VOLUME 18(2) 1980

Helictite

JOURNAL OF AUSTRALASIAN CAVE RESEARCH

Neil Hickson using the Cord Technique in Drum Cave, Bungonia.
Photograph by Alan Warild.

HELICTITE

Helictite was founded by Edward A. Lane and Aola M. Richards in 1962.

This Journal was (and is) intended to be wide ranging in scope from the scientific study of caves and their contents, to the history of caves and cave areas and the technical aspects of cave study and exploration. The territory covered is Australasia in the truest sense – Australia, New Zealand, the near Pacific Islands, New Guinea and surrounding areas, Indonesia and Borneo.

In 1974 the Speleological Research Council Limited agreed to support the Journal with financial assistance and in 1976 took over full responsibility for its production.

Speleological Research Council Limited

The Speleological Research Council Limited, the publisher and owner of Helictite, is a non-profit limited liability company incorporated in May 1964. The aims of the Speleological Research Council Limited are:-

To explore and chart and organize and promote the exploration and charting of caves and cave systems.

To promote, support and assist in the scientific evaluation and investigation of caves and to foster speleology as a science and a sport.

To promote and to assist in the promotion of speleology and speleological Societies and to assist such Societies with grants of money and otherwise.

Helictite

JOURNAL OF AUSTRALASIAN CAVE RESEARCH

VOLUME 18(2) 1980

CONTENTS

Review: Elements de Karstologie Physique by Richard Maire - Jane Dyson 30

A Review of the Cord Technique (La Technique Cordelette) - A.T. Warild 31

Equilibrium versus Events in River Behaviour and Blind Valleys at Yarrangobilly, New South Wales - J.N. Jennings, Bao Haosheng and A.P. Spate 39

Caves, Graves and Folklore of Normanby Island, Papua New Guinea - C.D. Ollier and C.F. Pain 55

"HELICTITE", Volume 18, 1980 consists of two issues. Price per volume Aust. $8.00 post paid. "HELICTITE" is printed and published by the Speleological Research Council Ltd. Except for abstracting and review, the contents may not be reproduced without permission of the Editors. All correspondence to: P.O. Box 183, Broadway, N.S.W. 2007.

REVIEW

ELEMENTS DE KARSTOLOGIE PHYSIQUE, by Richard Maire. Spelunca Spécial No.3, 1980. Pp 56

This publication is a special issue of the French caving journal Spelunca, and is devoted to a summary of the study of physical aspects of karst, "karstologie physique". It is divided into five parts:

1. Fundamentals of the study of physical aspects of karst,
2. Hydrology of karst,
3. Geomorphology of surface karst features,
4. Physical study of caves,
5. Karst regions.

The publication is a French language summary of material we would normally expect to find in such books as Karst, by J.N. Jennings (A.N.U. Press, 1971) and The Science of Speleology, by T.D. Ford and C.H. Cullingford (Academic Press, 1976). As an introduction to cave and karst study for those who would not usually read a reference such as those quoted, this publication has definite value. It also includes a brief summary of caving and karst areas around the world (Part 5).

This review does not present much in the way of new ideas, but concentrates on giving a concise summary of previous work. In some cases this brevity is a little extreme, causing the text to assume more the nature of a list of technical terms than a coherent essay. The opening chapter assumes absolutely no geological knowledge on the part of the reader - one section introduces him to "Scientific Importance of Fossils - Palaeontology", and a later section of the same chapter shows several very clear though rather elementary diagrams of folds, faults, etc. Clearly this section is intended for the geologically rusty reader. It could also have a real interest for those who know the material in English, in that the French terms for many geological features and processes are quite different from ours (so much for the "international language of science"!).

The publication has many black and white photographs of good (not excellent) quality, and many line drawings which are always clear and well-labelled. On the whole it is an interesting summary, strictly for the layman caver, of physical studies of caves and karst.

Jane Dyson

A REVIEW OF THE CORD TECHNIQUE (LA TECHNIQUE CORDELETTE)

A.T. Warild

Abstract

The technique of descending a multi-pitch cave with only one rope, leaving a thin cord on each pitch for re-rigging the ascent, has recently become popular in France. This paper described some improvements to the technique and assesses its place in Australasian caving.

INTRODUCTION

The Cord Technique is a modification of the usual Single Rope Technique, which can be used to reduce the amount of prusiking rope required for a multi-pitch cave to such a degree that solo or lightweight trips are possible. The technique involves the use of a light cord and a modified prusiking rope which is as long as the longest pitch to be encountered. The rope is lowered to the bottom of the pitch by the use of the cord, a double length of which is left hanging down the pitch. On the return journey the rope is replaced in position by hauling it up on the cord.

The Cord Technique was first developed for rock climbing, however it has been successfully adapted for caving and has been used for several years. Recently there has been an upsurge in lightweight and fast caving and this has probably led to the renewed interest in the Cord Technique.

In the Australian context, the Cord Technique finds only limited application as there are few multi-pitch caves here. The equipment for most of these can easily be carried by one caver. It may not be much use at Cliefden but for anyone contemplating expedition caving in New Guinea or New Zealand, a few hours dangling around with a bag of cord could be useful. For the technically minded Australian caver it is a new development.

THE TECHNIQUE

"Why use the Cord Technique?"

The Cord Technique is not for SRT beginners, the level of expertise needed is such that it should only be attempted by those completely familiar with SRT. Even then it is first necessary to practise in a safe place where there is unlikely to be any danger should the rigging tangle. With this proviso, the technique has several potential applications:

1. On expeditions, the Cord Technique can be used to increase the effective amount of rope available. By taking along a few rolls of cord a cave may be pushed much deeper than budgeted for. When the rope has completely run out, suitable pitches could be re-rigged using the Cord Technique so that the rope gained may be used to further extend the cave.

2. A fixed line can be left on an upward climbed pitch, e.g., a blind shaft so that a rope may be installed for future exploration or work. During the exploration of Nettlebed Cave in New Zealand, a considerable length of rope was left behind during de-rigging when the retrieval cord tangled. Had the cavers involved had a knowledge of the Cord Technique as described here, their chances of successfully retrieving the rope and leaving a fixed line might have been increased.

3. When the amount of equipment needed to tackle a cave is so large that the number of cavers involved would have difficulty carrying or have to resort to ferrying it, the Cord Technique can be used to lighten the load. The ideal quantity of equipment is one pack per person. With the use of the Cord Technique it is now possible for a small group of cavers to tackle the deepest caves which in the past have required major expeditions. The Gouffre Berger (Vercors, France) is an ideal cave in which to use the Cord Technique. It has a large number of pitches, which formerly required a vast amount of tackle; most of these pitches can be rigged free, (usually from bolts) and are of moderate length. In the Berger the Cord Technique works so well that this very deep cave has now been soloed; a virtually impossible task without its use.

Rigging for the Cord Technique

The cave must be rigged with each pitch free to ensure that the cord and rope will run without snagging. This may require extra rigging equipment to be carried.

Karabiners may be used to anchor the rope but it is preferable to use some sort of chain-linking device such as 7 or 8 mm Maillon Rapide, Super Link or Quick Link (Plate 1); all three are different brands of the same device. These are used because they are safer than karabiners as they can withstand considerable sideways loads; because they are smaller and more suitable for jamming the figure of 8 knot (Figure 2a); and because they are considerably cheaper (around half the price of the cheapest locking karabiner). They are not commonly used in Australian caving, but Quick Links are available from some hardware shops.

It appears from the available literature that French cavers use 3 mm nylon kernmantel (Perlon) for the cord, but it can be an extravagance unless it is to be left as a permanent fixture. Perlon is twice the price of nylon No. 16 venetian blind cord and while it is much stronger and possibly easier to handle, blind cord is adequately strong, lighter and less bulky. When in the cave, much care must be taken in handling the cord and although diver's line spools have been suggested, the author prefers a small sack about 30 cm tall from which the cord will run freely. Such a sack will also pack easily when not in use.

The SRT rope used in the Cord Technique must be adapted in that one of its ends must taper from 10 mm diameter down to 3 mm diameter without a sudden change in size. While the French tapering method is adequate (Martinez, 1979) it involves two knots passing through the Quick Link instead of one; also, as the cores in many ropes are somewhat loose, an external knot may lack durability. The method used by the author attaches the rope to a 3 mm cord (Figure 1) inside the rope thus giving a perfectly smooth transition from 3 mm to 10 mm. The most suitable rope for the Cord Technique is a 10 mm rope with a substantial core, and a thin sheath, such as Downs 10 mm 16 plait multifilament polyester. A staple rope such as Marlow 10 mm is not suitable because of its thick sheath. Thicker ropes such as 11 mm Bluewater are stronger but heavier and thus much harder to replace on the pitch because of their extra weight. This extra weight affects the length of pitches which can be rigged and the extra bulk of thick ropes can also cause problems. The increased abrasion resistance of thicker ropes is unnecessary for a system which is essentially rigged free. The 10 mm and 9 mm Bluewater ropes that have recently reached the Australian market may be suitable but as yet have not been tried.

Preparing the SRT rope (Figure 1)

a & b) The rope is prepared by first pushing back the sheath to expose about 30 to 40 cm of the core.
c) The core is then tapered so that it thins down to a single strand which is 15 cm longer than any of the others.
d) On to this one strand of core a metre of 3 mm Perlon cord is tied with a single fishermans knot (a double fishermans knot is too large to fit inside the rope sheath).
e) Next the sheath is dragged into its original position so that the knot is 15 cm inside the rope (this is difficult with a 10 mm rope especially if the sheath is too thick). The rope sheath is whipped with thick synthetic thread to the 3 mm Perlon, starting about 2 cm from the sheath's end and continued, pruning bundles from the sheath, to give a smooth transition to the 3 mm cord.

The resulting rope end should taper unformly from 10 mm to 3 mm diameter over a distance of 30 cm, with only a slight bulge where the knot lies.

Selection of suitable pitches

With this special gear, and the SRT caver's usual collection of traces, slings and bolts, a caver is equipped to use the Cord Technique on any suitable pitch. For a pitch to be suitable, it must be able to be rigged free or almost free of the wall so that the cord and rope will run freely without snagging. It may be possible to rig sloping pitches provided the rock is sufficiently smooth. However, in this case the Quick Link should be completely away from the rock. A suitable pitch must also be relatively dry, or water movement may cause the cord to tangle or abrade. The length of the pitch appears to be limited to about 40 m; on longer pitches wet ropes may be too difficult to replace because of their weight. On long pitches a pulley will make replacing the rope easier but the pulley should not be one in which the cord can jam. The pulley is also completely supporting the caver and it is therefore preferable to use a Petzel safety pulley rather than the more common split type. To satisy these requirements and make the pitch suitable the caver must often spend considerable time and effort arranging the rope so it hangs free. This frequently makes the start of the pitch more difficult because the Quick Link will be located below the lip of the pitch (Figure 2 f). In the case, it is occasionally necessary to use a handline for a safe approach. Back- up belays may be required and where these are involved a large amount of extra rope may be required.

Figure 1 PREPARING THE SRT ROPE

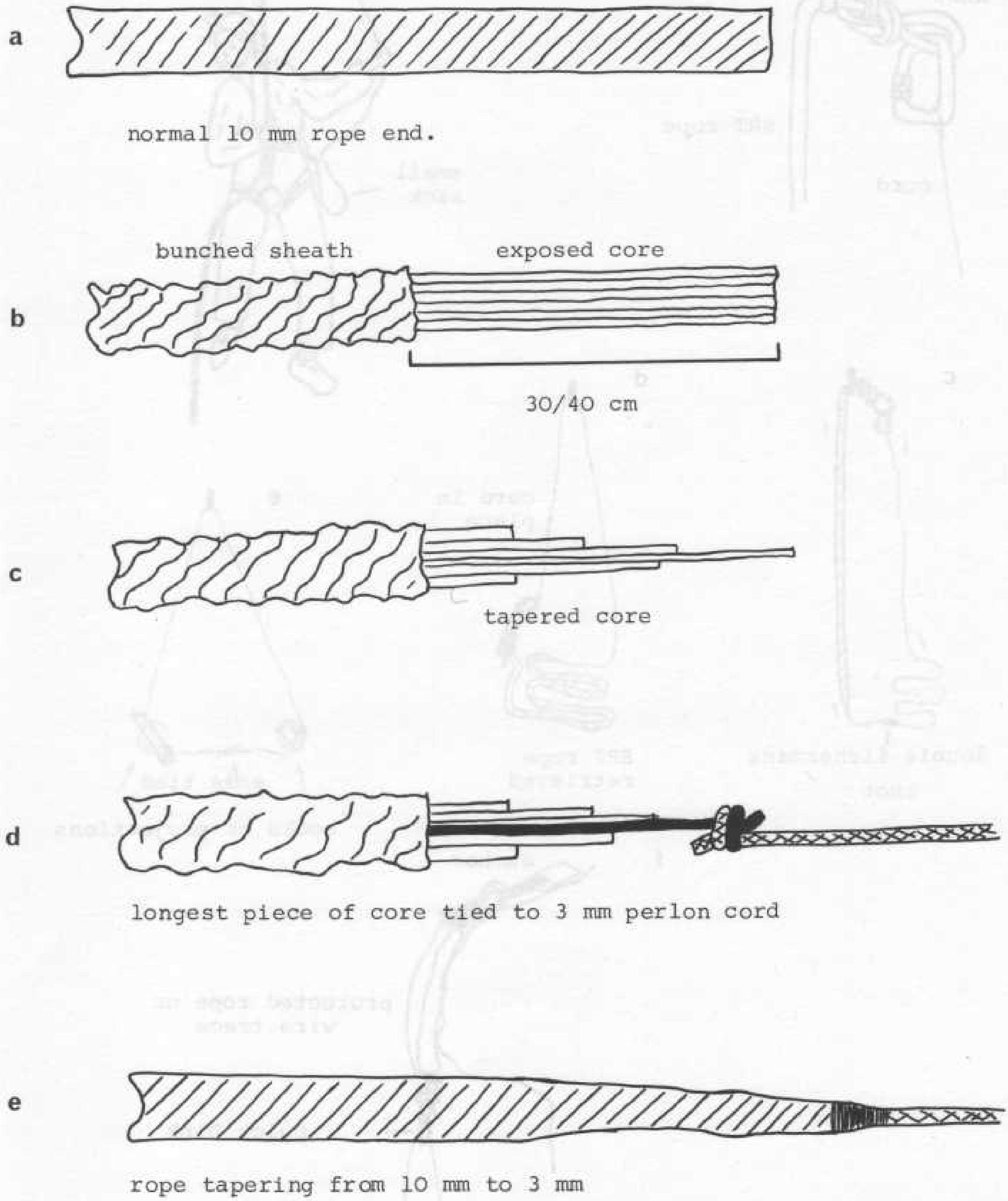
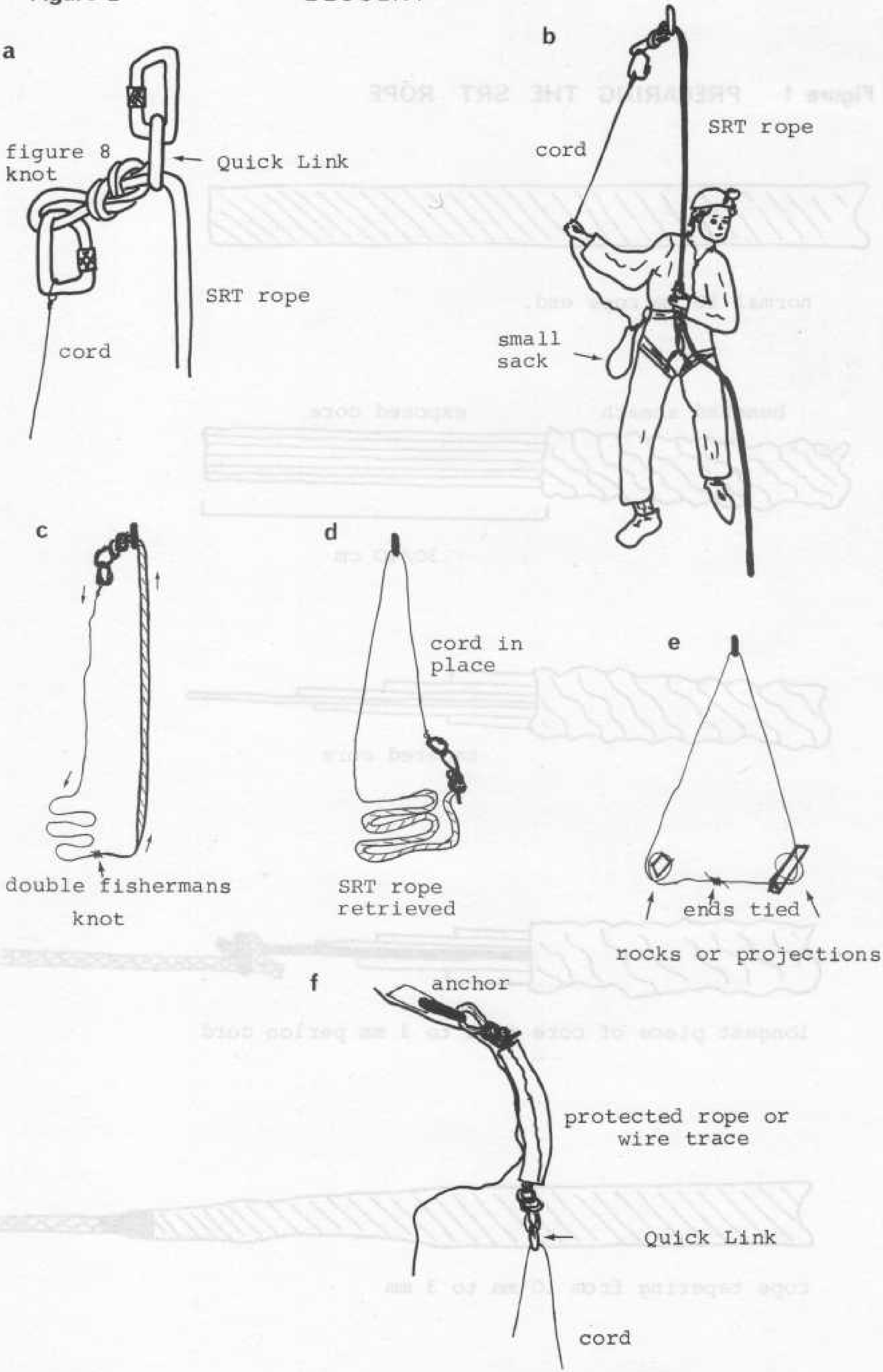


