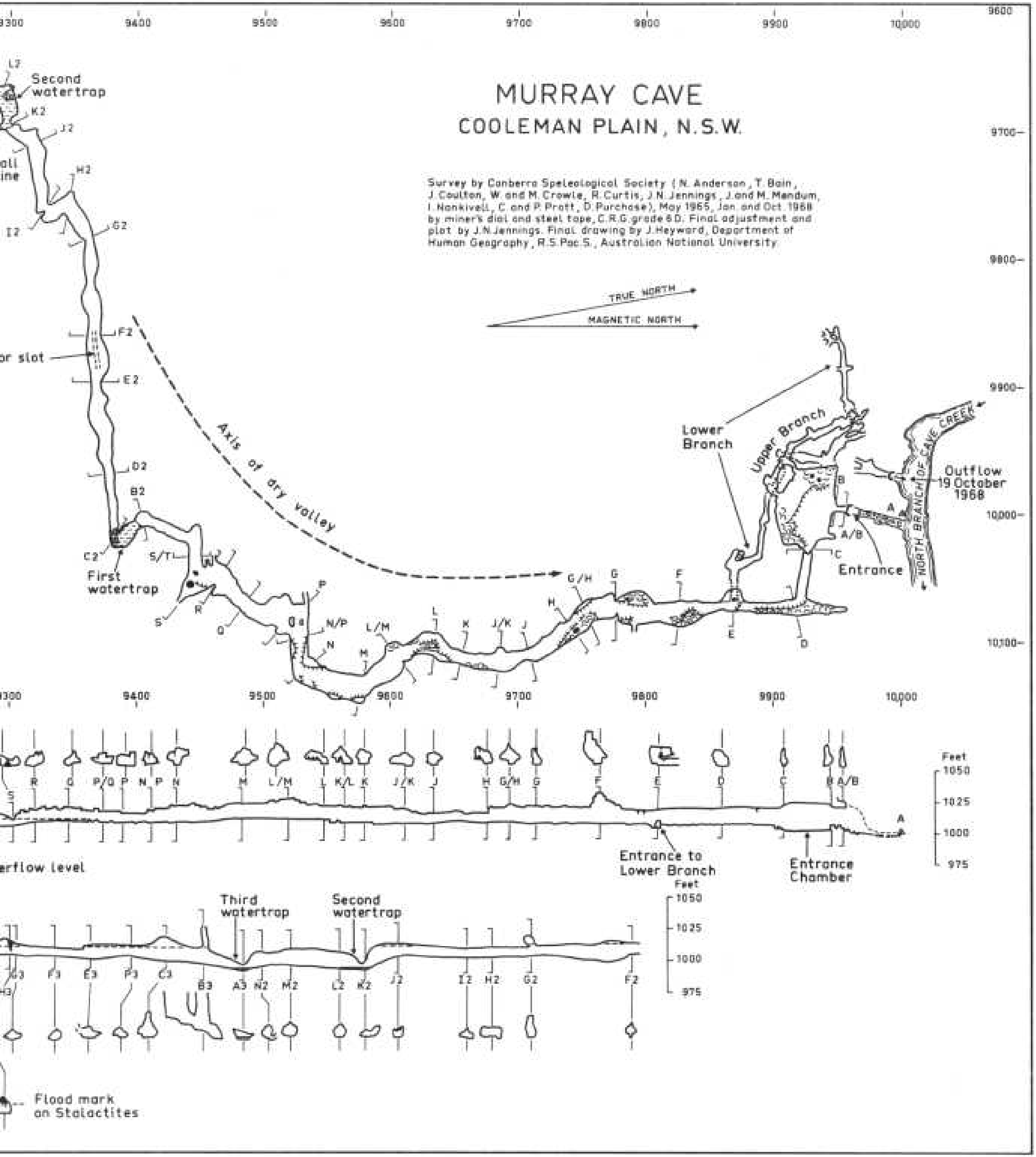
The southernmost doline lies just beyond the proven limit of the cave; it has steeper flanks than the others, including a 10 feet vertical cliff of bedrock, and has a flatter, more sedimented floor. On the western slope there is a large tilted mass of rock projecting from the soil slope. The cave ends in a rockfall 40 feet high against the northern flank of this doline in horizontal position but some 125 feet below it (Figure 1). This proximity strongly favours the idea that the doline is partly of collapse origin.

The next doline, the largest, is more bowl-shaped. Even though the cave roof is higher than average under the southern third of this doline, it is a solid bedrock roof and, under the rest, it is very low and of intact limestone. Cave collapse therefore has played no role in the formation of this doline. The roof is punctured along a joint plane by a tall, narrow aven at least 50 feet high. Reaching to within 100 feet of the surface it has provided for the removal of solutes and residues from the depression which must be regarded as a solution doline. For the aven itself there are the alternatives that it developed from below and localised doline formation or that the doline developed first, concentrated seepage water down a particular joint plane, which was thus enlarged to form the aven.

