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JOURNAL COMMITTEE - G. SMITH, E. CRABB

Many thanks to Miss P. Horn for typing many of the articles and to members of the H.C.G. for their help in production.

INTRODUCTION

It has been five years since the last Highland Caving Group journal appeared and, unfortunately, this irregularity of publication will be the rule rather than the exception. Journals 1 and 2 were filled with the work mostly carried out during the years in which the club had no formal publication. Rather than print whatever was to hand in order to maintain annual publications it was decided to delay publication until sufficient material of the high quality of previous journals was available.

Highland Caving Group also publishes Calcite on a four issue per year basis. Here, trip reports and casual articles are presented so that a complete record of club activities are available. Furthermore, this is an excellent avenue by which to publish observations made on trips. These observations, on their own, may mean little, but such "useless" observations may fit into a much broader series that has been accruing in a readers mind. Publication of such broader overviews is the function of the Journal.

Journals 1 and 2 show a heavy bias towards Bungonia. At the time this was the major area of interest of club members. Since that time interests have diversified. Cooleman Plain and Mudgee currently attract more attention. Articles covering some aspect of each area appear in this issue. There are fewer maps than in previous issues but this is more than balanced by specialist articles on isometric maps biology, photography and digging. In coming years we believe, that by our policy of irregular publication, we can continue our high standard of documentation.

GRAEME SMITH

TECHNIQUES

QUALITY CONTROL IN CAVE PHOTOGRAPHY

Evalt Crabb

INTRODUCTION

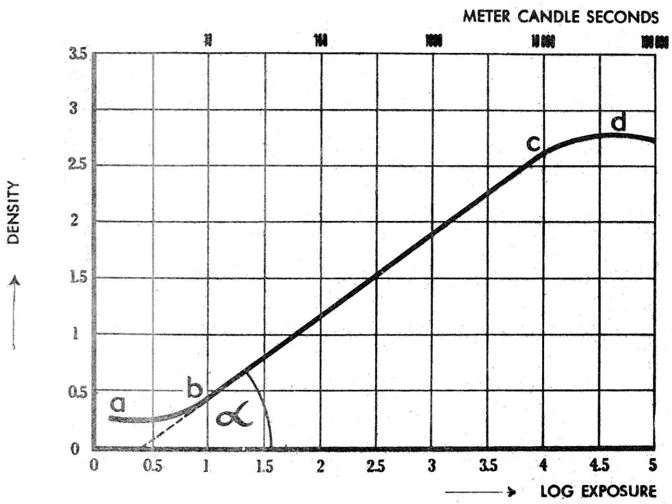
All cavers use photography, as either supplier or consumer, quite extensively during their caving life. Most reasonable publications use photography to illustrate points in the text; probably all cavers have photographic mementos of particular trips and particular friends; a few cave photographers try to explore creative pictorial techniques; and a small minority use photography seriously as a tool in documentation.

The need for quality control, particularly tonal control, rises as we progress from souvenir snapshot through pictorial work to objective recording of cave phenomena. This article is intended to describe the limitations of the medium, and to describe how control can be exercised.

Although slightly confusing, it has been found necessary to build up each aspect with black-and-white systems first, then to expand to colour emulsions; no attempt has been made to comment on "instant" photography as very little control is possible and is therefore - to the writer - beneath contempt. For the sake of brevity it is assumed the reader is familiar with basic instructions such as are available in leaflets, operating instructions, etc., and understands basic photographic terminology.

EMULSIONS

All current materials depend on the sensitivity of silver salts, mainly the nitrate and iodide salts, to light. With sufficient light, and in the presence of gelatine, these salts can be reduced to metallic silver by chemical processes, the density of the silver image varying according to the amount of light and the chemical process used. Thus a negative exposed in a camera has greatest density where the most light has fallen, i.e. the "highlights", and minimum density in the shadow areas. By means of a graph, called a characteristic curve (of gradation or blackening), we can show graphicly how the blackening increases progressively with the amount of light received. This allows one to take in the main characteristics of the film at a glance.



A typical characteristic curve is shown in fig. 1. The figures on the horizontal axis represent the light intensity and those on the vertical axis represent the density. The exposures are standardised in Candella-seconds and are plotted logarithmically. It will be noticed that the curve starts somewhat above the base; this represents a basic fog level - the density of the film base and the various coatings. At (a) the first visible density is produced and this point is called the "threshold value" or "threshold sensitivity". From (a) to (b) - the "toe" - density rises at first slowly but then with increasing rapidity. The part between (b) and (c) is called the "straight line portion".