Figure 2 **DESCENT**



Thus it becomes advisable to think in terms of pitches which are suitable for the Cord Technique rather than whole caves. Whereas this approach has less finesse than doing an entire cave with one rope, a sack of cord and a bag of bolts, in the Australian context it is the only approach to take. The Cord Technique must be regarded as a method of reducing the amount of tackle required.

Descent (Figure 2)

To descend, the rope is fixed as in Figure 2 a with the rope jammed in place with a figure-8 knot and a large karabiner for security (too large to fit through jthe Quick Link). The cord is paid out from a small sack as the caver descends (Figure 2 b) (see cover plate) taking care not to spin and twist the cord around the abseil rope. When the bottom is reached, the lower end of the cord is tied onto the 3 mm perlon with a double fisherman's or double figure-8 knot (Figure 2 c). The rope is then retrieved by pulling on the cord until all the rope is on the bottom and the pitch is rigged with a double length of cord (Figure 2 d). After the ends of the cord are knotted together, it is lightly anchored to prevent it tangling due to air or water movements (Figure 2 e). The caver is now free to move onto the next pitch, having left behind a minimum of equipment.

Ascent (Figure 3)

Ascent is simply the reverse of the descent procedure. The 3 mm Perlon is attached to one end of the cord and the rope is pulled back up until the figure-8 knot is once again jammed against the Quick Link (Figure 3a , b and c). As the rope reaches the top of the pitch a double bump is felt; the first occurs when the cord-Perlon knot goes through the Quick Link (Figure 3 b). With the change from cord to rope through the Quick Link more friction is felt in the system but this reduces as the rope comes down the pitch until it eventually moves by itself. When using a pulley the "double bump" cannot be felt; in this case the hauling becomes progressively harder until the rope reaches the top, then it becomes progressively easier as it comes down the pitch.

When the pitch is against the wall, it is recommended that the other end of the cord is tied to the large security karabiner so that the rope can be moved gently into place to avoid the rope wrapping around itself below the Quick Link (Figure 3 d); this is especially important when the top of the pitch cannot be clearly seen but it does require more time to place the rope. However the extra time is well spent if a saving on rigging equipment can be made.

The rope is now ready for the caver to ascend (Figure 3 c). The lower end of the cord must be untied from the 3 mm Perlon before leaving the ground or the joined ends may snag on the bottom of the pitch.

USING THE CORD TECHNIQUE IN AUSTRALIA

The author's interest in the Cord Technique was triggered when it was realized that this would enable him to make a solo descent of Khazad Dûm. First the Cord Technique was used in an exercise in Argyle Hole (Bungonia, NSW). The successful descent of this cave indicated that it was possible to use the technique in the deeper Tasmanian cave. A plan was drawn up in which the equipment load for Khazad Dûm could be reduced to fit into one pack. The cave is by no means perfect for the Cord Technique because it contains a number of wet pitches and sloping handlines. Of the thirteen pitches (Table 1), three are near the entrance and only require two short ropes, so that there are only ten pitches for which the equipment has to be carried any distance. Of these, only six could safely be rigged using the Cord Technique. The equipment fitted into one medium sized caving pack, and Khazad Dûm was descended and ascended in a trip which lasted just under seven hours.

CONCLUSIONS

Advantages of the Cord Technique:-

1) Considerable reduction in the weight and bulk of equipment.
2) Less expensive because cord is considerably cheaper than rope.
3) It requires no specialist equipment except the Quick Links.
4) It allows a small party to do a cave of many pitches efficently with groups of two or more, one SRT rope per person could be taken and leap-frogged to the front of the party to enable more than one pitch to be climbed simultaneously.

Figure 3 **ASCENT**

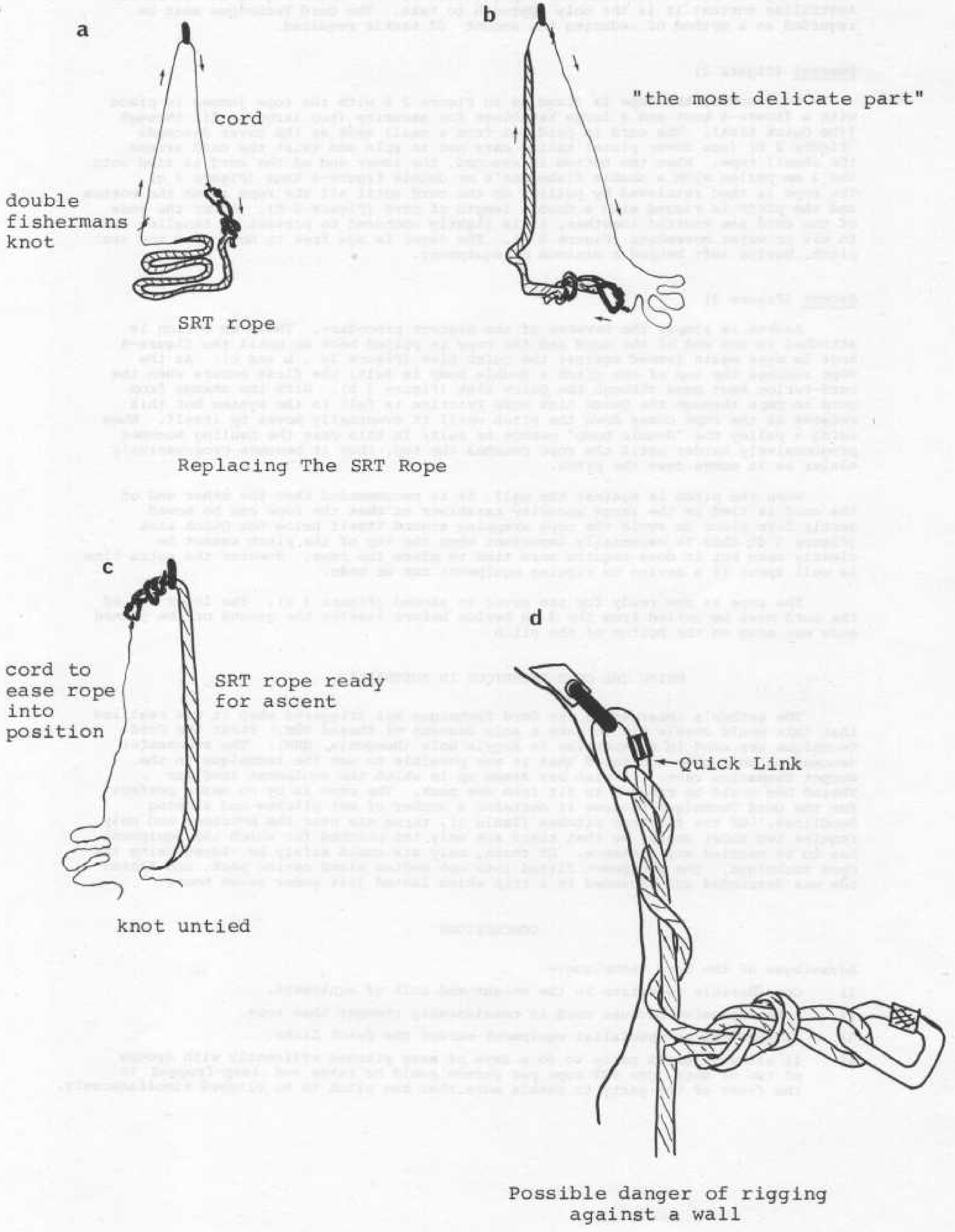


Table 1 Cord Technique Equipment for Khazad Dûm

Pitch	Rigging Equipment						Rope (m)	
	Height(m)	Cord	Karabiners	Quick Links	Tiebacks(m)	Protectors	CT	SRT
1	5	-	-	-	-	-	7*	7*
2	6	-	-	-	-	-	7*	7*
3	12	-	-	-	-	-	15	15
4	27	60	2	pulley	3	-	-	27
5	10	20	1	1	2	1	-	10
6	21	-	1	-	3	2	21	21
7	7	15	1	1	3	-	-	7
8	13	25	2	1	4	-	-	13
9	10	20	1	1	5**	-	-	10
10	8	-	1	-	-	-	12	12
11	6	10	1	1	4	-	-	6
12	11	-	-	-	-	1	11	11
13	40	-	1	-	2	3	50	50

* same rope used for both pitches

** a wire trace is also required

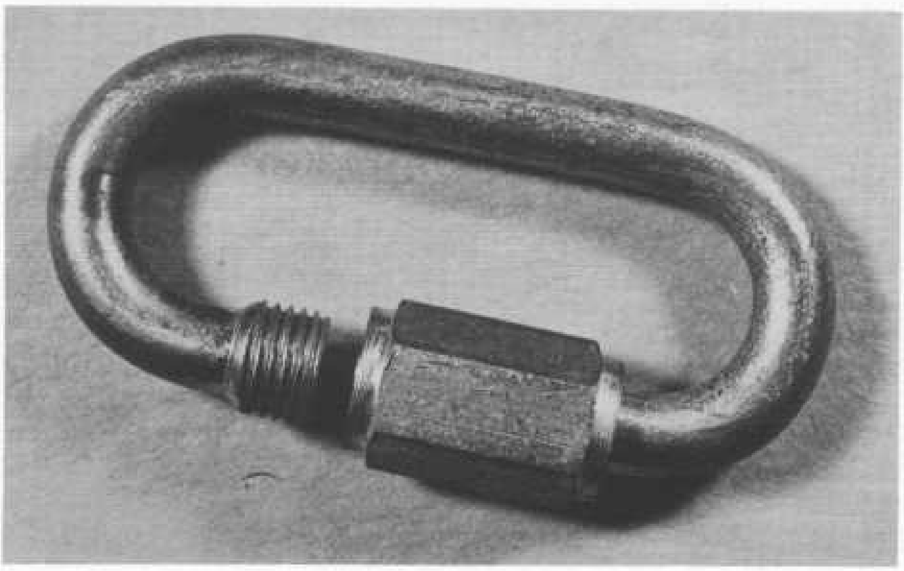


Plate 1. A Quick-Link.

Disadvantages of the Cord Technique:-

1) Must have a suitable (usually free-hanging) pitch.

2) Pitch must be a maximum length of 40 m or the rope becomes too heavy to haul especially when wet.

3) Requires extra care and expertise to rig.

4) Easily disturbed by other cavers descending the pitches.

As already mentioned the Cord Technique is a specialist technique most suited to super-light weight caving in a known cave. In almost all caves in Australia, its disadvantages will outweight its advantages, but on those occasions when the Cord Technique is worth using, it presents an excellent challenge to the vertical caver.

REFERENCES

Martinez, D., 1979 The Cord Technique. Caving International 4, 35-37. (Tranlsated from Spelunca 1979 (2), 77-79).

Further reading: Lombard, P., and Quivy, D., 1978 La Technique Cordelette, 24 pp. Published by D. Quivy, 13 rue Adolphe-Dietrich, 21000 Dijon, France. 25 FF.

Address for correspondence: 51 Northwood St., Newtown, NSW 2042.

EQUILIBRIUM VERSUS EVENTS IN RIVER BEHAVIOUR AND BLIND VALLEYS AT YARRANGOBILLY, NEW SOUTH WALES

J.N. Jennings, Bao Haosheng and A.P. Spate

Abstract

Seventeen blind valleys of the Yarrangobilly karst are described especially with reference to shifting streamsink location and phases of downward incision. A series of measures of them, based partly on ground traverses and partly on contoured maps, is presented and discussed. Standard morphometry of the basins ending in the blind valleys is presented also. These truncated basins are shown to have normal morphometric relationships. Whether a stream sinks or not in the limestone appears generally to relate to the length of limestone to be crossed in relation to full stream or basin length, though basin relief ratio may intervene.

The hypothesis that there will be dynamic equilibrium between the dimensions of blind valleys and sinking stream catchments finds only limited support in the data. This is because underground stream capture represents an abnormal event in drainage basin development liable to upset equilibrium relationships and its timing may be adventitious in that development. With a larger population of blind valleys to be analysed, this factor of timing might become subordinate, and a better predictive model of blind valley volume be derived.

INTRODUCTION

In recent decades a major theme in fluvial geomorphology has been the analysis of various morphometric attributes of drainage basins amongst themselves and in relation to basin hydrology (cf. Gregory & Walling,1973). This has led to the interpretation of geometric relationships between these attributes as indicative of dynamic equilibria. Though some relationships appear to be products of the system of analysis, many reflect natural phenomena.