The same conclusion about the manner of formation applies to the third large doline, similar in shape to the middle one but having a large projecting, undisturbed bedrock mass in its centre. The cave directly below shows no sign of collapse, though there are solution-widened joints. North of this basin, a short joint-controlled side passage leads back towards the doline and has two fissure avens rising to estimated heights of over 140 and 80 feet, respectively. The higher one must reach very close to the surface if this estimate is correct and must be acting as the chief debris chute for this doline.

A broad col separates the three dolines previously discussed above from the head of a short, steep dry valley, which has a gently curving path to


9600
8800
8900
9000
9100
9200
9300
9400
950
-9700
-9800
-9900
-10,000
-10,100
Doline
Boulder choke
R3
Q3
P3
O3
Low passages
N3/O3
N3
M3/N3
M3
L3/M3
L3
K3/L3
K3
J3
I3
H3
G3
F3
E3
G3/H3
D3
L3
B3
A3
Third watertrap
Small Doline
N2
M2
L2
Second watertrap
K2
J2
H2
G2
I2
F2
Floor slot
E2
Axis of
D2
B2
C2
First watertrap
S/T
S
R
Q
Cave entrance
Flowstone
Stalagmite
Rock benches and steps
Fallen rock
Pool on 24 January 1968
Aven
Passage under
Feet
1050
1025
1000
975
G2
F2
E2
D2
C2
B2
S/T
S
R
Q
P/Q
P
N
P
N
M
First watertrap
Overflow level
Overflow level
Third watert
Boulder choke
R3
Q3
P3
O3
N3
M3
L3
K3
J3
I3
H3
G3
F3
E3
F3
C3
B3
A3
N2
N3/O3
M3/N3
L3/M3
K3/L3
G3/H3
Low passages
Flood mark on Stalactites



MURRAY CAVE
COOLEMAN PLAIN, N.S.W.

Survey by Canberra Speleological Society (N. Anderson, T. Bain, J. Coulton, W. and M. Crowle, R. Curtis, J.N. Jennings, J. and M. Mendum, I. Nankivell, C. and P. Pratt, D. Purchase), May 1965, Jan. and Oct. 1968 by miner's dial and steel tape, C.R.G. grade 6D. Final adjustment and plot by J.N. Jennings. Final drawing by J. Heyward, Department of Human Geography, R.S.Pac.S., Australian National University the rocky slopes above Murray Cave entrance. The cave roughly follows the trend of this dry valley, though displaced laterally to lie beneath its eastern and southern flank. Four cave/dry valley relationships can be envisaged:

(1) The correspondence is fortuitous,

(2) the surface and underground features are independently localised by the same structural factors,

(3) the dry valley formed first and it induced sympathetic development of the cave,

(4) the formation of the cave promoted the development of a dry valley above.

The first standpoint is unsatisfactory unless all real explanations are demonstrably inapplicable.

With regard to the second, it has to be recognised that although joints have undoubtedly influenced the cave pattern and similar joints are visible in surface outcrops along the dry valley, outcrops outside the dry valley exhibit similar joints also, and there appear to be no major structural lineaments involved. There seems no good reason to think that one set of structural factors has commanded the development of the dry valley and the cave.

The third type of connection was inferred by Ollier and Tratman (1956) from similar correspondence in pattern between much longer dry valleys and caves in County Clare, Ireland, that the caves developed subsequently to the dry valleys which had gathered drainage to themselves and so promoted underground drainage to replace their surface flow. It must be noted that the geological context is very different from that of Cooleman Plain; in Clare the valleys developed first in a thin shale veneer. Nevertheless, the idea may apply in the case of Frustration and New Year Caves on Cooleman Plain; they follow at shallow depth the trend of the valley beneath which they lie. Part of this valley has an intermittent stream channel and partly it is a dry valley; its length is much longer than the one above Murray Cave and its longitudinal gradient gentler. The caves themselves have youthful features, small cross-section, much braiding, and many sharp projections from all surfaces. However, Murray Cave reaches proportionately a long way beyond its dry valley headwards and, also, there is good reason to think that it was formerly part of a much longer system running across the line of the River Cave dry valley. Consequently it does not seem likely that its downstream part was separately localised by the short dry valley above.

The fourth relationship could be elaborated in the following way. If solution dolines developed over the downstream part of the cave and then a cold climate supervened, which caused more surface flow over frozen ground, (seasonal or permanent), then the assumed line of dolines may have led to overflow from one to another and headward erosion may have linked them to form the dry valley. There is evidence of a cold period on Cooleman Plain from periglacial blockstreams and blocky solifluction earths (Jennings, 1967). However, the time relationship of the dry valleys to it is not completely clear. Several of the longer dry valleys have substantial fills of rather angular fluviatile gravel most probably laid down by periglacial streams. But one of them undoubtedly antedates this phase of aggradation because excavations (Jennings, unpublished data) have shown that the fill has restored a continuous downward longitudinal profile to a former blind valley with a watersink upvalley of a rock threshold (similar to the present situation nearby at River Cave entrance). The periglacial fill choked the watersink and restored surface drainage along the valley floor for a time. The valley was therefore cut prior to the aggradational phase at least of the periglacial period. So it is not possible to argue very strongly that the Murray Cave dry valley formed in the periglacial period. In addition, no avens similar to those associated with the two solution dolines farther back are known in the forward part of the cave.