Above (c) the gradient of the curve decreases at what is known as the "shoulder", and this indicates the region of over-exposure and the beginning of "solarization" - tonal reversal of the grains of silver halide. At (d) exposure differences are no longer associated with differences in density, the silver halide being completely solarized. The straight line portion defines the range in which density increases proportionally to log. exposure and it is therefore the only portion of the characteristic curve which is of practical use from the photographic point of view.

Colour films are composed of three layers of emulsion, each sensitive to a narrow band of the spectrum. In optimum conditions the characteristic curves og all layers are identical, but in practice this is seldom, if ever, achieved.

CONTRAST AND GAMMA

The different parts of a scene are photographicly distinguished solely by their different brightnesses. Outdoors, this can range from 2:1 (landscapes with mist) to over 1000:1 (back-lit landscape). Even greater extremes are encountered in cave photography when a light source is included within the photograph.

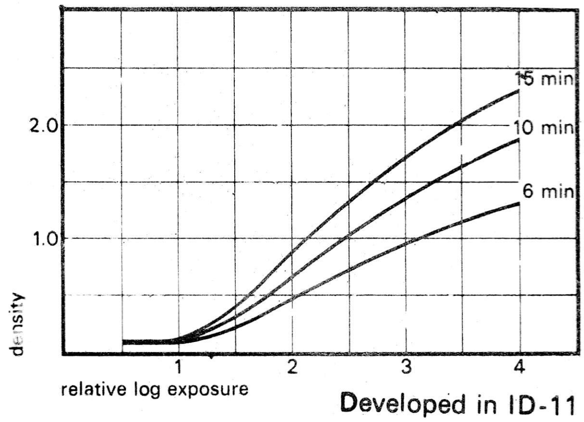
A B&W negative is capable of recording a brightness range of 1000:1 on the straight line portion of its curve if very accurately exposed. Any variation in exposure would lead to compression of tones; alternatively if the subject contrast is only, say, 25:1, then there is considerable latitude in exposure.

It must be remembered, nowever, that this range is discernable by transmitted light only, and here is a clue to the deserved popularity, years ago, of "lantern plates", where positive prints on film or glass exhibited a full tonal range as they were viewed by transmitted light. Here is where all photographic papers fail. On prints, a pure white does not exist, and in even the brightest parts of a print where the emulsion has not been affected by light, the paper itself absorbs a fraction of the incident light and reflects a maximum of 80%. The light reflected from the deepest shadows, which should be totally black, gives a type of fog which makes it difficult to discriminate between the different shadows and makes them merge together into a single tone. Thus the contrast is between 16:1 and 40:1.

Use of matt or semi-matt surfaced papers can lower the contrast to as little as 6:1.

Photo-mechanical reproduction further decreases the contrast. The continuous tone of an original photographic print is represented by a series of black dots printed on white (or worse, tinted) paper, the size of the dot varying according to the density of the original print. However light tones are reproduced with dots covering 5% of the available area. Black in the deepest shadows is reproduced with a residual 5% white space. This is done for purely mechanical reasons. Due to the reflective properties of the image and paper, together with the common use of low opacity inks, the highest contrast reproducible is in the order of 7:1 on glossy white art paper. This is the cause of much dissapointment in the reproductions in caving literature, particularly as so many illustrations contain large areas of shadow tone.

With B&W films, extreme brightness ranges can be controlled to some degree by development of the film to a lower contrast, or more correctly - gamma. This can be defined as the ratio between negative contrast and subject brightness. In normal processing negatives are usually developed to a gamma of 0.7. Thus not only is the contrast reduced but the exposure latitude is enhanced.