Extension of morphometry to karst geomorphology in this period has led likewise to the recognition of similar dynamic equilibria in what was previously regarded as chaotic relief. Although one of the early papers (Williams,1966) was mainly concerned with streamsinks, most effort has been applied in other directions, notably towards the understanding of dolines and cockpits (e.g. Williams, 1972; Kemmerley, 1976). In general the idea has developed that these characteristically karst landforms are evolving in manners closely akin to those governing fluvial relief. The studies of White and White (1979) on Appalachian basins and Gams (1961) on Slovenian blind valleys are the most relevant to the analysis which follows.

Like most karsts in the Eastern Uplands of Australia, the Yarrangobilly karst in the Australian Alps is a fluviokarst; this is so despite the purity and mechanical strength of its Silurian limestone and because of its small, impounded nature and the recessiveness of the limestone amongst the surrounding rocks (Jennings, 1977). Therefore its valleys provide much of the interest in its surface geomorphology, though previous comments have related them to cave development rather than considered them intrinsically (Rose, 1964-6; Nicoll, 1977). This paper will describe the valleys at Yarrangobilly and see what simple morphometry may reveal about them. In particular it will test the hypothesis that there will be geometrical relationships between the size of blind valleys and the streams sinking in them indicative of dynamic equilibrium.

THE YARRANGOBILLY KARST

The Yarrangobilly limestone forms a north-south strike belt about 9 km long and 1 km wide (Figure 1). To the east, the Fiery Range, including Yarrangobilly Mountain (1630 m), consists of Goobragandra Volcanics (dacitic and andesitic extrusive rocks of Silurian age). These dip steeply westwards and are overlain by the limestone, which in turn dips under Silurian shales, sandstones, siltstones and cherts that make up the Toll Bar Ridge west of the Yarrangobilly River valley.

That river initially flows SSW between the Kennedy Ridge and the Fiery Range but then turns west to cross the northern end of the limestone down dip. However the limestone is here broken up into detached masses and there is interbedding with both overlying and underlying rocks. The river has cut some 30 m below the general level of the limestone. Though other rocks rise higher, cliffs line the

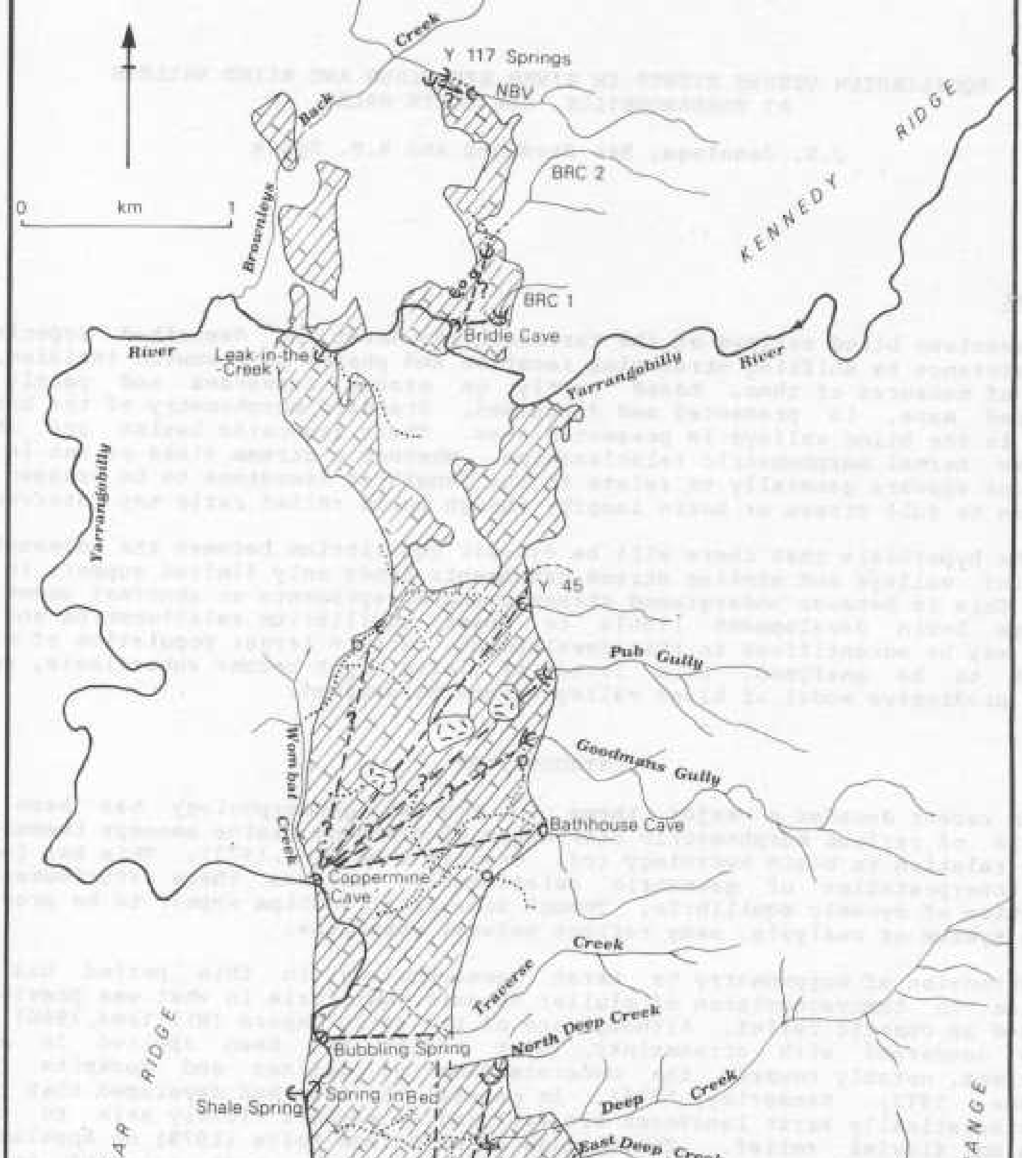


Figure 1 Map of the Yarrangobilly limestone belt.

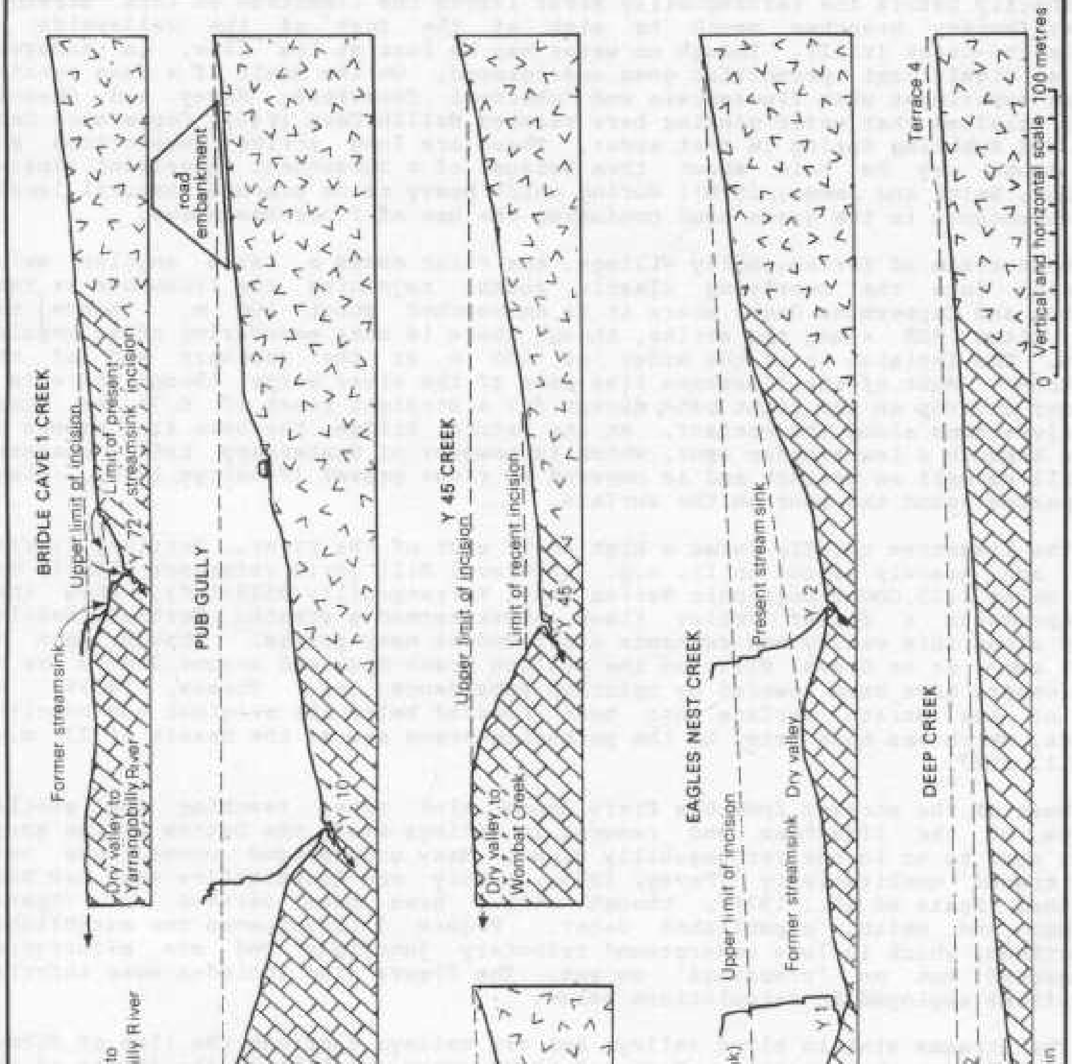


Figure 2 Longitudinal profiles of representative blind valleys at Yarrangobilly.

valley where the stream impinges on limestone.

Shortly before the Yarrangobilly River leaves the limestone on this stretch, a distributary branches south to sink at the foot of the valleyside in Leak-in-the-Creek (Y112). Though no water may be lost at low flow, in moderate flow a significant proportion goes underground. On the basis of a long running tracing experiment with fluorescein and charcoal detectors, Pavey and Shannon (1974) claimed that water sinking here reached Hollin Cave (Y46), Coppermine Cave (Y12) and Bubbling Spring in that order. These are long strike connections and some doubt may be held about them because of a subsequent experiment (Spate, Jennings, Smith and James, 1976)) during which heavy rains produced natural levels of fluorescence in the green band confusing the use of fluorescein dye.

Downstream of Yarrangobilly Village, the river makes a large angular swing westwards into the overlying clastic rocks, rejoining the limestone at Yans Crossing and Coppermine Cave, where it is entrenched about 100 m. Thence the river flows SSE along the strike, though there is some meandering of an angular nature. The incision is of the order of 150 m at the southern end of the limestone. Most of the limestone lies east of the river gorge, though there is a narrower outcrop on the right bank, except for a straight reach of 0.75 km where the river runs along the contact. At the Natural Bridge, the base flow passes in a cave through a low meander spur, which is however of Quaternary tufa - cemented rockfall as well as bedrock and is covered by river gravel (Jennings, 1977). Flood flow passes round the spur on the surface.

The limestone chiefly forms a high shelf east of the river. Tertiary fluvial sands and gravels found on it, e.g. at Gravel Hill (grid reference 336511, New South Wales 1:25,000 Topographic Series Sheet Yarrangobilly 8526-1-S), show that it represents a former valley floor, best termed a strath. Tertiary basalts flowed along this valley and remnants are found at many points. Though some of these such as on Gravel Hill, on the Bullock Track Spur and around 344479 are in situ, others have been lowered by solution subsidence (cf. Thomas, 1973). So some of the strath surface has been lowered below the original sub-basaltic surface, which has been dated by the potassium-argon age of the basalt of 22 m.y. (Nicoll, 1977).

Most of the streams from the Fiery Range sink after reaching the gentler surface of the limestone and resurge in springs along the bottom of the gorge either near to or in the Yarrangobilly River. Many underground connections have been traced qualitatively (Pavey, 1975). Only one quantitative test has been published (Spate et al., 1976), though others have been carried out (Spate, Jennings and Smith, unpublished data). Figure 1 illustrates the established connections, which include underground tributary junctions and one bifurcation underground but no 'crossings' as yet. The figure also includes some inferred connections employed in calculations below.

The streams sink in blind valleys but dry valleys continue the line of former streams across the strath. Most of these peter out high in the flanks of the Yarrangobilly gorge so that the condition of the tributary valleys is a hanging one (cf. Sweeting, 1950). This is taken to imply that the gorge has been deepened considerably since these tributary streams ceased to join the main river on the surface.

There has also been a tendency to develop a strike depression along the contact of the volcanics with the limestone so that the former continuation of flow beyond a streamsink was sometimes lateral, to a neighbouring tributary valley.

DESCRIPTION OF BLIND VALLEYS

Not all blind valleys at Yarrangobilly fall into the pattern described above but it would be misleading to confine this analysis to those complying with it. The working definition of a blind valley, which has been employed, requires the presence of a stream channel, perennial or intermittent in its flow, which ends against a reversed slope in the valley or in a doline. A dry valley, which lacks such a channel, ending in the same way has not been included in this study and there are a few such in the area. The seventeen instances fitting this definition will now be described briefly; the grid references locate the streamsinks on the Yarrangobilly 1:25,000 sheet. Selected long profiles are illustrated in Figure 2.

Northernmost Blind Valley (NBV) - 339547. A tributary of Brownleys Back Creek impinges for some 200 m along the northern margin of the limestone. This contact has been sufficient for the stream to sink but with minimal incision. A depression follows round the edge of the limestone to Y117 Spring and its neighbouring spring. It is assumed that this is where the stream resurges but there has been no test. Between sink and spring there is no sign of a channel or of disturbance of plants or litter. However it would be rash to assume that this is a true blind valley rather than a semi-blind valley, with rare floods following the depression.

Bridle Cave 1 (BRC1) - 339535. Here a small stream has sharply incised its bed soon after crossing onto the limestone (Figure 2) and sinks in a pit (Y72). Just beyond is a hemispherical hollow with steep limestone outcrop behind; the floor here represents a former sinking point. Formerly the surface flow detoured to the south and then headed for the Yarrangobilly River near to Bridle Cave (Y76), to which its present underground flow has been traced.

Bridle Cave 2 (BRC2) - 339538. At this streamsink, an intermittent stream course ends in a small doline (Y99) at the foot of a limestone bluff. Beyond a dry valley descends through two shallow dolines to end at an amphitheatre of rocky slopes some 200 m farther on. From this former streamsink, there had previously been continuation northwestwards of the amphitheatre, descending through shallow dolines to the flank of the Yarrangobilly River. Water sinking in this valley is assumed to resurge at Bridle Cave but no test has been made.

Wombat Creek (WC) - 332516. Wombat Creek does not have the typical blind valley arrangement described earlier. In its case, most of the headwater part of the catchment is on limestone and on overlying Tertiary sands and gravels. It is in the lower part of the catchment that the impervious clastics occupy the western valleyside. As a result of this pattern, shallow dry valleys join up at the head and then an intermittent course reaches a group of small, shallow but interconnecting dolines, which constitute a kind of blind valley. Beyond is a somewhat larger doline, which no longer appears to be reached by surface flow but which formerly acted as a streamsink. A descending dry valley continues to another doline and then to a dry steephead. Farther on the valley bottom is marked by an intermittent streamcourse down to the Yarrangobilly River, fed from the impervious rocks to the west. The water sinking in the upper part of the Wombat Creek valley is assumed to reappear in Coppermine Cave at the mouth of this valley.

Y45 Cave Creek (Y45) - 341518. Here a perennial creek drains at right angles into a strike depression along the volcanics/limestone contact, from which it receives an intermittent tributary before sinking in Y45 Cave (Figure 2). There has been no shift in streamsink position here but the topography indicates recent fresh incision in the base of the depression, in part into poorly bedded and poorly sorted alluvial-colluvial deposits exposed on one side. Former flow continued over the lowest part of the high rocky threshold behind the streamsink towards the Wombat Creek drainage basin. Y45 water has been traced to Coppermine Cave.