No firm conclusion seems possible therefore on the relationship between the cave and the overlying dry valley.

Jennings (1966) previously interpreted Murray Cave as a former outflow cave of the River Cave stream. The new data strengthen this hypothesis. Murray Cave has now been traced some 650 feet in a straight line closer to River Cave and the persisting horizontality along the extension keeps it at an appropriate level for such a connection to have existed before. Coarse allogenic gravel occurs along the full length of Murray Cave similar to that found in River Cave. Strong draughts in the final rockfall and low water-filled passages in bedrock to one side suggest continuity beyond the present exploration limit. River Cave has not yet been surveyed at its downstream end, but it is thought to be heading towards Murray Cave. It may be significant that both caves terminate in a rockfall. Rockfall may have helped underground deflection or capture of River Cave into another artery draining directly to the Blue Waterholes.

If cross-sectional area is taken as a measure of capacity, the inner part of Murray Cave's main passage matches the outer part in this respect. However, the whole of the main passage is significantly larger in cross-section than the Lower Branch which is now the effective outflow passage when the cave is active. This suggests that whilst the present entrance to the cave was acting as outlet, the discharge was greater than during the subsequent period when the Lower Branch has been receiving it, perhaps only intermittently from the beginning of its functioning.

It has been suggested previously (Jennings, 1966) that the cave entrance acted as the outlet when an aggradational terrace in the North Branch

Gorge outside, which is at the same level, formed. Aggradation of both stream and dry valleys on Cooleman Plain is common and, as noted earlier, seems related to a former cold climate phase (Jennings, 1967). However, the reduction of discharge in Murray Cave since that time can only be in small part of a product of the change from a periglacial to the present climate, with accompanying reduction of effective precipitation and infiltration; the underground capture discussed above is probably the major cause.

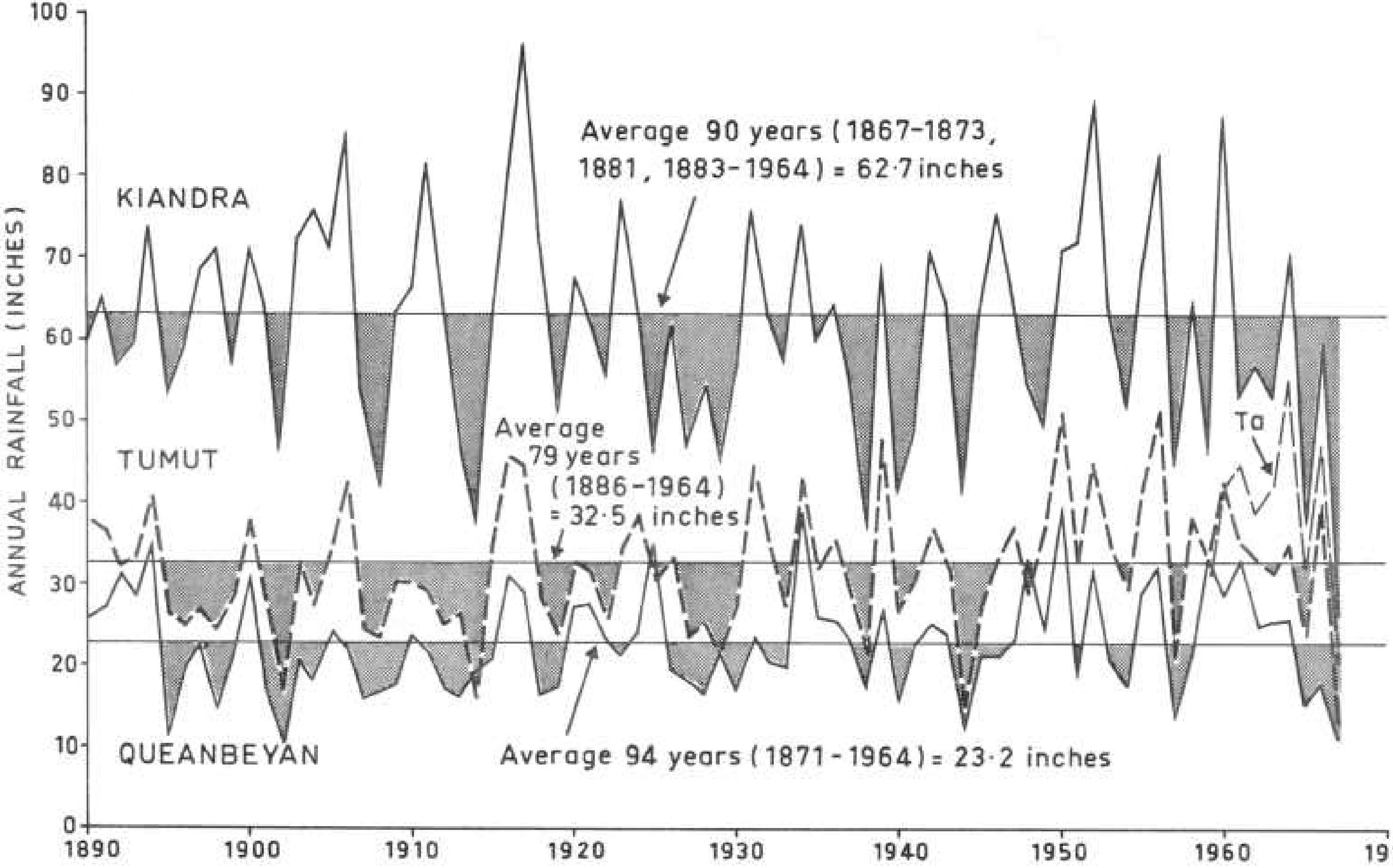
Present Hydrology of the Cave and Precipitation Record