Developed in ID-11

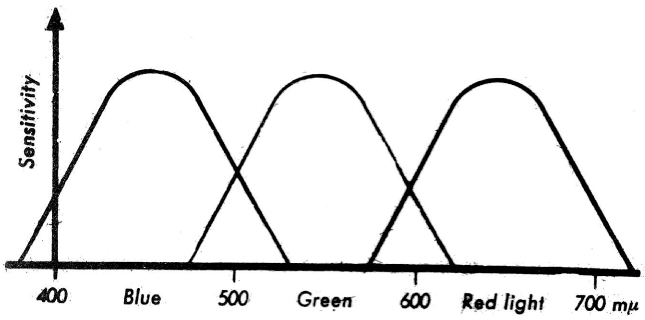
Fig. 2 shows the characteristic curves for Ilford FP4 35mm film. As can be seen, the lower gamma, the more shallow the gradient, simplifying the tonal control. Also obvious is that the toe of the curve is hardly affected. This is relevant as the sensitivity, or speed rating, of the film, is determined by the position of 0.1 density above fog level for DIN rating, and a similar parameter for ASA rating.

To gain more control of the medium, it is necessary to have knowledge of the characteristics of the chosen film, to control lighting to a pre-determined contrast situation, and to develop the film to a known gamma. Such control is at its peak in the work of Ansel Adams and Edward Weston (U.S.A.), and is well detailed in their published works. In particular, the Ansel Adams "zone system" cannot be bettered.

Knowledge of a chosen film is gained by photographing a step-wedge (described later), and developing short strips of the film to different gammas. Prints are then made on the chosen paper. In the field, reflected light readings are taken from many parts of the selected scene, a decision is made of what density is needed in the key component of the picture as well as the highlight and shadow tones, and an exposure and development selected to produce a pre-conceived result. It is then far easier to print the desired result if the negative exhibits the required tonal range and placement of mid-tones.

CONTRAST AND COLOUR FILM

Colour films are composed of three layers of emulsion, each of which is sensitive to a narrow part of the spectrum as shown in the typical sensitivity graph in fig. 3.



This is achieved by the use of colour sensitising dyes in each silver halide layer. The emulsion layers also contain what are known as colour couplers - e.g. a-naphthol (cyan), pyrazolon derivatives (magenta) or acetoacetic esters (yellow). When the film is developed (i.e. the silver halides are reduced to silver) in paraphenylenediamine (or a derivative) it reacts with the colour couplers in the emulsion to form insoluble dyestuffs. The silver image and all unused components are subsequently rendered soluble and are removed, leaving an image composed of three dyes. (This is a simplified description of complex processes which vary between different manufacturers but which all result in a three-colour dye image.)

Colour film can only record and reproduce faithfully a somewhat restricted brightness range. The subject contrast must, therefore, be kept within rather narrow limits.

In all these considerations we are exempting the specular highlights (such as reflections from eyes, water etc.) which need to be recorded as white and trapped shadows, where no light falls and where we wish to see no detail at all, merely rendering them as the fullest black.

A film characteristic which is important with colour transparencies is the maximum density (D.max). Every film, due to its particular dye-forming process and sensitising system achieves its own D.max and contrast. For the sake of a particular characteristic (enhanced sensitivity, good flesh colour, accurate colour in mid-tones) the D.max may be less than ideal and the "black" areas may not be a solid, opaque block. Accordingly, shadow areas will bias towards a particular colour. As cave photography depends for effect, rather than information, on trapped shadows, a factor in choosing a film type is its D.max characteristics.

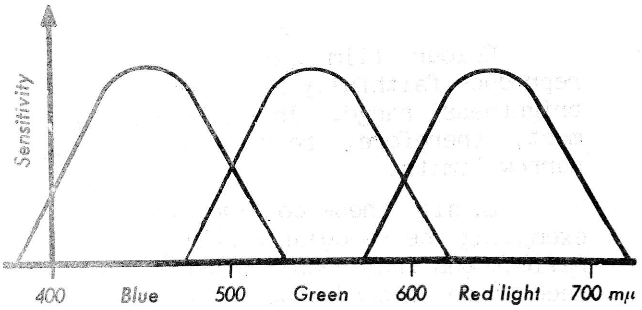
The much lower subject brightness range recommended for colour material, particularly transparencies, may appear contradictory in view of the earlier paragraphs, but this is not so. As the colour image is composed entirely of dyes of limited light absorbancy, then D.max of colour film cannot approach the opacity of metallic silver particles present on B&W film.

The other problem is the different colour balance resulting from the quality of the incident light falling on different parts of the picture area, and this is dealt with in later paragraphs.