Pub Gully (PG) - 342513. Pub Gully also enters a strike depression to sink into Old Inn Cave (Y10) at the foot of the most impressive cliff blocking any Yarrangobilly blind valley (Figure 2). However the former valley led over a slightly lower saddle east of this cliff to follow the contact to the next blind valley to the south. Although there are thick alluvial-colluvial deposits in this blind valley, it is not possible from breaks of slope to separate different phases of incision as it is in the case of Y45. Y10 water is assumed to drain to Coppermine Cave in the absence of a test.

Goodmans Gully (GG) - 348509. Goodmans Gully sinks into Innstable Cave (Y9) close to the volcanics/limestone contact. Breaks of slope separate incision in relation to the present sinking point from a terrace surface extending southwards with two shallow dolines in it (former streamsinks) before a descending dry valley is reached. Y9 water is assumed to feed Coppermine Cave.

Bathhouse Cave Creek (BCC) - 342504. This was chosen as a typical example of a simple blind valley (Jennings, 1967). A perennial stream from the Fiery Range starts to cut down its bed as soon as it crosses from the volcanics onto the limestone and enters Bathhouse Cave (Y8) at the foot of a limestone bluff. The former course leads over the saddle to its north and is marked by a descending dry valley with dolines along it. This streamsink has been proven to connect with Coppermine Cave.

North Deep Creek (NDC) - 339490. North Deep Creek sinks into Y48 Cave shortly after reaching the limestone but caves Y47 and Y7 (North Deep Creek Cave), on the same southern side of the valley, represent former streamsinks (Figure 2). There are slightly lower saddles on either side of the line of cliffs ending this blind valley and it is not certain which way the former stream went. The south-east saddle leads via the Janus Cave (Y58) doline to the Deep Creek blind valley whereas the northwest saddle heads through a doline to a dry valley tributary to the larger one linking the Deep Creek blind valley with the Yarrangobilly gorge. Water tracing has linked North Deep Creek with Hollin Cave (Y46).

Deep Creek (DC) - 339486. Deep Creek sinks into Deep Creek Cave (Y6) at the foot of a high cliff but the continuing dry valley round a saddle to the north first faces a shallow amphitheatre, containing a small doline and a tiny cave entrance, which represent a former streamsink (Figure 2). Beyond it descends to the flank of the Yarrangobilly gorge. Incision into the terrace surface (terrace 3) running into this dry valley is quite sharp and farther up the valley there is a still higher, older terrace 4 (Figure 3). Associated with the present streamsink there are two terrace levels (2 and 1). As these are at least in part of a built nature, this terrace sequence implies alternations of aggradation and incision. Deep Creek drains underground to Hollin Cave.

East Deep Creek (EDC) - 344484. This short creek sinks into East Deep Creek Cave (Y5) at the foot of a high cliff but the lowest saddle is on the northern side of the blind valley, leading to a dry valley with two dolines along it, which descends along the volcanics/limestone contact to Deep Creek at the head of its

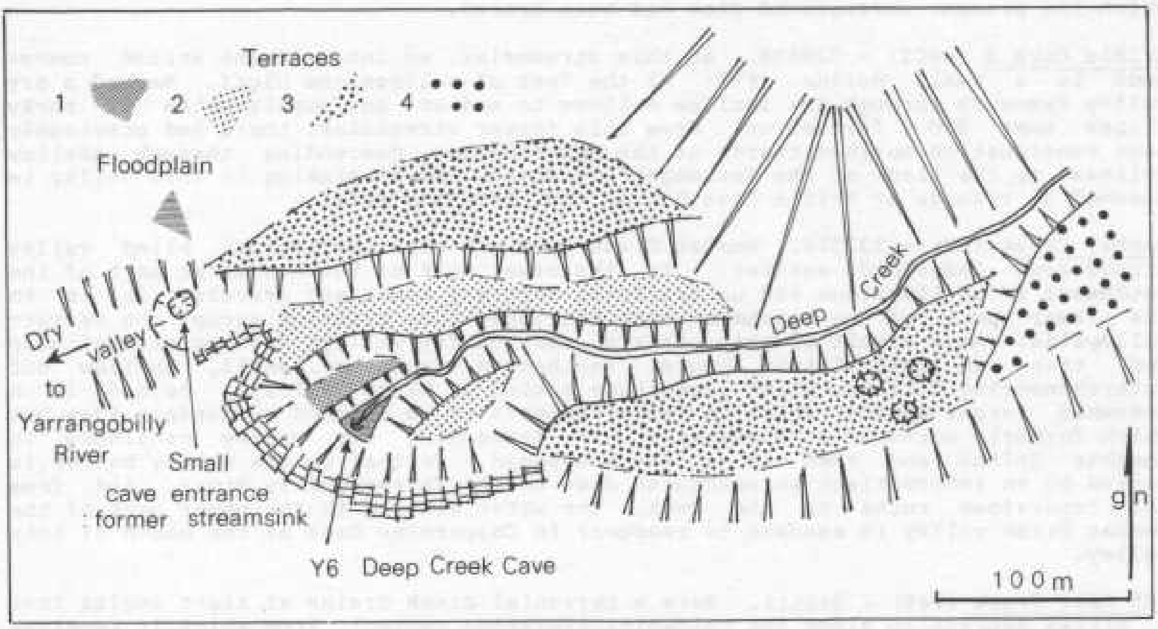


Figure 3 Sketch map of the Deep Creek blind valley and its terraces.

blind valley incision. The topography favours recognition of this route as the former continuation as against that proposed by Nicoll (1977). He favoured a link southwards over a higher saddle to Eagles Nest Creek on the grounds of the disparities between the known sizes of the caves at the streamsinks and the streams supplying them. It is, however, unlikely that the known cave development comprises the whole. East Deep Creek resurges at Hollin Cave.

Eagles Nest Creek (ENC) - 343474. Eagles Nest Creek's sinking point is the active stream entrance (Y2) to the large cave system here (Figure 2). This is at the foot of a line of cliffs on the northern side of the valley. A low saddle leads westwards down a short dry valley into the largest doline at Yarrangobilly, at the bottom of which is the former entrance into that system (Y1). High up in the cliffs is the entrance to The Eyrie (Y3) at about the level of the saddle closing the doline on the west and leading to a descending dry valley to the Yarrangobilly gorge. This sinking creek rises again in Hollin Cave.

Negative Series (NS) - 343468. A short intermittent creek sinks in the bottom of a doline beyond which are two smaller dolines, former streamsinks, before a dry valley begins to descend to the gorge wall (Figure 2). No result from water tracing here is available and the likely spring seems to be One Tree Hill Spring to the west, since the water chemistry of the nearer Overhang and Hanging Springs suggests these are fed by percolation water only.

Mill Creek (MC) - 343460. One of the larger tributaries, Mill Creek, has cut its valley so deeply prior to encountering the limestone that its course across the old valley strath is known as Harrie Wood Gorge. As a result, the stream sinks at a much lower altitude and farther down its course to the Yarrangobilly River than is common with the tributaries (Figure 2). It sinks into a mass of large boulders before entering the bedrock cave, Mill Creek Swallet (Y29). The saddle does not rise very much above the cave lintel and is in fact made up of a pile of large boulders, which have fallen from the northern gorge wall. Although this rockfall has triggered the sinking of the stream, there has been a modest amount of incision since the underground capture, registered in breaks of slopes on the valley sides for a short distance above it. Below the barrier, Harrie Wood Gorge continues practically to the junction with the river, though the rock detritus on its floor is angular rockfall material. Despite the low threshold height and big floods on Mill Creek, there is no knowledge of any overflow. Mill Creek Swallet drains to Federation Cave (Y44).

Rules Creek (RC) - 346454. Rules Creek has also cut deeply across the limestone outcrop which is narrower here near its southern end. The streamsink (Y43) lies at the foot of a talus slope below a cliff. This barrier has a deep slice cut out of it on the southern side through which the road runs, and only a few metres of threshold prevent overflow. The ground just here has been modified by road and carpark construction but the natural line of the valley bottom can be traced under rockfall from the northern wall. Beyond this is the most remarkable continuation of all the Yarrangobilly blind valleys in a vertically walled gorge down to the river, overlooked by the track to the Glory Caves (Y24, 25). Despite its fresh appearance, the rock in its bed is angular with no suggestion of present overflow into it, nor does local knowledge give credence to any such happening nowadays.

Above its streamsink, Rules Creek has a low gradient and meanders to produce a shallow but broad blind valley. There are terrace remnants well above the incision related to the present streamsink and by eye these appear to grade to a former overflow higher than the present saddle beyond the streamsink. The whole arrangement provokes the speculation that there has formerly been a deeper blind valley here behind which terrace aggradation took place. Subsequently surface flow spilled over again and cut the slice out of the barrier which had previously developed. Finally Rules Creek sank afresh at its present sinking point. It has been traced to Federation Cave.

The 1:25,000 map shows a tributary on the right bank at the top end of the picnicking ground. Its channel peters out at the top of a steep alluvial fan now fixed by vegetation. Below the fan is a substantial doline which may represent a former streamsink of this tributary, matching that of Saddle Creek on the left bank. Because the tributary fails to reach the doline nowadays it has not been treated as a blind valley.

Saddle Creek (SC) - 352452. Saddle Creek drains northwestwards to the southern end of the limestone and nearly reaches Rules Creek to which it formerly flowed. However its encounter with the limestone prior to that ensures that it goes underground in a small doline. It appears possible that this creek could on a favourable occasion - heavy rain causing snowmelt - fill its doline and temporarily rejoin Rules Creek but there is neither any suggestion of a temporary channel nor local knowledge of such an effect. No water tracing has been attempted here and it is assumed it feeds Federation Cave as part of the Rules Creek system.

Right Bank Tributaries : RB1 to RB7. Of these right bank tributaries of the Yarrangobilly River which cross some limestone along the main gorge, only one - Right Bank 2 - has created a blind valley at 327478. Just above the limestone contact, this creek is shallowly incised into an alluvial cover and then sinks in a doline at the foot of a limestone cliff (Figure 2). A low saddle leads to a dry valley running down to the river. The nearest known spring is at 328482, issuing from a hole at the base of a meander cliff of the Yarrangobilly at normal river level.

THE MORPHOMETRIC DATA, THEIR COLLECTION AND VALIDITY

(a) Blind valley measures (Table 1)

Table 1 Blind valley morphometry

BLIND VALLEY	THRESHOLD HEIGHT present m	THRESHOLD HEIGHT total m	LONG PROFILE AREA present m^2	LONG PROFILE AREA total m^2	BLIND VALLEY VOLUME present m^3	BLIND VALLEY VOLUME total m^3	HYDRAULIC GRADIENT present	HYDRAULIC GRADIENT former
NBV	0.5		6		20		0.02	
BRC1	3.5	12	116	641	400	5500	0.06	0.06
BRC2	3	10	17	2310	30	13000	0.04	0.03
WC	3	4	125	200	900	1100	0.08	0.08
Y45	6.5	26	360	3359	2600	47000	0.06	
PG	37		6267		265000		0.07	
GG	15	23	1291	3250	34000	190000	0.08	0.08
BCC	17				15000		0.09	
NDC	1	19	62	2526	50	95000	0.09	0.10
DC	15*	19			32000	170000	0.09	0.09
EDC	20.5		1429		42000		0.12	
ENC	8	31	1137	8867	12000	371000	0.15	0.17
NS	8	10	448	949	7200	8300	0.19	
MC	3		75		400		0.10	
RC	6				38000		0.16	
SC	4				3600		0.09	
RB2	4		326		1500		0.11	

* A youngest phase of incision has threshold height of 4 m, long profile area of 195 m^2, volume of 1580 m^3.

The volume of rock removed since the stream went underground is the proper measure of the work of erosion done in this condition of karst river capture. For this a detailed contour map is necessary. One of the Bathhouse Cave blind valley had been published (Jennings, 1967); this was on a scale of 1:600 with a contour interval of 5 feet. Recently A.P. Spate constructed one of the Eagles Nest Creek blind valley on a scale of 1:500 with a contour interval of 5 m. From these maps, contour areas were taken off with a digitising table linked to a DEC-10 computer. From these data, volumes were calculated by the method of end areas (Clark, 1946). The resulting volumes are well based but there is error in deciding on the upper limit of incision of the blind valley, which, of course, rises up the valley from the threshold. An error of less than 5% has probably been achieved.

It was patently too laborious a task to prepare similar large scale contour maps for all the blind valleys. For a few of the larger cases, the same method was employed but using a 1:10,000 photographic enlargement of the relevant part of the Yarrangobilly 1:25,000 topographic sheet, kindly provided by R.S. Nicoll. In these cases, though the error in deciding the upper limit of incision may be no greater, the areas measured will be less precise. An error of less than 20% is thought to be involved.

For the remainder, survey traverses, normally by prismatic compass, Abney Level and plastic tape, were carried from an altitude greater than that of the blind valley threshold down the stream to the sinking point and thence over the threshold to the start of the descent of the dry valley beyond. Such traverses were in fact carried out also for the valleys for which the topographic map was used for volume determination.

Dense vegetation (particularly where it consisted largely of briars and brambles), caused variations in method including the substitution of a rangefinder for the tape. The rangefinder error varied from 0.5 m at 15 m to 2 m at 60 m. Alternatively the traverse was carried along the valley side and side shots made down to the stream at points of easier access to it. In the case of Pub Gully, where the 'jungle' was worst, J. Whitaker and R. Rourke, of the N.S.W. National Parks and Wildlife Service, kindly cut a line along the stream in their spare time. Where breaks of slope were identifiable on the valleysides belonging to different phases of incision of the blind valley, these were measured in cross-sections through survey points in the stream. Where possible, traverses, forced out of the line of the stream by the 'jungle', followed such breaks of slope.

From the stream profiles, measured directly or indirectly, and the cross-sections, blind valley volumes were calculated by treating successive parts as simple geometrical forms such as triangular and trapezoidal prisms, whilst the amphitheatre round the streamsink was regarded as a quarter sphere or a half cone. It is difficult to estimate the error term involved in these approximations; in the extreme it may be of the order of 20%.

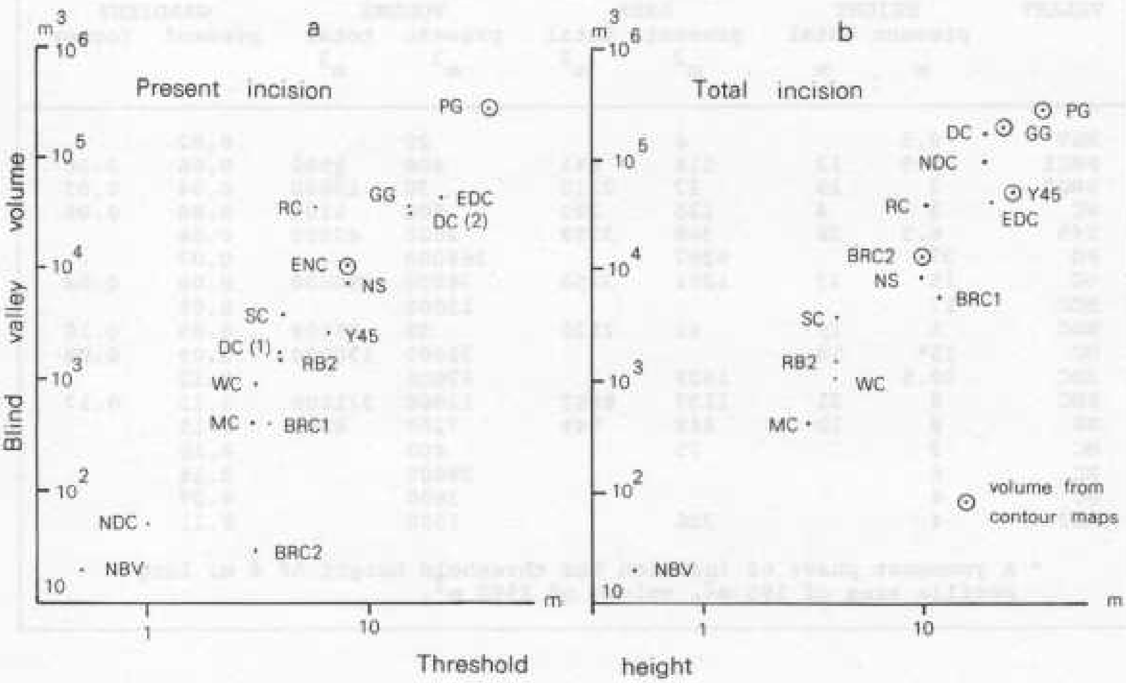


Figure 4 Scatter diagrams of blind valley volume against threshold height.