In Murray Cave it is usual for flow downstream of the first watertrap to occur annually. In the majority of the last 14 years this has happened for a few days or a few weeks in winter or springtime. This flow is seldom seen, having only once been recorded by Canberra Speleological Society - October, 1966. Instead, its occurrence is inferred from the reshaping and rippling of sand banks with the removal of the tell-tale footmarks of visitors in the long intervening periods of no flow. After such short-lived flow, the water levels in the first watertrap of the main passage and in those of the Lower Branch gradually fall.

On October 19 and again on November 17, 1968, a strong outward flow of water from the short, low cave a few feet north of Murray Cave entrance was feeding into the North Branch stream. This small cave is penetrable to within 10 feet of the main watertrap in the Lower Branch of Murray Cave and fissures lead further in this direction. Nevertheless, there was no flow along the main passage of Murray Cave on October 19. There had been recent flow prior to October 19 and the water level in the first watertrap was very high, not much below overspill. The Lower Branch watertrap was also high. Thus there seems to be an unknown line of flow directly to it. Observations in the inner part of the main passage are relevant here. On January 20 and 21, 1968, all main passage watertraps were open but there was a good rain over the weekend and on October 24 the third watertrap was closed. Water was seen escaping from the second watertrap pool through several deep and narrow cracks leading north from the northern wall of the cave here. Thus there may be connections between the second watertrap and the Lower Branch, probably of a most exiguous nature, unfortunately.

The case for regarding the cave as the former outflow of River Cave has been restated above. There is a separate but related question as to whether the episodic flow occurring in Murray Cave nowadays represents flood surplus from River Cave. River Cave is so near to Murray Cave that the possibility seems slight of any other major underground river being involved. There is the further possibility to be considered that seepage water accumulates in Murray Cave to cause overflow.

Using Trombe graphs, water from the first watertrap was found to be



ANNUAL RAINFALLS 1890—1967

Figure 2.

aggressive with respect to $CaCO_3$ in seven out of eight samples collected on seasonally scattered occasions in the years since 1956. The odd sample was just saturated and was collected after a long dry spell. Seepage water usually has been found to be saturated after infiltrating through a modest thickness of limestone (Holland and others, 1964; Williams, 1968). However, only eight out of 19 drip samples from Murray Cave (admittedly collected on three occasions only) showed saturation. Nevertheless, using Student's t-test, significant difference at the 0.1% level between the drip and watertrap samples was determined in respect of both calcium and total hardness.

	Mean Calcium Hardness mg/1	Mean Total Hardness mg/1
Drip Samples	147 ($\sigma = 22$)	157 ($\sigma = 18$)
Watertrap Samples	103 ($\sigma = 19$)	111 ($\sigma = 18$)

These figures show that the watertrap water cannot be primarily supplied by local seepage especially as stagnant conditions in the trap would probably increase the hardness of river water ponded there; there are certainly no signs of precipitation in the trap, which might point to loss of carbonate.

Although there are some stalactites and stalagmites in the inner part of the cave, they are much less frequent than in the forward part. This also points to the unlikelihood of the upstream section filling up and discharging as a result of accumulation of seepage water. Furthermore, many of the straw stalactites in the inner part terminate at common levels suggesting solutional removal when the cave has a high water level through influx of aggressive river water. The mud coatings are also more indicative of river flow than seepage.

Lastly, even in wet weather, the amount of seepage water entering the forward part of the cave is incapable of causing river flow there. There is no reason to think that the quantities of seepage water entering the inner part will be substantially greater in proportion to length. The reworking of masses of sand by river flow in the forward part of the cave when it is functioning witnesses a substantial flow. The conclusion is drawn therefore that the episodic flow in Murray Cave is due to flood overflow from another cave, in all probability River Cave.