SPECTRAL RESPONSE

The sensitivity of normal films is balanced to "white" light, i.e. sunlight or similar lighting forms which exhibit an emission continuous across the visible spectrum.

Fig. 4. illustrates a wedge spectrogram for Ilford FP4 film. Emissions of light from some oxidation processes and various gas discharge lamps do not however have a continuous spectral emission, and this can greatly affect the sensitivity (i.e. speed rating) of the film.



With colour film (see fig. 3) narrow band emissions may fall into the overlap areas between each colour peak, not only effectively reducing the speed rating of the film, but also causing the colour rendering to be so far out of balance that no filtering could correct the situation. A well known example is fluorescent lighting, which has an almost total red deficiency.

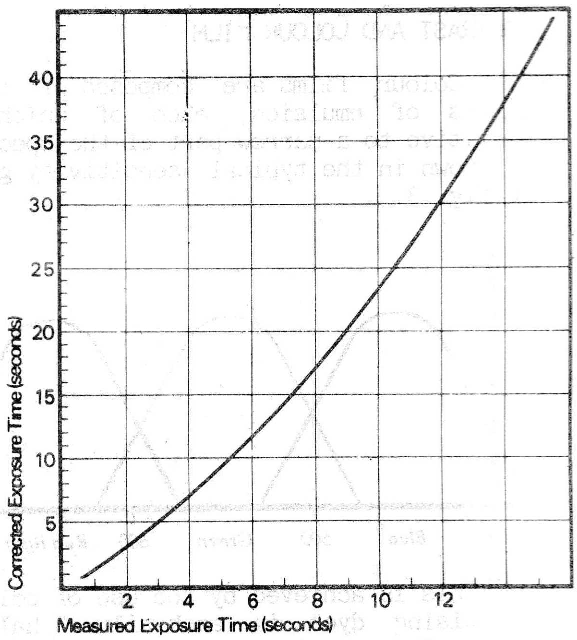
The chromatic quality of continuous spectrum lighting is measured using a " colour temperature " scale. Colour temperature is defined as the temperature, in degrees Kelvin, to which a theoretical black body would be raised to produce a spectrum of the required quality. For example, direct sunlight received at or near sea-level is said to have a colour temperature of 5700°K, incandescent electric lighting is around 2800°K, floodlighting 3200-3400°K, and cloud-filtered sunlight 8000-10000°K.

With some exceptions still colour films available to-day are balanced for lighting at 5700°K, and are usually tolerant to electronic flash at 6000 - 6500°K. Blue coated flash bulbs have an emission similar to sunlight.

A common difficulty is that although the subject may be correctly lighted, the shadows are often lit by diffuse (i.e. filtered) light, or even worse, by reflected light, where there has been selective absorption. In some cases, highlight density may be affected by reflection from a surface absorbing part of the spectrum. It would be possible to have, in the one photo, neutral mid-tones, excessively blue shadows and excessively yellow (i.e. minus blue) highlights. Although the mind re-interprets visual stimuli, colour film does not rationalise, and the resultant photos are unacceptable. By limiting subject contrast by controlling lighting and camera position, control of colour balance is possible.

Reciprocity Failure

Within the limits normally found in photography the response of an emulsion to light is constant and there is a reciprocal relationship between the intensity of the light and the time of the exposure required. Hence, if the exposure time is halved the light intensity must be doubled to achieve a similar result. This is known as the " reciprocity law " and is applicable over the range of intensities and exposure times commonly employed. Under extreme conditions of exposure, however, it is found that densities are lower than the law predicts, i.e. the film is underexposed. This effect is known as "reciprocity failure". Fig. 5 illustrates the compensation needed for Ilford FP4 film.



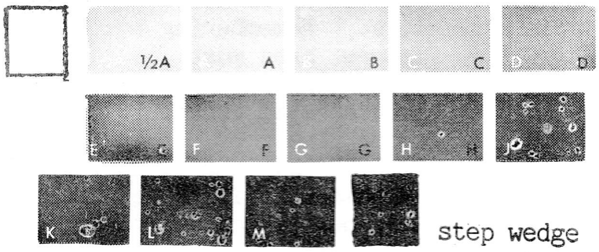
Reciprocity failure also affects contrast; contrast becomes greater when the exposure is very long and lower when it is very short. Unusually low contrast can result from extremely short exposures such as are obtained from high voltage electronic flashes, or first generation computer flashes used close up.