The greater precision of the traverses themselves compared with other inputs into the volume determinations permits some enquiry into the latter. The traverse data permitted calculation of heights of thresholds above the streamsinks and also of the construction of longitudinal profiles along the stream to the sink and thence to the lowest lip of the former overflow saddle. From the latter an area related to the valley incision could be digitised. The volume determinations depend also, however, on the cross-sections. Moreover the volumes based on contours drew on independent sources altogether. Figures 4 and 5 show close relationships between the volumes and both threshold heights and long profile areas. These results give confidence that the volumes are realistic determinations. Moreover the range of five orders of magnitude of the blind valley volumes validates their use in the analyses which follow.

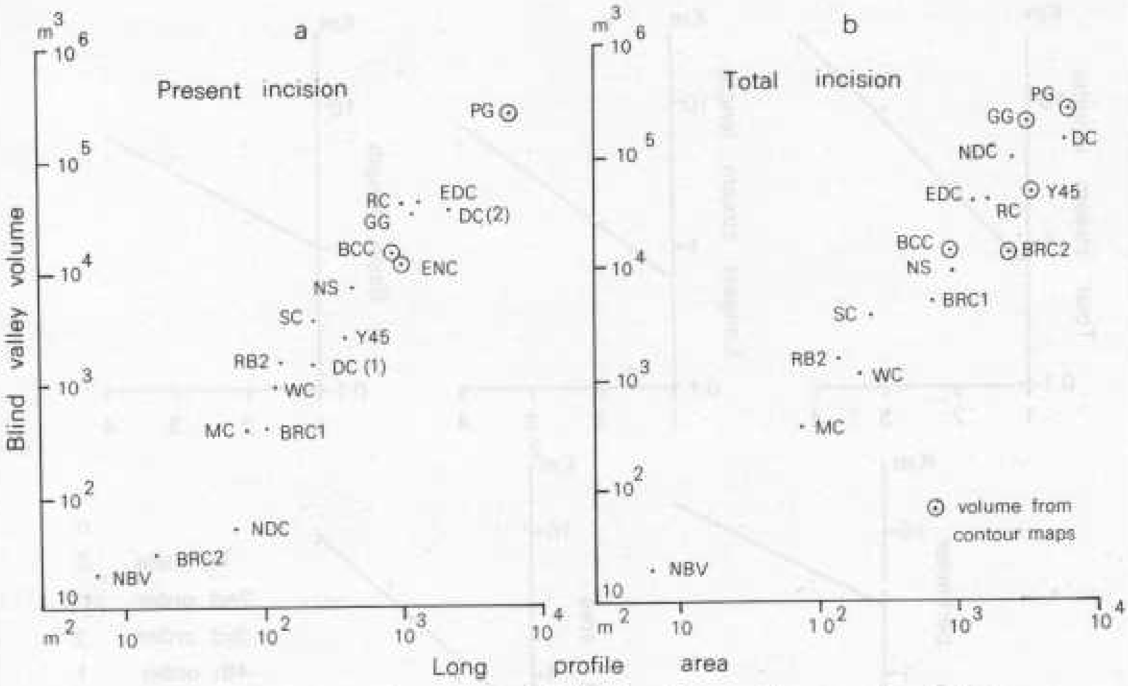


Figure 5 Scatter diagrams of blind valley volume against long profile area.

As these figures indicate, where former as well as present streamsinks could be identified, volumes of incision were determined both for the present streamsink as well as for the total excavation since underground capture. Likewise separate calculations were made where there were separable phases of incision without the point of sinking shifting. At Deep Creek three such volumes were determinable.

(b) Sinking stream basin measures (Table 2).

Table 2 Morphometry of basins above streamsinks

BLIND VALLEY	STRAHLER ORDER	TOTAL STREAM LENGTHS km	LONGEST STREAM LENGTH km	BASIN PERIMETER km	BASIN LENGTH km	BASIN AREA km^2	BASIN RATIO
NBV	2	2.01	1.61	4.20	1.74	0.57	0.13
BRC1	1	0.58	0.58	2.33	0.81	0.22	0.16
BRC2	2	3.61	1.81	5.40	1.85	0.98	0.14
WC	1	0.33	0.33	4.28	1.00	1.01	0.11
Y45	2	1.48	0.98	3.14	1.13	0.43	0.10
PG	2	3.17	1.82	4.98	1.89	1.02	0.12
GG	2	5.07	3.17	7.95	2.94	1.76	0.15
BCC	2	2.06	1.67	4.26	1.58	0.76	0.15
NDC	2	1.01	0.65	2.47	1.03	0.50	0.16
DC	3	7.60	4.20	9.47	3.75	4.24	0.16
EDC	1	0.58	0.58	4.18	1.70	0.68	0.16
ENC	2	3.58	1.71	5.24	1.58	1.47	0.13
NS	2	0.94	0.60	2.33	0.75	0.24	0.22
MC	3	11.17	5.36	12.46	4.81	5.09	0.14
RC	4	22.41	5.26	12.32	4.20	8.12	0.13
SC	2	2.69	1.40	5.07	1.93	0.94	0.16
RB2	2	2.33	1.61	2.51	0.63	0.37	0.30

Long term records of stream discharge and velocity, the indicators of erosional capacity, are of course not available; geomorphic surrogates have to be employed in their place. It is advisable therefore first of all to consider whether truncated systems of the type under consideration behave like normal drainage basins. The burden of Williams' original essay (1966) into karst morphometry was that this was so. Applying Strahler stream ordering to Craven streamsinks, he found that Horton fluvial laws applied to them and he reported later (1972) that Chambers had made the same finding for the Gower limestone in South Wales.

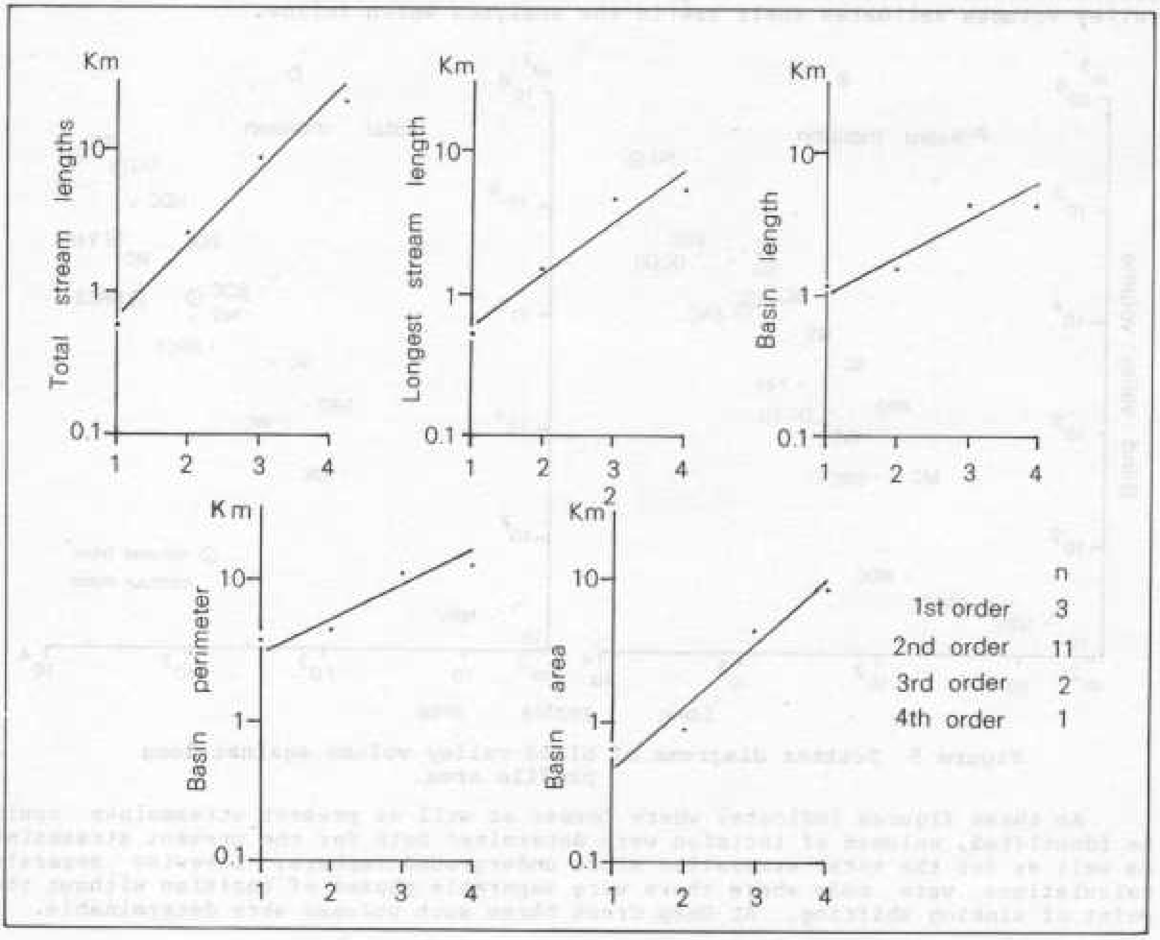


Figure 6 Mean values of various basin attributes against Strahler order. Lines of best fit by eye.

Figure 6 illustrates similar results for the Yarrangobilly streamsinks, though the small numbers in different orders must be borne in mind. Figure 7 shows a strong regression between two of the most commonly used basin parameters, total stream lengths and basin area. With total stream length (L) in km and basin area (A) in km^2 :

$$L = 2.24\ A^{1.13} \qquad (P = 0.001 \ ; \ r^2 = 0.95)$$

The case with the greatest departure from the regression is Wombat Creek where dry valleys prevail above the streamsink and have not been included the total length.

Basin area is the most commonly used surrogate for discharge, though of course many other factors intervene. Table 3 sets out a few measures of instantaneous discharge per unit area from discharge determinations on the same days for Deep Creek, East Deep Creek and Eagles Nest Creek. The close comparability between streams on the same occasion is reassuring because even though these are neighbouring catchments, they are typical of the blind valley catchments between Y45 and Saddle Creek.

Table 3 Comparative catchment discharges (Q/A) in litres/second/km^2

Date	Deep Creek	Eagles Nest Creek	East Deep Creek
30/9/78	31.3	25.3	29.7
7/10/78	17.4	14.2	N.D.
15/10/78	16.3	14.4	N.D

Relationships of the form $Q = aA^b$ have been established for many areas (cf. Gregory & Walling, 1973), linking mean annual flood ((Q) with drainage area(A) in this way where a and b are constants. Floods are responsible for much of a river's mechanical attack. Solution, which will enter into blind valley formation more than into normal valley formation, is not so preponderantly influenced by flood flow, so that total annual runoff could be regarded as a suitable measure here. Relationships between basin area and mean annual runoff are more complex than those with mean annual flood, though evidence from humid climates suggests a direct relationship though of higher degree polynomial order (Gregory & Walling, 1973).

Relationships of the kind $Q = aL^b$ have been found between mean annual runoff (Q) and lengths of total stream channel (L). Figure 7 suggests that there will be little difference between the use of total stream length and of basin area for this Yarrangobilly analysis. Basin area will be preferred.

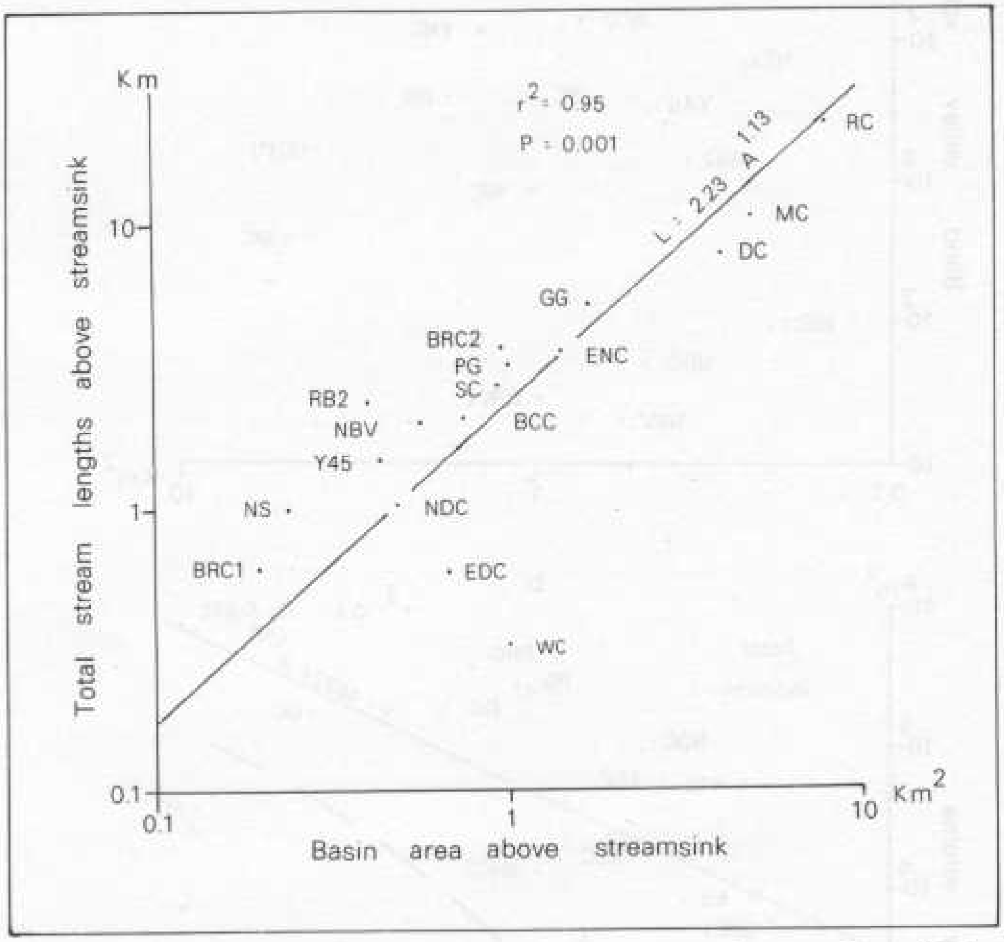


Figure 7 Regression of total streamlengths on basin area for sinking stream basins.

The velocity factor can be approached in two ways, by use of Schumm's basin relief ratio above the streamsink and of underground hydraulic gradient below. The hydraulic gradient was calculated on the basis of altitude difference between streamsink and resurgence and straightline distance between the two.