The nearest long-established rainfall station to Cooleman Plain is at Kiandra 20 miles to the southwest. Figure 2 shows how sympathetically the annual rainfall records of Kiandra, Tumut 34 miles to the northwest of the Plain and Queanbeyan, 37 miles to the northeast, followed one another since 1890. Thus, although the absolute values of Kiandra cannot be applied to Cooleman Plain, the trends can be used with some confidence as an indication of what has happened there. Over a much shorter period Tantangara Dam also has moved sympathetically. Its closeness in position and altitude make it possible to make extrapolation of absolute values to Cooleman Plain of some worth, but in the present context its chief value resides in the support it gives to using Kiandra's long record as a guide to precipitation history in Murray Cave's vicinity. Nevertheless, elaborate mathematical manipulation of the figures is not justified when there is extrapolation over such a distance.

In 1968, the interval between the two extremes of emptiness and overflow in the Murray Cave watertraps was seven months at the most and may have been a good deal less. At Tantangara the months of May, August and October were rainy but the winter was only an average one in this respect. Prior to October 17, there were only three days of more than one inch of rain - October 7 (1.79 in.), August 10 (1.50 in.) and May 11 (3.05 in.) (Figure 3). Again a markedly wet winter overall does not seem necessary for flooding on the basis of the October 1966 overflow. At Kiandra only one month, July, in the preceding six had above average rainfall. However, at the nearer station of Tantangara, this month had 8.23 in. and included falls of 2.2 and 1.5 in. on successive days. The winter as a whole was marked by a number of very intense rainfalls for the area. Nevertheless, there was also flow during the winter of 1965 when the winter was generally less wet than 1966 and there were fewer heavy raindays at Tantangara. Flow is recorded to have occurred in the winter of 1959 as well, and this also was a drier winter at Tantangara and Kiandra. All this goes to confirm piecemeal records over the years that overflow from the watertrap approaches an annual event.

There is no truly dry season on the average in this part of New South Wales but the driest months are usually December to March (Figure 4). These are also the months of greatest evapotranspiration. It is at this time of the year that cavers visit the Plain most frequently and, in consequence, it is unlikely that an opening up of the watertraps in Murray Cave has gone unnoticed since 1954. The infrequency of this happening may suggest therefore that it is a product of several dry years, not solely of a single dry season. After a flood surplus has topped up the inner part of the cave, we know that the first watertrap lowers in level very slowly most of the time. This loss will mostly be by percolation through narrow joints, rather than by evaporation, since the air nearby is close to 100% relative humidity. Several years of drought, therefore, may be necessary in which this process of gradual loss is not interrupted by refilling of the traps.

On the basis of the Kiandra figures, the 1967-68 summer has followed a series of years since the 1960-61 summer when rainfall has been below normal or reached drought conditions, and interrupted only by 1964 when the annual rainfall went modestly above the long-term mean (Figures 2 and 4). Whatever the comparisions elsewhere in Australia, at Kiandra the great drought of 1895-1903 was by no means so rigorous. Only four of these nine