The effects of reciprocity failure, especially the variation in contrast, are particularly troublesome with colour film. This is because the three emulsion layers rarely have the same reciprocity failure characteristics and there is no way of compensating for unequal contrast changes.

SIMPLE FILM TESTING

It is very difficult to evaluate the performance of a film from actual pictorial photographs, so it is valuable to use a fixed testing system. The subjects used for a test photo are a neutral grey step wedge, colour testing patches, a lens testing chart, and an 18% neutral test card.

The step wedge is used as a check on contrast - the white patch should print white, the black patch should print black, and the intermediate grey scale will indicate any compression or extension of tones in the upper, middle or lower scales.



step wedge

The use of standard colour patches is obvious - to determine the accuracy of the colour responses of the film to the range of primary colours using a particular light source. Any deviation is immediately noticable.

The lens test card records the detail-rendering ability of the lens and film in terms of lines per millimeter at the film plane. This gives a quantitative index to apparent visual sharpness, and also it is possible to calculate what size object (e.g. a leaf) at what distance will be recorded.

The 18% neutral test card is normally used to determine reflected-light exposure and is more accurate than a general reading off the subject with an exposure meter. It offers a reasonable compromise to separate highlight and shadow readings. On a negative or print, the tone produced by this card gives an indication of the accuracy of the exposure, and with colour film the neutral grey card soon indicates any colour bias.

If one exposure per roll of film were allocated for test purposes, it would soon be possible to compare films, to determine the effect of various light sources and exposure techniques and even to determine the variations that occur as a film ages. Essential, of course, is an accurate recording of the many variables in each test.

THE HUMAN FACTOR

For a photograph to be acceptable to the viewer - for the viewer to feel comfortable with the photo - it must appear to have two characteristics. These are for it to be illuminated by a single source of light and for the light source to be above the eye level of the viewer.

Since the arrival of man we have been conditioned to seeing the light from the sun or moon or diffused through clouds. Indoors, at night, we have for many generations used a lamp hung from the ceiling, with, in modern times, banks of fluorescent lamps simulating the soft cloud skylight. Our minds cannot correctly interpret the effect of low or multiple light sources, with two exceptions. These are, firstly, a campfire scene where the light has one source at ground level and must be included in the picture area; the other exception is a cave scene which appears to be illuminated by the personal lights of members of the party. In the latter case there should be some detail between each illuminated area to give some sense of unity.

These two rules, with the two exceptions, are mandatory. In practice, we can use any amount of supplementary lighting, from any position, provided the visual effect is of a single top light.

THE CAMERA

Much has been written about the ideal camera for cave photography, but in reality this is of little concern. Cavers use the camera they already own and seldom is the most suitable camera purchased with cave photography the major intended use. Obviously, the larger the format and the better the lens, then the results will be better. Other features merely affect the ease of operation. Even the well-known waterproof cameras, essential for underwater use, are optically impared due to their additional glass/air interfaces. The only other needs are a locking cable release that is positive and a tripod that doesn't tremble, quiver or drop the camera noisily to the ground. Too often cave photographers loose sight of their objective - a good photograph - in a maze of equipment and gimmicry.

LIGHTING

Photography of caves is unique in that there is absolutely no ambient light. This allows the photographer the greatest freedom in lighting techniques, with attendant complete control of the finished result. Unfortunately, light sources are usually selected from an economic basis, rather than for their suitability. This is a false economy, as ideal lighting usually costs far less than the film and its subsequent processing. Also, the introduced lighting must cater to the characteristics and limitations of the film emulsion.

The following paragraphs deal with specific lighting forms.

PORTABLE FLOODLIGHTS

These are usually used for movie, rather than still, photography. In their so-called portable form, their light output is not very great in relation to bulk, weight and cost. Although it is possible to measure the reflected light to ensure tonal control, techniques of main and supplementary lighting are very hard to implement compared to multi-flash techniques. " Painting with light " is simple, but this technique seldom gives good results due to lack of any sense of depth.

FLASHBULBS

These have been largely condemned because of cost but they offer the greatest versatility due to the variety available, ranging from the humble "magi-cube" to the impressive PF100's. In multi-flash work it is possible to lock the shutter open, and illuminate different sections of the scene progressively, selecting bulbs according to flash to subject distance.