The various stream length and area measures of the sinking streams were taken from the relevant New South Wales 1:25,000 topographical maps (some in preliminary draft) using the digitising table and computer setup mentioned above.

DISCUSSION

When the volume of incision above present streamsink (or of the younger incision where there are separable phases of incision at the one sinking location) is plotted against basin area above the sinking point, both on a logarithmic scale, (Figure 8a), the scatter is great and no relationship between the two is to be discerned. The implication is taken to be that the periods of time, over which dynamic factors have been operating to produce a definite relationship between the two, have been far too different from one streamsink to another for this to be achieved.

Figure 8b is a logarithmic plot of the total volume of incision since stream engulfment, as the dependent variable, against the independent variable of basin area above streamsink. There is likely to be less variability in overall

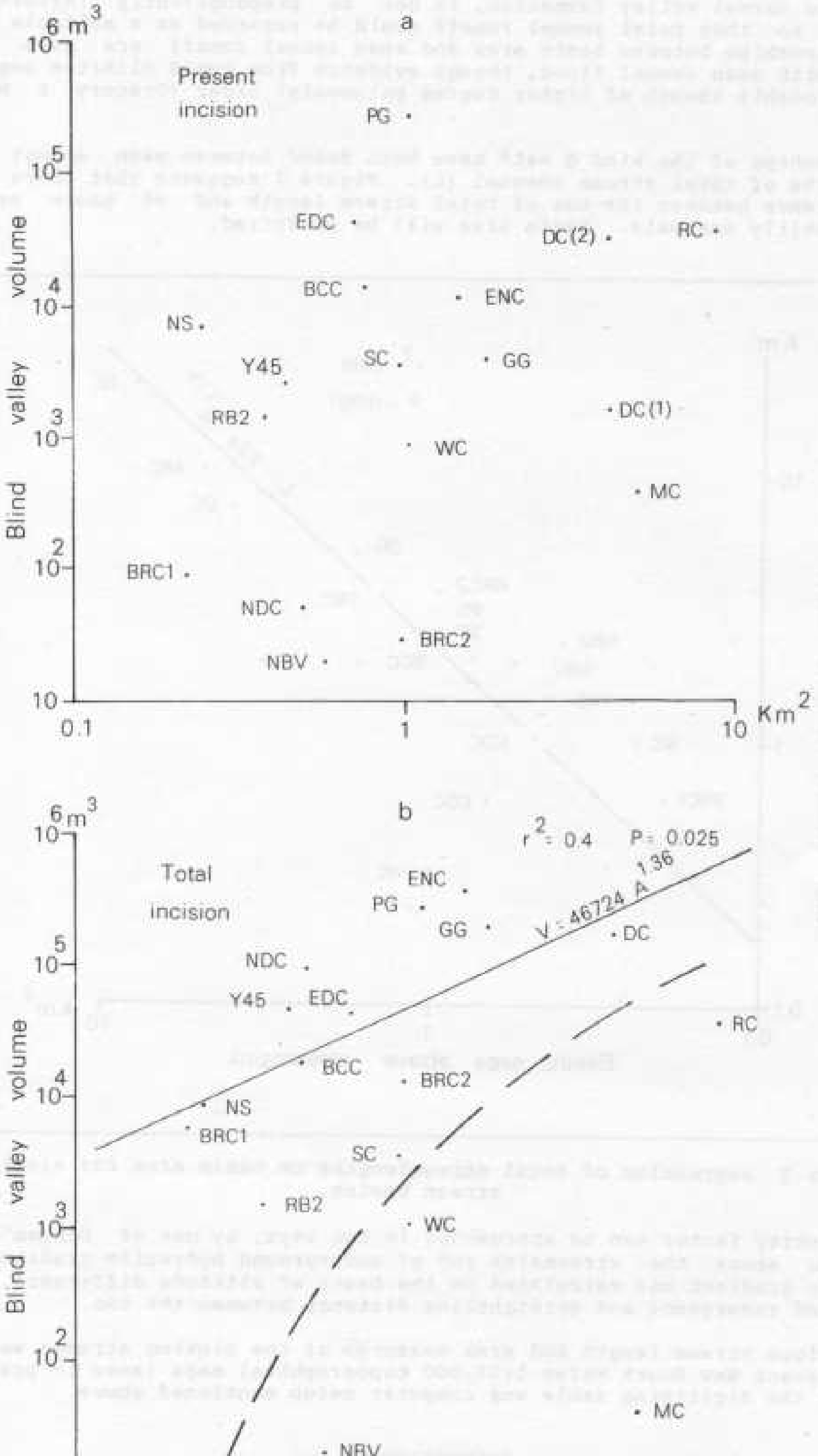


Figure 8 Scatter diagrams of blind valley volume against basin area of sinking streams. In 8b, the regression is for a restricted set of blind valleys, excluding the four below the dashed line.

length of time during which there has been a stream sinking at each blind valley. This figure shows a greater tendency to a linear bundle of points but the scatter remains too great for a statistically significant regression.

However the instances which depart most from the tendency to a linear relationship form a sensible, not a random group. Northernmost Blind Valley only just touches along the margin of the limestone and may well be in only a semi-blind condition. Mill Creek is atypical in that a recent rockfall has triggered engulfment of this stream and this is altogether a younger event than the initiation of most of the blind valleys. Rules Creek deviates on a somewhat similar basis in that the gorge below the streamsink here testifies to recent overflow. It may be that such overflow has lowered the level of a higher lip and reduced a formerly larger blind valley volume which would have matched better with the magnitude of this creek. Finally Wombat Creek is aberrant because its allogenic stream input from non-karst rocks is from a flank rather than from the head of the catchment.

Exclusion of these four anomalous cases leaves a set of 13 blind valleys where the head of the basin leads down to limestone in the lower part of the catchment and where there is evidence of sinking for some length of time. A regression can be calculated for this set. With blind valley volume (V) in m^3 and basin area above streamsink (A) in km^2:

$$V = 46724 \quad A^{1.36}$$

This is statistically significant with a probability of 0.025 but the r^2 is low and only 40% of the variation in blind valley volume is explained statistically.

Semi-logarithmic plots of total incision in the blind valleys against basin relief ratio (Figure 9a) and against underground hydraulic gradient (Figure 9b) show pronounced scatter and exclusion of the four anomalous cases would fail to yield significant patterns. These gradients do not vary greatly and other factors may easily obscure any influence they have.

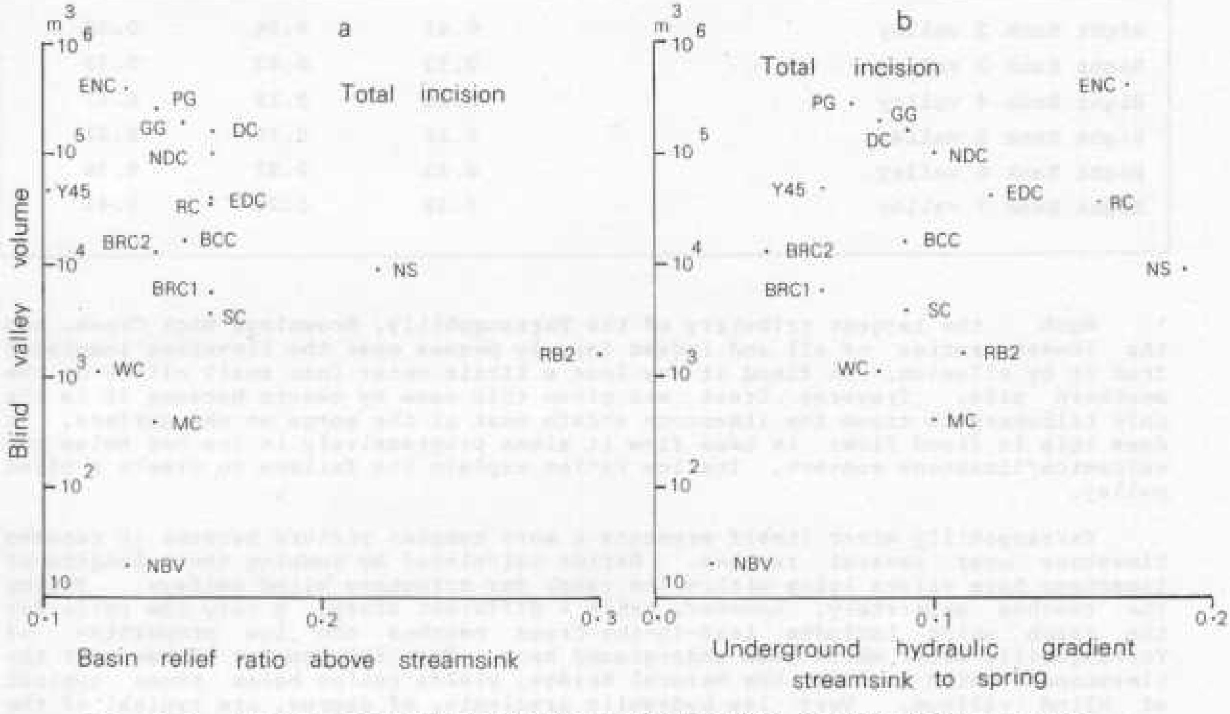


Figure 9 Scatter diagrams of blind valley volume against basin relief ratio and underground hydraulic gradient.

These limited and largely negative results of the morphometric analysis of the blind valleys are not considered to be the result of the level of accuracy in the dependent variable because the great variation in magnitude of blind valley volumes swamps the errors. Though no complete predictive equation for blind valley volume has been derived, the results do help forward understanding of this fluviokarst relief in that they bring out the vital role of the timing of events, i.e. of underground capture and the partially contradictory operation of the factors at work.

Thus, although the blind valley volume/basin area regression sustains the principle that the higher the discharge the greater the capacity to deepen a valley at a streamsink, this only comes into operation after underground capture has taken place and before the occasion the same factor will operate in the opposite sense, to prevent or delay that capture. The probability of such capture will depend in part on how big the stream is in relation to the length of limestone to be crossed.

Two ratios (Table 4) have been calculated as measure of this relationship:

$$\frac{LL}{TL} \quad \frac{\text{length of present or former streamcourse over limestone}}{\text{whole length of streamcourse}}$$

$$\frac{SL}{BL} \quad \frac{\text{straight line length across limestone}}{\text{basin length}}$$

Table 4 Ratio of limestone to full lengths in catchments

Name	LL/TL	SL/BL	Basin relief ratio
Brownleys Back Creek	0.01	0.01	0.06
Traverse Creek	0.13	0.13	0.16
Yarrangobilly River - all limestone	0.22	0.29	0.04
Yarrangobilly - Leak-in-the-Creek limestone	0.02	0.09	0.05
Yarrangobilly - Natural Bridge limestone	0.14	0.17	0.04
Northernmost Blind Valley	0.09	0.09	0.13
Mill Creek	0.10	0.11	0.14
Rules Creek	0.14	0.20	0.13
Other blind valleys	0.25-0.77	0.23-0.63	0.11-0.30
Mean of all blind valleys	0.39 (S.D. 0.19)	0.36 (S.D. 0.15)	0.16
Right Bank 2 valley	0.41	0.36	0.30
Right Bank 3 valley	0.52	0.42	0.32
Right Bank 4 valley	0.15	0.19	0.17
Right Bank 5 valley	0.10	0.10	0.21
Right Bank 6 valley	0.32	0.27	0.36
Right Bank 7 valley	0.38	0.24	0.41

Much the largest tributary of the Yarrangobilly, Brownleys Back Creek, has the lowest ratios of all and indeed largely passes over the limestone insulated from it by alluvium. In flood it may lose a little water into small cliffs on the southern side. Traverse Creek was given this name by cavers because it is the only tributary to cross the limestone strath east of the gorge on the surface. It does this in flood flow; in base flow it sinks progressively in its bed below the volcanics/limestone contact. Its low ratios explain its failure to create a blind valley.

Yarrangobilly River itself presents a more complex picture because it crosses limestone over several reaches. Ratios calculated by summing these lengths of limestone have values lying within the range for tributary blind valleys. Taking the reaches separately, however, tells a different story. A very low ratio for the reach which includes Leak-in-the-Creek matches the low proportion of Yarrangobilly water which goes underground here. Even its longest course over the limestones, which includes the Natural Bridge, yields ratios below those typical of blind valleys. Very low hydraulic gradients, of course, are typical of the main river reaches over limestone, also militating against complete capture.

The low ratios for Northernmost Blind Valley combine with its course tangential to the limestone to explain why blind valley development is rudimentary in its case.

Mill Creek and Rules Creek have ratios below the mean values for all blind valleys and below the full range for the typical blind valleys of the valley strath. These low ratios help to explain why these streams have managed to cut deeply into the limestone and staved off sinking till late in their history.

The right bank tributaries do not sustain this argument in a simple way. Only Right Bank 2 has a blind valley, the rest become intermittent in flow down their channels over the limestone near to the Yarrangobilly. Right Bank 4 and Right Bank 5 have low $\frac{LL}{TL}$ and $\frac{SL}{BL}$ ratios consistent with their behaviour. But Right

Bank 3, Right Bank 6 and Right Bank 7 might be expected to have formed blind valleys on this count. With Right Bank 6 and Right Bank 7 failure to do this can be linked to another factor, namely the high relief ratios of their whole catchments. This entails the well known principle that very steep ground promotes surface runoff and inhibits sinking underground of streams. One of the most surprising instances of this in Australia is to be found at Bungonia (Jennings, James, Counsell and Thwaite, 1972) at the Devils Staircase. This strike arête of limestone drops very steeply but is double for most of its length with a narrow gully between. A small plateau catchment feeds water into this gully, which flows down it after heavy rain in short waterfalls until escaping laterally just above the final buttress. The steep right bank tributaries of the Yarrangobilly face something of the same relief situation whereas the left bank tributaries meet the reduced gradients of the limestone strath conducive to sinking. The difference in behaviour of Right Bank 2 and Right Bank 3 remains inexplicable along these lines however and some other cause must be sought.

CONCLUSION

In Slovenia, Gams (1961) dealt with much larger blind valleys than those at Yarrangobilly and the attributes which he compared were the ratio of blind valley length in impervious rocks to length in limestone, the ratio of their volume in impervious rocks to volume in limestone, and the hardness of the stream water where it passed onto the limestone. These were related to a threefold division of the blind valleys into those which widened in the limestone, those which narrowed and those which did not change in width. The ones which narrowed down were characterised by high hardness on the stream on entry into the limestone and this was due to dolomite looming large in the upper catchment. He was also concerned to demonstrate from his data that corrosion below pervious alluvium was more responsible for blind valley enlargement in the limestone than lateral corrosion.

This kind of approach is not transferable to Yarrangobilly. Most of the blind valleys widen when they pass onto the limestone and there is little variation in hardness from one allogenic stream to another, though there is temporal variation of these streams as a whole.

The sinking streams and blind valleys, which White and White (1979) studied in the Appalachians, are much more comparable in their ranges of dimensions with the Yarrangobilly blind valleys than Gams' Slovenian ones. However these authors integrated data from neighbouring blind valleys lying within a larger closed depression so that their analysis is not fully comparable with the present one. Nevertheless as an example of the basic similarity one can compare their regression from 39 such composite blind valleys between total length of sinking stream and basin area

$$L = 2.29\ A^{0.85} \qquad r^2 = 0.88$$

with that of similar result from the smaller Yarrangobilly blind valley population presented above. There is no reason therefore to depart for Yarrangobilly from their conclusion that karstic drainage does not upset the normal fluvial morphometric relationships easily. Their reasoning applies here also; the basins have a high fraction of non-carbonate to carbonate rocks in the catchments and as a result there is a big input of sediment to the caves, hindering underground development by sediment blockage.