DAILY RAINFALLS AT TANTANGARA DURING TWO YEARS WHEN MURRAY CAVE WAS ACTIVE

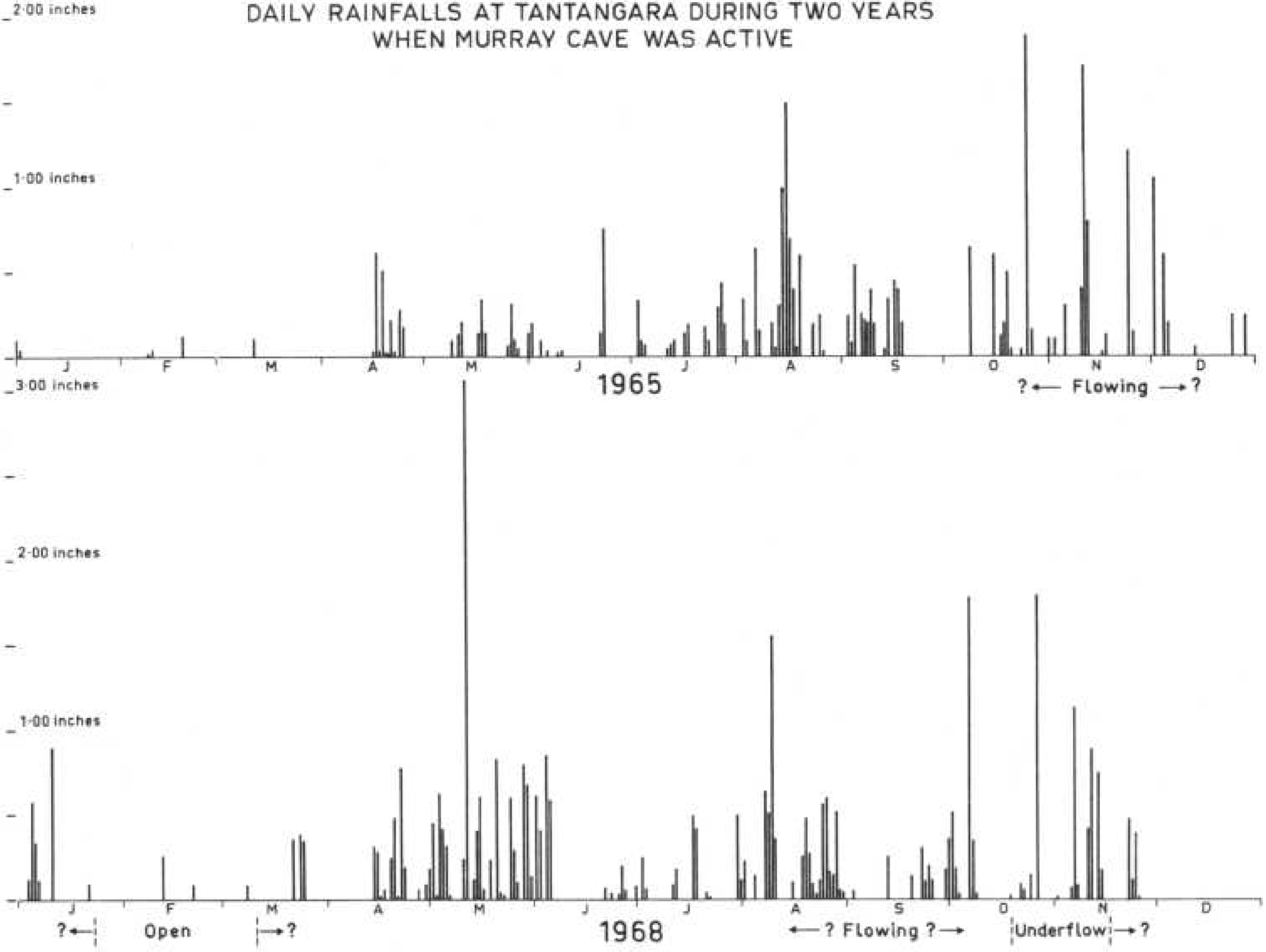


Figure 3.

years went below the mean annual rainfall and of these only 1902 fell drastically below normal. Nevertheless, we know that this sequence of years did lead to the drying out of Murray Cave for a period in the 1902-3 summer equivalent at least to the recent occasion. On the counterbalancing side it must be noticed that none of the above normal rainfall years was excessively so. Moreover, the Tumut and Queanbeyan records show only one year above normal rainfall in the 1895-1903 period; so Cooleman Plain may have been somewhat drier than Kiandra during the great drought.

If a period of this type of several unfavourable seasons governs the draining of Murray Cave, Figures 2 and 4 suggest that the inner part of the cave may have been open on two other occasions - namely, 1924-30 and 1936-41. From the 1923-24 summer to that of 1929-30, not one annual rainfall reached the mean figure and so this long drought may have drained the cave in the summers of 1928-29 and 1929-30. The 1936-41 period was perhaps not quite so conducive to emptying because an above-average year, 1939, interrupted the sequence to top up the traps and generally sequences of wet and dry months were more intermingled. Nevertheless, the 1938-39 summer and the 1940-41 spring may have been good for caving in Murray Cave.

An alternative view of the watertrap behaviour is to assume that the traps are replenished annually, if not necessarily to overflow level, and that one markedly dry season alone will open them up. The 1967-68 instance suits this hypothesis well since 1967 produced the lowest annual rainfall on record at Kiandra, 25.8 in. (41% of the mean), with 11 out of 12 months below their own means. (It was also at 21.1 in., the lowest annual rainfall in nine years of record at Tantangara). In contrast the 1902-3 case is much less rigorous. 1902 had 47.4 in. (75.6% of the mean). However, nine out of the 12 months preceding November, 1902, the month of the first entry into the cave extension, had less than their normals and of them two had practically no rain at all. On this basis at least two more must be added to the potential number of years when Murray Cave is likely to have been open. Prior to April, 1915, only two of the preceding 12 months had more than their normals and 1914 had the third lowest annual total recorded, 37.47 in. Also March, 1909, followed an identical proportion of dry to wet months in the preceding 12. Nevertheless, there is no certainty about these comparisons because matching statistics can be produced from the 1965-66 period when water levels remained too high for free passage.

On balance, it seems likely that there were several occasions between the departure of the Southwells from Cooleman Plain in 1908 and the beginning of intensive caving there in 1954 when Murray Cave was passable readily from end to end. This is more promising for the future than the bare facts of actual entry in 1902-3 and 1968. Moreover, knowledge of the length and trends of the first watertrap may encourage properly equipped divers to venture through at water levels quite often found when the trap is only some 60-70 feet long.