Exposure control is simple and accurate using the published guide numbers available for each type of flashbulb. The guide number is simply the product of the f-stop and the distance between the flash and the subject. Each flashbulb has a guide number relevant to the film speed. For example, the PF1B flashbulb, used with 50 A.S.A. film has a guide number of 20 (in meters). With the subject at 4 meters then 20 divided by 4 = f5.

As an example of the technique of multiple flash work, imagine photographing a large, complex chamber in its entirety. The camera's position is at one end, with the shutter locked open. A black card is placed in front of the lens while movement occurs.

A key feature to be highlighted is selected, and the lens is stopped down to give sufficient depth of field (f8 say). Deciding to highlight the feature with side lighting, and assuming the only possible flash position is 7 meters away, f8 X 7 = 56; therefore a PF60, with a guide number of 60 is selected, the error is negligible. Remembering that the rest of the picture area must be lit to fit within the straight line portion of the film's characteristic curve, it is decided to underexpose the rest of the scene by one stop. Accordingly the distance suitable for each flashbulb is calculated by multiplying the correct distance by $\sqrt{2}$. For example, a PF1 bulb, G.N. 27, at f8 normally used at 3m would be used at 4.5m. A PF5, G.N. 38, normally used at 5m, would be used at 7m, and so on. The cave is then lit, illuminating a section at a time, using whichever bulb is appropriate to wherever it is practical to set one up and using the above principle of highlight andunderexposure. Care is taken to ensure that a person holding a flash is not silhouetted; normally a person in any position is not recorded as no illumination falls on him. At the far end a couple of people (in action) are included to add scale to the photograph. As far as possible, all flashes are directed at an angle of 45° forward from the central axis of the camera, except for the harsher key feature-light.

A similar technique is used to photograph a procession of people in a cave, each simulating their light with a flashgun.

Against the cost factor, the advantages of flashbulbs are lightweight; ease of use; controlled output; constant colour temperature; and compatability with reciprocity law.

ELECTRONIC FLASH

The most obvious advantages of the electronic flash are the low running cost, portability, and constant output. Against these are their danger due to high voltages, potential unreliability, and (often) low output. The larger professional units approach medium sized flashbulbs in light output, but are very expensive.

In use, they offer the versatility of flashbulbs, particularly in multi-flash work, where their low output can be compensated for by repeated flashing. With repeated flashing from the same point, the exposure guide number is adjusted by multiplying by the square root of the number of flashes. Thus to double the guide number, four flashes must be used, and to triple the guide number, nine flashes must be used.

Multiple synchronised flash is also possible using light sensitive "slave" units to trigger remote flash units.

The brief expoxure time (usually 1-3 milliseconds) permits action photography, even with multiple flash.

Ringflash heads permit shadow-free lighting for extreme close-ups.

The danger and unreliability of these units are due to the high humidity and pervasive moisture in caves. This dampness can cause leakage in the triggering circuit where voltages of up to 20KV are encountered. In addition there is a possibility of receiving the power of the main capacitors, which are often of 1000μF at 500V, which can be fatal.

The computer flash measures the amount of light bounced back from the target and stops its output when the correct exposure has been reached. This is an advantage over other flash units as cave walls can be unusually light-absorbent and can cause under-exposure when calculated exposures are used. However, they have proved to be extremely unreliable as moisture affects their complex circuitry, and their performance (and possible damage) is unknown in those situations where there is insufficient reflection to operate their sensing circuitry. In addition reciprocity failure can occur when there are extremely short exposure times in close-ups (down to 30μs) with these devices. Professional units particularly operate down to these times.

Although regarded as having constant output, electronic flashes may vary considerably under certain conditions. With infrequent use, the capacitors can become "leaky" and need to be re-formed before use. This is done by charging, without triggering, for 15 minutes, then charging and triggering a few times before actual use. The neon "ready" indicator may start to glow long before the capacitor is fully charged (say 70%). The unit will discharge but at a greatly reduced output. Full charge can often be recognised by a brightening of the indicator. In addition, with use of multi-flash photography, the flash tube may behave erratically due to temperature rise. This can be overcome by resting the unit after about six rapid flashes to permit dissipation of heat.