The present study is primarily directed at the further question of the relationship of blind valley development to the fluvial system of which it is part. In volumetric terms, this relationship fails to find simple expression because of the complex operation of factors involved. The size of the stream in proportion to the limestone to be crossed operates in two anatagonistic senses. The bigger the stream the more able it will be to maintain a surface course; once captured, however, greater discharge will fashion a larger blind valley. River gradient functions in an even more conflicting way; very low and very high gradients are unfavourable to underground capture, with an intermediate range which favours it. With low gradients, capture commonly takes the form of meander spur cutoffs where gradient across the base of the spur is greater than the general gradient of the river.

These factors, and others such as the details of geological structure, will greatly vary the timing of capture and the main conclusion from the analysis is that the factor of time intervenes so much that little in the way of dynamic equilibrium can be identified. Capture represents to a degree an accident or an intervention in a fluvial system and some derangement of morphometric relationships is to be expected. Such capture is probably more prevalent in a small, impounded karst of the Yarrangobilly type than elsewhere. However, there is no system to be discerned in the modification of the Yarrangobilly blind valleys by shifting of the streamsink and phases of incision, the number of events varying from one to three. Howard (1971) in a simulation modelling study has maintained that the introduction of capture simulation permits a better prediction of the statistical properties of surface river networks than completely random simulation. Perhaps the study of blind valleys along the present lines but in a karst which provides a larger population of them may permit more positive conclusions than are possible at Yarrangobilly.

ACKNOWLEDGEMENTS

Dr. J.M. Chappell and Mr. P.M. Fleming kindly read the manuscript of this paper; we are grateful for their comments. We also acknowledge help from the N.S.W. N.P.W.S. rangers in the Yarrangobilly area.

REFERENCES

CLARK D., 1946 Plane and Geodetic Surveying. Vol.1 Plane Surveying. 4th Ed. revised by J. CLENDINNING, Constable, London.

GAMS I., 1961 Slepe doline Slovenije v primerjalni metodi. Zbornik VI.kongresa geografov FLRJ v Ljubljani 1961.

GREGORY K.J. and WALLING D.E., 1973 Drainage Basin Form and Process. A Geomorphological Approach. Arnold, London.

HOWARD A.D., 1971 Simulation model of stream capture. Bull. Geol. Soc. Amer. 82: 1355-1376.

JENNINGS J.N., 1977 Caves around Canberra. Proc. XI Bienn. Conf., Aust. Spel. Fed., Canberra 1976: 79-95.

JENNINGS J.N., JAMES J.M., COUNSELL W.J., WHAITE T.M., 1972. Geomorphology of Bungonia Caves and Gorge. In: R. Ellis, L. Hawkins, R. Hawkins, J. James, S. Middleton, B. Nurse, G. Wellings (eds), Bungonia Caves: 113-43. Sydney Speleological Society Occ. Pap. 4.

KEMMERLEY P.R., 1976 Definitive doline characteristics in the Clarksville quadrangle, Tennessee. Bull. Geol. Soc. Amer. 87: 42-6.

NICOLL R.S., 1977 Preliminary report on drainage modifications in the Deep Creek-Eagles Nest basins, Yarrangobilly, NSW. Proc. XI Bienn. Conf. Aust. Spel. Fed., Canberra 1976: 96-103.

PAVEY A., 1975 A history of water-tracing attempts at Yarrangobilly. Spar 44: 5-10.

PAVEY A., SHANNON H., 1974 Water tracing results-Yarrangobilly. Spar 33: 18-20.

ROSE P., 1964-6 An introduction to the Yarrangobilly caves, New South Wales Australia. Cave Science 5: 203-15, 239-49, 413-25.

SPATE A.P., JENNINGS J.N., SMITH D.I., JAMES J.M., 1977 A triple dye tracing experiment at Yarrangobilly. Helictite 14: 27-48.

SWEETING M.M., 1950 Erosion cycles and limestone caverns in the Ingleborough district. Geog. Jour. 115: 63-78.

THOMAS T.M., 1973 Solution subsidence mechanisms and end-products in south-east Breconshire. Trans. Inst. Brit. Geog. 60: 69-86.

WHITE E.L., WHITE W.B., 1979 Quantitative morphology of landforms in carbonate rock basins in the Appalachian Highlands. Bull. Geol. Soc. Amer. 90: 385-96.

WILLIAMS P.W., 1966 Morphometric analysis of temperate karst landforms. Irish Speleol. 1: 23-31.

WILLIAMS P.W., 1972 The analysis of spatial characteristics of karst terrains. In: R.J. CHORLEY (ed), Spatial Analysis in Geomorphology: 135-63. Methuen, London.

Addresses for correspondence: J.N. Jennings and Bao Haosheng, Department of Biogeography and Geomorphology, The Australian National University, Box 4 G.P.O., Canberra, ACT 2600.

A.P. Spate, CSIRO, Division of Land Use Research, P.O. Box 1666, Canberra City, ACT 2601.

CAVES, GRAVES AND FOLKLORE OF NORMANBY ISLAND, PAPUA NEW GUINEA

C.D. Ollier and C.F. Pain

Abstract

A rock shelter in gneiss and several caves in raised coral limestone are described from Normanby Island. Songs and stories that relate some of the caves to ancestors and to the mythical origin of the island population are recounted. Cave burials are described, which are predominantly accumulations of human skulls.

INTRODUCTION

Normanby Island is the southernmost of the three largest islands of the D'Entrecasteaux Islands (Figure 1). It is about 25 km north of East Cape, the eastern extremity of the Papua New Guinea mainland. The island is mountainous, with only small areas of lowlying ground near the cost. Airstrips of Eas'ala and Sehulea are served by scheduled flights from Alatau, the capital of Milne Bay Province, of which Normanby Island is a part.

The geology of the island is depicted on the Fergusson Island 1:250,000 sheet (Davies, 1973) and has been described by Davies (1967). It consists of granite, metamorphic rocks and ultrabasics, with a few patches of raised coral on the northern coast. Our fieldwork was confined to the northern and northeastern parts of the island. In this paper, we report a cave or rock shelter in the gneiss, and a number of caves in the main limestone. This limestone consisting of uplifted coral, forms a very dissected terrace reaching elevations of over 200 m in the Luboda-Kwanaula area (Figure 1). We also report stories connected with some of the caves.

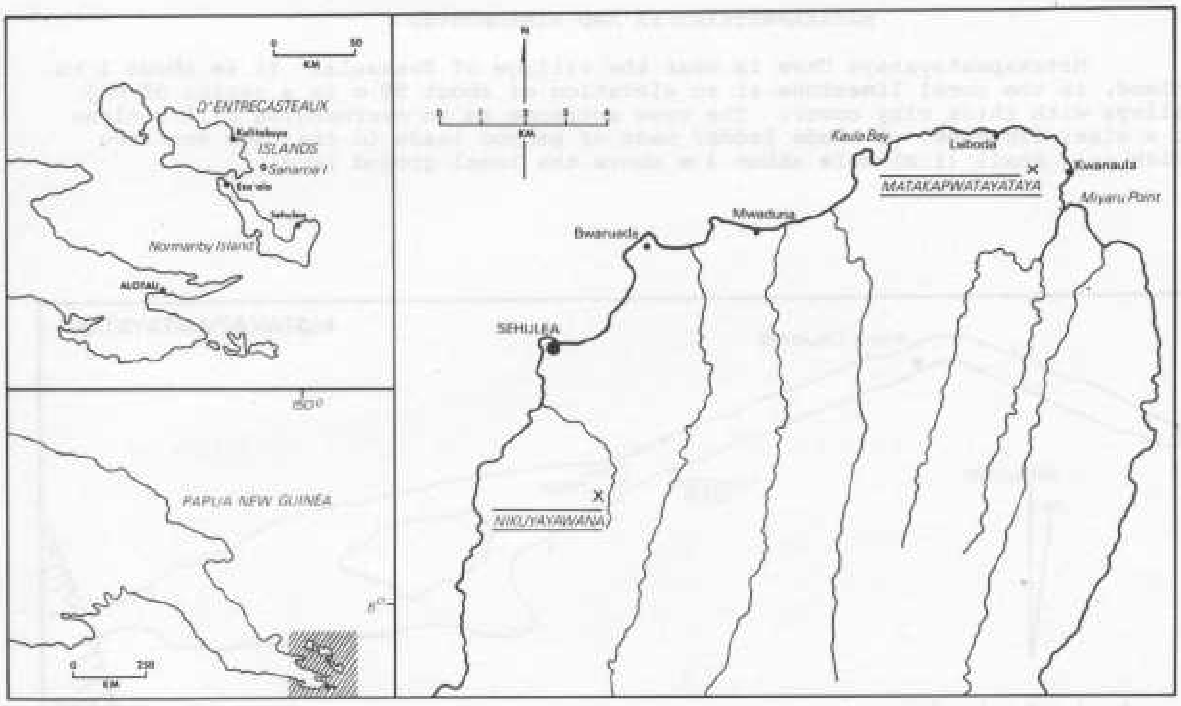


Figure 1. Location of Normanby Island, and places named in the text.

NIKUYAYAWANA

This is the fissure or cave located near the head of the valley immediately south of Sehulea (Figure 1). The cave may be reached from Sehulea in about 1½ hours of difficult walk over boulder piles and rotten log jams.

The fissure is in gneiss, with gneissosity dipping about 15° on a bearing of 280° magnetic. Two vertical joints parallel to the dip direction are 3 m apart, and the rock between them is eroded away. The floor slopes at 30° and the upper part has an overhang inhabited by flying foxes. The fissure is about 30 m long, but the overhung part is only about 5 m.

The story of the cave

It is said that a man was out walking with his family. The split appeared in the mountain, with the man on one side and his family on the other. The old man who told me this story said the man was his grandfather, but I think he may have meant simply forefather or ancestor. He also sang a song about the cave, in Dobuan language.

The song of the cave

1. Ya luho bena ilugu koya kelibu ninaya
2. Tauwasiwasilele mabotanina ikena

Translated this means:

1. The split goes in. The mountain breaks apart.
2. A man [the one in the story] made it happen by magic.

The song consists of line 1 followed by line 2, and then the couplet repeated many times over.

MATAKAPWATAYATAYA AND SINEDADAUYO

Matakapwatayataya Cave is near the village of Kwanaula. It is about 1 km inland, in the coral limestone at an elevation of about 50 m in a region of dry valleys with thick clay cover. The cave entrance is an overhanging cliff, close to a giant fig tree. A crude ladder made of bamboo leads to the cave entrance which is a small (1 m) hole about 3 m above the local ground level.

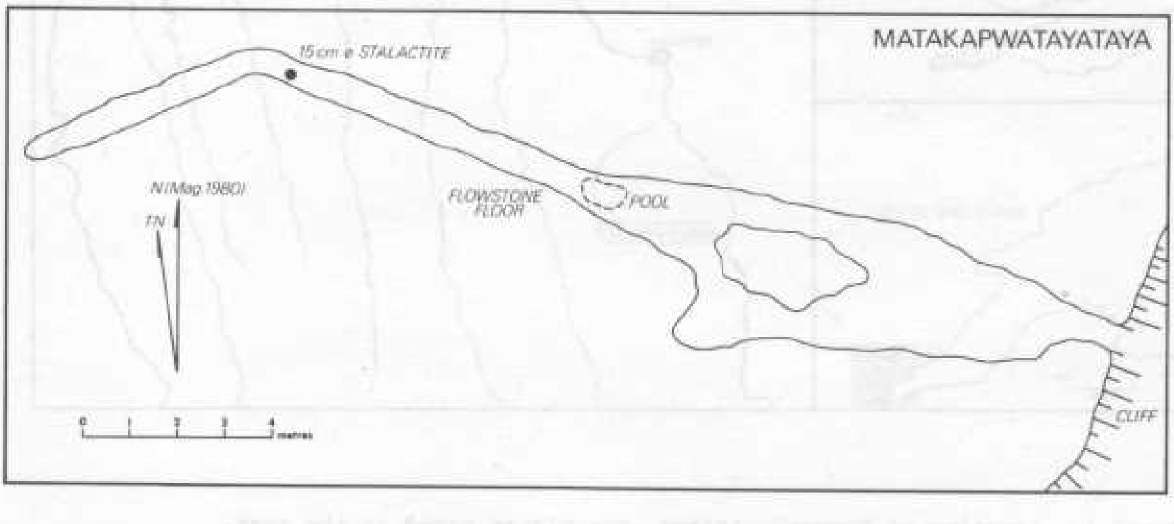


Figure 2. Matakapwatayataya Cave, Normanby Island.

Much of the cave (Figure 2) consists of a short stream passage which is floored by alluvium, mostly clay but also including pebbles of metamorphic rock. The coral limestone contains occasional pebbles of metamorphic rock, so those in the cave might be derived from the limestone rather than carried from more distant outcrops of metamorphic rock. The cave walls and ceiling show distinct phreatic features including bell holes and elliptical scallops and holes the size of a football. Most of the walls are obscured by flowstone, and the cave is decorated with a few straws, stalactites, shawls, and one column 15 cm in diameter.

Close to and uphill from Matakapwatayataya is a bigger cave with no name. It has a roof showing similar features of flowstone and phreatic solution, and a convex floor of clay.

Sinedadauyo Cave is at the bottom of a doline about 5 m deep, and is a coalescence of several steep sided holes. Like the other caves it has walls partly obscured by flowstone, and partly indicating phreatic solution. Solution has been somewhat complex, with an initial development of broad solutional cavities, followed by etching out of rock detail, so that fossils and structures in the limestone stand out like the grain on an old piece of wood. This may result from contrasting transport limited and solution-limited reactions. Berner (1978) has suggested that transport-limited solution reactions tend to produce smooth surfaces, since they are associated with high acidity and/or long solvent/solid contact times, whereas with low acidity and/or short contact times the solution process becomes reaction-limited, which favours the development of fretted or etched surfaces.

The Story of Matakapwatayataya and his mother Sinedadauyo

Matakapwatayataya's mother was called Sinedadauyo. She had no husband.

She had two sons. The first was IGU (bird) and the second one was WENYASIU (dog).[1]

They were living with relatives, but a giant called KEDAHUTUWANA[2] was killing many people.

So the relatives all ran away by canoe to Woodlark Island, except for Sinedadauyo who hid in a cave with her two sons. At this time, she was pregnant and gave birth to Matakapwatayataya.

Matakapwatayataya had two eyes at the front and also two eyes at the back of his head.

When Matakapwatayataya grew up, he asked his mother "Where are our relatives?"

His mother told him that the giant had frightened them away to Woodlark Island because he killed many people.

Matakapwatayataya said he wanted to kill the giant, but his mother said he was too young.

He made spears to kill the giant.

Then he killed the giant, took his body home to the cave, and they ate him.

After that he asked his mother "Do we have any enemies?"

She told him "We have one enemy, a big wild pig called BAWEGALAGALA."

So Matakapwatayataya went and killed the wild pig. He cut off the pig's tail. He also cut off the giant's beard.

He made a small sailing canoe. He put the tail and the beard on the boat and he sent it to Woodlark. He told the boat "If you hear people talking different languages don't go to them, but when you hear people talking our language, go to them."

On Woodlark the relatives came down to the beach and saw the sailing boat. They saw the pig's tail and the giant's beard. They realised that Sinedadauyo's baby had grown up and killed their enemies.

---

[1] As we understand she really did give birth to a bird and a dog, not to humans who bore these names.

[2] The giant's house, Kedahutuwana, is a rock shelter near Kwanaula.

So the relatives came back to Normanby Island. They landed at KEKULA (Kwanaula).