MONTHLY RAINFALLS IN INCHES AT KIANDRA, N.S.W., FOR DROUGHT PERIODS SINCE 1894

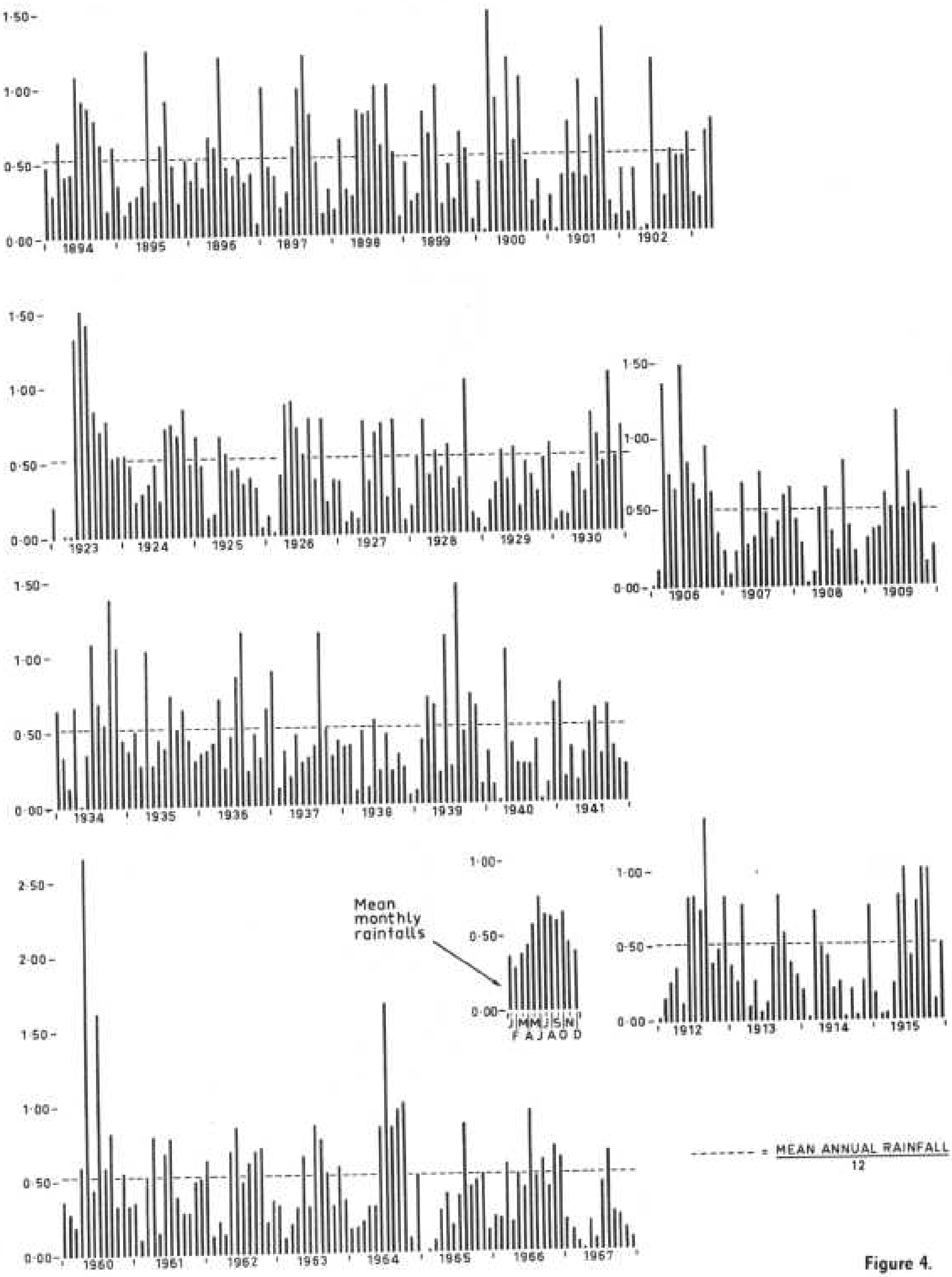


Figure 4.

Acknowledgments

Mrs. N. Phillips, History Department, R.S.S.S. in the Australian National University, Canberra, kindly directed us towards likely informants on the local history. Mr. P.B. Sheedy, Mrs. E. Mackinnon (née Southwell) and Miss P.E. Oldfield were most helpful in providing material from which the account of the early explorers was drawn. Most of the hardness determinations were done by Mr. K. Fitchett, Department of Biogeography and Geomorphology, ANU. Rainfall statistics were provided by the Sydney branch of the Commonwealth Bureau of Meteorology and the Snowy Mountains Hydro Electric Authority. The article has benefited from the criticism of Dr. P.W. Williams.

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REVIEWS AND ABSTRACTS

SOIL DEVELOPMENT ASSOCIATED WITH STRANDED BEACH RIDGES IN SOUTH-EAST SOUTH AUSTRALIA. By G. Blackburn, R.D. Bond and A.R.P. Clarke. Appendix by N.H. Ludbrook. CSIRO Soil Pub. No. 22, 1965 : 76 pp. + 4 folded maps in pocket.

This paper has considerable interest for speleologists concerned with cave areas ranging from Kangaroo Island, south of Adelaide, and the mainland coastal areas from the Murray River and Lake Alexandrina southeast to the Glenelg River. The main types of soil in the area are considered, their derivation and development, variation within each type, climatic effects, and age sequences. Some of the soils probably represent the effect of weathering and soil formation during hundreds of thousands of years, while others, particularly the soils at Mount Gambier on volcanic ash, represent a soil formation period of no more than a few thousand years. Limestones are discussed (e.g. the Gambier Limestone, the Naracoorte Limestone) and the very extensive areas of Quaternary calcareous beach sands. Vertical solution pipes, mostly filled with earthy material, are discussed at length and are compared with similar earthy pipes in limestone in dune limestone in Western Australia and Victoria, as well as Bermuda and the Mediterranean coast in Syria. Hollow concretionary limestone structures 2-3 feet high and 1-2 feet in diameter in southwest Victoria, for example, are suggested as the hardened sides of former solution tubes. The existence of pipes in the Quaternary limestone in the area under consideration is regarded as evidence of karst development and it is regarded as significant that sinkholes and limestone caves also are known in this limestone as well as in the Tertiary limestone at Naracoorte and Mount Gambier. Karst features include terra rossa, lapies, sinkholes and associated forms, natural tunnels and bridges, erosion remnants and solution caves. Solution caves are present in several of the stranded beach ridges, mainly in the more inward ones. Similar solution caves are found in the dune limestone of Kangaroo Island and southwest Victoria. Solution pipes are a much more widespread karst feature than caves and although such pipes show only shallow development nearer the coast, they are found even at the coast.

Four folded maps are contained in a pocket at the end of the publication. One of these maps, "Distribution of Major Karst Features in South-east South Australia" (1963) plots sink holes, earth-filled solution pipes 6 ft or more below the upper surface of the limestone, and solution caves. The map limits are 139 to 141 deg. East and approximately 35 deg. 30' to 38 deg. 10' South. Another of the maps shows "Distribution and Depth of Solution Pipes at Sites Studied" in the same area. It shows earth-filled solution pipes and the approximate boundary of solution pipe occurrence. - E. A. L.

FOSSIL BANDICOOTS (MARSUPIALIA, PERAMELIDAE) FROM MAMMOTH CAVE, WESTERN AUSTRALIA, AND THEIR CLIMATIC IMPLICATIONS. By D. Merrilees. *J. Roy. Soc. W.A.*, *50*, 1967 : 121 - 128.

It is shown that the bandicoot genera *Isoodon* and *Perameles* are represented in fossil deposits from Mammoth Cave, Western Australia, but not *Macrotis* or *Chaeropus*. The abundance of *Perameles* relative to *Isoodon* appears to have declined markedly between the times of accumulation of the Mammoth Cave fossil deposits and the present. Some environmental change must be postulated for this decline, and such change may be dated as late Pleistocene. It is possible but not proven, that the environmental change may have been associated with an increase in rainfall.

PHILONTHUS PARCUS SHARP (COLEOPTERA : STAPHYLINIDAE), A JAPANESE ROVE BEETLE ESTABLISHED IN AUSTRALIAN CAVES. By B.P. Moore. *J. Aust. ent. Soc.*, *7*, 1968 : 163 - 164.

Philonthus parcus Sharp, first described from Japan in 1874, has recently been recorded from Britain and Australia. In Australia it occurs in both caves and epigean habitats. It is recorded from rotting vegetable matter near Leongatha, Victoria; Guano Cave, Lake Gillear, Victoria; Church Cave, Wee Jasper, N.S.W.; and Carrai Bat Cave, near Kempsey, N.S.W. The diagnostic features of the species are figured and described. - A. M. R.

THE CAVERNICOLOUS STATUS OF SOME SPECIES OF MACROPATHINAE (ORTHOPTERA : RHAPHIDOPHORIDAE). By Aola M. Richards. *J. Aust. ent. Soc.*, *7*, 1968 : 87 - 89.

The cavernicolous status of some species of Macropathinae from New South Wales and Tasmania is discussed as their ecological status has recently been questioned by Y. Leroy and E. Hamilton-Smith. Their comments are refuted due to lack of evidence. All cavernicolous species studied so far are classified as troglophiles. No trogloxenic Macropathinae are known. - A. M. R.

AN INTRODUCTION TO THE GEOMORPHOLOGY OF AUSTRALIA. By G.H. Dury. P. 1 - 36 in *Studies in Australian Geography*, 1968. Heinemann Educational Australia.

A highly condensed geomorphological background to the Australian environment written primarily for undergraduates and High School students in final years. Only one or two brief passing references to caves (e.g. the Nullarbor Plain), but a useful reference for speleologists. - E. A. L.

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