Sinedadauyo left the cave to bring saltwater, and she found the relatives on the beach.

She returned to the cave and told her son that the people had returned.

Matakapwatayataya decorated his face and his body with ash[3], and left the cave. He went to see the people on the beach.

The people were frightened of him. The saw his four eyes. The people all turned into stones.

He went back to the cave and told his mother.

She said "Get a big octopus called HANEBUYUWETA."

He speared this octopus[4]. The ink from the octopus splashed up and closed the eyes at the back of his head. He ran back to his mother. He cried to his mother that the octopus had got him.

Sinedadauyo said "It is your own fault. I told you not to kill the octopus."

She said "We will leave this cave and go to another place to live." They went straight to BWARUADA.

Matakapwatayataya went into a deep hole in the sea. He called from the bottom "Mother, do you see me or not?"

She said "I cannot see you. I will give you some advice."

He stood up.

She said "If you see people sailing around, do not kill them. If rainfall and floods come, logs will come out of the river, and then you can do what you want."

She then gave advice to the two brothers. She told Igu to stay at ULOGU (on Sanaroa Island, just east of Fergusson Island). She told Wenyasiu to stay at KALITABUYA (northeastern Fergusson Island). Then Matakapwatayataya said to his mother, "Mother, you stay there and I'll stay down here." Matakapwatayataya and Sinedadauyo both turned into stones.

Our stories in western culture tend to have a strong story line, reaching a climax and evan a moral principle or a punch line. The cave legends we have heard in Papua often seem to western ears to be rambling, pointless and illogical, and on this basis, the story of Matakapwatayataya and his relations is authentic. Like other stories of Papua it relates to certain features of the landscape. Just how these are selected is not clear, for there are other, un-named caves that appear just as impressive as those included in the story, and similarly there are more spectacular rocks and bigger bays than those in the legend. We read this story to several groups of people in Esa'ala, and it was always received with great interest and pleasure, and a few adults remember hearing the story when they were children.

It was also clear that the guides who took us to the cave were familar with the tale, but would not tell it to us. Instead they took us to an old man in Luboda village, perhaps the official teller of tales, who told it with considerable verve. It seems that the story is not tabu, but neither is it quite free to be told by anyone, at least in the villages close to the caves.

BWAKWAITABAULA

This may be a big cave, but all we saw was the entrance which is a vertical cleft about 2m by 60 cm, and 7 m deep. The bottom is clearly visible, and is a flat floor, part of a chamber considerably bigger than the cleft.

The special interest of this cave is its former use, for it is said that in olden days mad people were thrown down this hole. No further details are available, but it seemed to us that the drop is not sufficient to ensure instant death, and anyone thrown down might survive, although injured. There is no account of any mad people escaping, so presumably they would die of starvation. No bones were visible from the top.

---

[3] Covering the body with ash or soot is still done at times, such as when a widow is in mourning.

[4] The place of the octopus is a deep embayment in the coast near Mwaduna.

Plate 1. Skulls in a natural coral depression at Nesai, Normanby Island.

Plate 2. Skulls on a coral ledge near Kwanalau School, Normanby Island.

Plate 3. Pottery associated with skulls near Kwanalau School, Normanby Island.

Plate 4. Skulls at Miyaru Point, Normanby Island. Note the wall made of coral blocks.

CAVE BURIALS

A number of caves and other suitable sites in limestone have been used in the past for cave burials. Some of these sites are still tabu; we were on the verge of being taken to two caves but we were warned off by old people because "they are our relatives". We were not able to discover how recently cave burial has occurred, but in the light of what we known of cave burials in Milne Bay Province, it is likely that the burials are ancient, though on some islands, the practice continued into times of living memory (Ollier and Holdsworth, 1977).

Baruada Isoyena

This is actually the name of the hill on which the cave is found at an elevation of 190 m in limestone. Numerous skulls have been deposited in the cave but there are no other bones, no pottery remains, and no signs of structures.

On one high shelf there are 85 skulls. At lower levels many small solution hollows have served as containers for five to ten skulls.

Nesai

Behind the village of Lelebogai at an elevation estimated to be about 100 m there is a small patch of karst consisting of small tabular elevations about a metre high separated by narrow corridors. One of these "tables" is hollow, and has been used as a container for skulls. There is a natural partition inside, but both sides have been filled by skulls. At least ten skulls are present, but we did not disturb them, and there could be more if the hollow is deep. The skulls seem relatively large, so presumably are all adult, and have no signs of injuries. No other bones were present, nor any pottery fragments. The skull container is protected by slabs of slate, which were removed to examine and photograph the skulls (Plate 1) and then replaced, together with chunks of coral that help to hold the slabs down.

Meyabana

Kwanaula School (Figure 1) is on a plateau bounded by cliffs near a point called Meyabana. The same name is given to a burial site. This is on a ledge up to two metres wide, about 7 m below the plateau (at the base of a slightly overhanging cliff) and with a steep cliff below, perhaps 15 m above sea level. The cave is reached by descending a gully to the west and then traversing the cliff to the ledge. There is a small sky-light in the "roof" of the overhanging cliff, but it does not allow easy access.

There are 3 groups of bones on the ledge. The best preserved group is in the centre where a shelf has been constructed out of slabs of slate, and on this 18 skulls have been arranged. We are not experts on bones, but judge that both male and female were present, and in general the bones seemed on the small side, though we did not distrub them or measure them. No injuries or drill holes were evident.

To the east a small solution hole has been used to store skulls, and then been walled off by lumps of coral to make what we have previously called a crypt. The skulls were similar in the central heap, and without disturbing them were estimated to number 18.

To the west are the remains of another slate shelf, and the skulls that were originally piled on it. There are 16 skulls on this broken shelf, similar to the rest.

Scattered around on the platform are another 40 skulls (Plate 2). Whether these were originally neatly arranged is not known, but it is quite possible that they were and have been subsequently scattered. With this total of 94 skulls, which might easily exceed a hundred if the skulls were moved to reveal possible hidden ones, it is surprising that the only other bones present are four limb bones (thought to be the remains of two legs) amongst the scattered skulls.

On the ledge, in front of the western shelf-assemblage, are 2 pots with diameters of about 25 cm and 45 cm. Both were inverted and empty. We moved the pots to photograph their shape and their ornament (Plate 3) and replaced them as we found them. We do not yet know if the shape and ornament will be sufficient to determine their provenance. At present pottery used on Normanby Island comes from the Wale and Tubetube (south of Basilaki Is. in the Engineer Group), and pottery is still in general use in many of the villages.

Miyaru Point

South of Kwanaula School, near Miyaru Point (Figure 1) there is a group of burials in clefts and ledges in the coral limestone. At levels only about 1 - 2 m above sea level the following burials were observed:

1. At least 18 skulls are contained in a cleft walled off with lumps of coral.

2. A small cave a few metres away has a number of heads as well as a variety of other bones including ribs, vertebrae, and limb bones.

3. Ten heads were counted in a walled off notch cut under a large block of coral; these skulls could well obscure others behind (Plate 4).

In addition, 82 skulls are present on a ledge high up on a coral pinnacle, about 15 m from the beach, and 8 - 10 m above sea level. A few of these skulls are visible from below the pinnacle; the ledge is difficult of access. Our guides did not know whether the place had any special name. No pots were observed at this site.

CONCLUSIONS

Elsewhere in the Milne Bay Province (the most complete information comes from the Trobriands - Ollier and Holdsworth, 1977) burials include both skulls and large quantities of other bones as well. Dead bodies were first buried in the ground, and after some months when the flesh had decayed the bones were exhumed and often deposited in a cave. Usually many bones were transferred, and although many small bones were lost the cave burials included many limb bones, and smaller numbers of other bones as well as skulls. The remains were often placed in a container such as a pot, and pots and pottery fragments are frequently associated with the cave burials. Some of the skulls have injuries, and some have drill holes made after death.

On Normanby Island, by comparison, burials consist largely of skulls, with very few other bones; only one exception to this was found, in an admittedly small sample. The presence of large numbers of skulls in cave burials appear to be a special feature of the Normanby burials. We have observed a similar cave in only one other location. Hinauta Cave, on Misima, was floored wall-to-wall with skulls and in spite of a few other bones and pottery fragments, is pre-eminently a skull cave (Pain and Ollier, 1978). Perhaps there is a link between the skull cave on Misima and the similar cave burials on Normanby.

ACKNOWLEDGEMENTS

The work reported here was undertaken while we were receiving support from an ARGC grant. Mr. John Standing of Alatau provided accommodation and good company. We thank Francis Yura, D.O.I.C., Sehulea, and his wife for accommodation, and similarly the missionary family at Luboda, and thank Ganaia Elimo, D.O.I.C., Esa'ala for assistance with tranpsort.

REFERENCES

BERNER, R.A. 1978 Rate control of mineral dissolution under earth surface conditions, Amer. J. Sci. 278: 1235-1252.

DAVIES, H.L., 1967 Normanby Island, T.P.N.G. - Reconnaissance geology, Bureau of Mineral Resources Records, 1967/50.

DAVIES, H.L. 1973 Fergusson Island, Papua New Guinea, Sheet SC/56-5. 1: 250,000 Geological Series - Explanatory Notes, Map. Bureau of Mineral Resources, Australia.

OLLIER, C.D. and HOLDSWORTH, D.K., 1977 Cave Burials in Eastern Papua. Studies in Speleology, 3: 50-65.

PAIN, C.F. and OLLIER, C.D., 1978 Caves and karst on Misima Island, Papua New Guinea. Helictite, 16: 40-49.

Address for correspondence:

C.D. Ollier, Dept. of Geography, University of New England, Armidale, N.S.W. 2351.

C.F. Pain, Dept. of Geography, University of N.S.W., Kensington, N.S.W. 2033.

CAVES AND KARST OF THE MULLER RANGE: EXPLORATION IN PAPUA NEW GUINEA. Editors J.M. James and H.J. Dyson.

Report of Atea-78, Australasian Speleological Expedition.

160 pages, with full colour cover, 71 plates, 69 figures and maps, and three large loose-leaf maps. Published by Atea 78 in conjunction with Speleological Research Council Ltd.

Price: $15, post free

Pre-publication offer: price $10 for orders received with payment before January 14th, 1981.

Available from: SRC Ltd., P.O. Box 183, Broadway, NSW 2007

ATEA 1978

Speleological Research Council Limited

Recent publications from the

Speleological Research Council Limited

CAVES OF THE NULLARBOR
edited by J.R. Dunkley & T.M.L. Wigley
Second Edition. Published December 1978
$6 (post free)

....

THE CAVES OF JENOLAN –
Volume I : THE EXPLORATION & SPELEOGEOGRAPHY OF MAMMOTH CAVE, JENOLAN
by J.R. Dunkley & E.G. Anderson
Second Edition. Published December 1978
$6 (post free)

....

THE CAVES OF JENOLAN —
Volume II : THE NORTHERN LIMESTONE
edited by B. Welch
Published 1976
$6 (post free)

....

Available from :-

Speleological Research Council Limited
P.O. Box 183,
Broadway NSW 2007

INFORMATION FOR CONTRIBUTORS

SCOPE

Contributions from all fields of study related to speleology will be considered for publication. Suitable fields include Earth Sciences, Speleochemistry, Hydrology, Meteorology, Conservation, Biospeleology, History, Major Exploration (Expedition) Reports, Equipment and Techniques, Surveying and Cartography, Photography and Documentation. Comprehensive descriptive accounts of the exploration and morphology of individual caves will be welcomed, but simple trip reports and brief cave descriptions are not adequate. Papers overall should not exceed 20 printed pages in length. Contributors intending to write at greater length or requiring any advice on details of preparation are invited to correspond with the Editors. All manuscripts will be read by referees. Short 'Letters to the Editor', expressing a personal view or giving a preliminary report of interesting findings, are welcomed, and will be given preference for speedy publication.

MANUSCRIPTS

Submitted manuscripts should be in a final form ready for publication. As proofs are not normally sent to authors particular care should be taken to check for typing errors. Manuscripts should be typed, double spaced, on one side of the paper. The title should be uppercase and underlined, and the authors' names should follow. A brief and explicit summary of the notable aspects of the paper, headed Abstract, should precede the main text.

Throughout the main text major headings should be in upper case, centred and not underlined, while subheadings should use lower case, underlined and aligned with the left hand margin. Acknowledgements should be placed at the end of the text before the references, and the authors' addresses for correspondence should follow the references.

Authors with access to an IBM Golfball typewriter may wish to submit their papers in 'camera-ready' form. They should request our leaflet "Helictite Typographic Style". Papers should still be submitted in the above form in the first instance.

REFERENCES

References should be listed alphabetically at the end of the manuscript and cited in the text by the author's name and the year of publication (e.g. "(Grey, 1973)"). Where there is more than one reference to the same author in one year the letters a,b, c, etc. should be added. If there are more than two authors, they should all be named at the first citation and in the reference list, but the first name followed by 'et al.' should be used in subsequent citations. References should be checked particularly carefully for accuracy. Journal titles should be abbreviated following the "World List of Scientific Periodicals", which is available in most large libraries. The following examples illustrate the style:

GRAY, M.R., 1973 Cavernicolous spiders from the Nullarbor Plain and south-west Australia. J. Aust. ent. Soc. 12: 207-221.

VANDEL, A., 1965 Biospeleology. The Biology of the Cavernicolous Animals. Pergamon, London. Pp. xxiv, 524.

WIGLEY, T.M.L. and WOOD, I.D., 1967 Meteorology of the Nullarbor Plain caves. In: J.R. DUNKLEY and T.M.L. WIGLEY (eds), Caves of the Nullarbor. A Review of Speleological Investigations in the Nullarbor Plain. Southern Australia: 32-34. Speleological Research Council, Ltd., Sydney.

ILLUSTRATIONS

Figures and photographs should be kept to a minimum and generally should not duplicate information in tables or other material. Photographs should be clear black and white prints with sharp focus. Where several photographs are to form one plate they should be mounted together on white card. Any lettering required on photographs should be applied with 'Letraset'. Figures should be drawn in Indian ink on white card, heavy paper or tracing material and lettered using stencils or 'Letraset'.

All illustrations should be drawn to fit a print area of 160 x 260 mm. They may be larger provided that these proportions are maintained, but allowance for reduction must be made when choosing letter sizes and line thickness. Several diagrams or photographs can only be included in one page if they all require the same reduction. Diagrams for inclusion in the text must be drawn to a width of either 160 mm (to appear at the same size) or 220 mm (for reduction); they must be clear and simple as they will be reproduced by a lower-quality process.

Figures and plates should each be numbered consecutively and specifically referred to in the text. The numbers should be marked lightly in pencil on the margin or back of each illustration. Captions should be typed on a separate sheet.

UNITS

The S.I. system (Australian Standard AS 1000) should be used unless citing historical data, in which case the original units should be quoted and appropriately rounded metric equivalents added; e.g. "100 feet (30 m)".

OFFPRINTS

Offprints of papers will be supplied after publication, at the author's expense. The number required should be stated when submitting the manuscript.

HELICTITE

Journal of Australasian Cave Research

VOLUME 18(2) 1980

CONTENTS

Review: Elements de Karstologie Physique by Richard Maire - Jane Dyson	30
A Review of the Cord Technique (La Technique Cordelette) - A.T. Warild	31
Equilibrium versus Events in River Behaviour and Blind Valleys at Yarrangobilly, New South Wales - J.N. Jennings, Bao Haosheng and A.P. Spate	39
Caves, Graves and Folklore of Normanby Island, Papua New Guinea - C.D. Ollier and C.F. Pain	55

Speleological Research Council Limited