MAGNESIUM

In the early days flashpowder, consisting of magnesium powder and an ignition substance, was used extensively. There was little control of exposure, it was unreliable and occasionally exploded; it was often denigrated as "flashless smokepowder". This was replaced by magnesium ribbon; exposure control was achieved by measuring a particular length to suit the situation. This was used extensively until the evolution of the flashbulb, its weaknesses being inconsistent burning and the thick clouds of smoke emitted.

A more modern development is the use of a "gun" (the "Diprotodon" of Poulter, Hill and others) which ejects and ignites a stream of fine magnesium pellets, often in conjunction with oxygen or butane. Exposure control is by flame time, often running into many seconds. The claimed advantages are high light exposure (through extended burning times), relatively low cost, and portability. This is commonly regarded as the only feasible light source for remote, very large caves.

It is necessary to use filters to adjust the colour balance, which is a continuous spectrum at 4000°K.

There are several disadvantages when tonal and colour quality are considered.

These are:

The environmental effect of the smoke which also precludes a second photograph.

Long exposure times cause reciprocity failure.

Because a huge quantity of light is produced at one point, severe over-exposure of the fore-ground is hard to avoid. The smoke produced precludes a multi-flash technique.

The broad light source does not produce hard-edged highlights and shadows, causing a loss in apparent sharpness and softening contour rendition.

There is little control of the direction of light.

OTHER LIGHT SOURCES

Many photographs have been taken by the light emitted from candles, carbide lamps, caving lights, cyalumes, kerosine lamps, gas lamps and probably even glow-worms. These can only be regarded as interesting novelties - there can be no pretence of photographic quality.

BALANCED FLASH AND SUNLIGHT

A useful technique in recording a cave entrance from inside is to use the sunlight for the outside at the correct exposure, and to slightly under-expose the cave interior by flash, using a camera with a leaf shutter (which synchronises at all speeds).

Exposure control is by positioning the camera, then using the guide number for the flash determine the lens opening for correct exposure. Close the lens one stop (to under-expose the interior), then use an exposure meter outside to determine the correct shutter speed for the aperture chosen.

TEXTURE AND REFLECTANCE

Published guide numbers for various light-sources are based on normal domestic situations - a normal-sized room where light bounces off ceiling and walls to supplement the direct light. In a cave, these bounce conditions apply only in a chamber where there is a moderate amount of speleothems and little light-absorbing dark mud.

Each cave component reflects light to a different degree, ranging from wet, white speleothems having the highest reflectance, to black, dry mud which absorbs most of the incident light. The lowest possible reflectance occurs in some volcanic (lava) caves. Obviously, compensation must be made for this, and usually ranges from opening the lens half a stop in a large chamber where the walls are bare rock, to two or three stops where non-reflective surfaces predominate.

Conversely, overexposure can easily result where the subject is white speleothems. As averaged exposure is based on rendition of an 18% neutral tone, an all-white subject would be recorded on the upper part of the characteristic curve (i.e. overexposed) with consequent compression of tones. This is compounded by a characteristic of clean calcite - luminescence. Once the incident light has ceased, there is a faint emission of light from the surface.

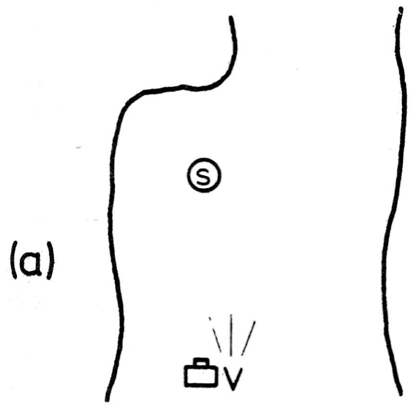
A reasonable compensation for such possible overexposure (white tones plus luminescence) is to lower the exposure by 50% - one stop.

LIGHTING DIRECTION

Given the factors of correct exposure, quality of light, sufficient intensity of light and wise choice of film, the greatest influence on the photographic result is how light is used - its direction and balance. Lighting control affects the rendition of contour, texture and perspective. It is important to recognise the effects of the size of the light-source; a point source, or its near equivalent - high output from a small reflector, gives small, spec ular highlights and sharply defined shadows; a medium to large reflector softens the shadow edges considerably; a broad light source, such as bounce-lighting, produces tonal definition with no shadows. These light forms each have their own applications in different circumstances - the following sections offer some guidance on these applications.

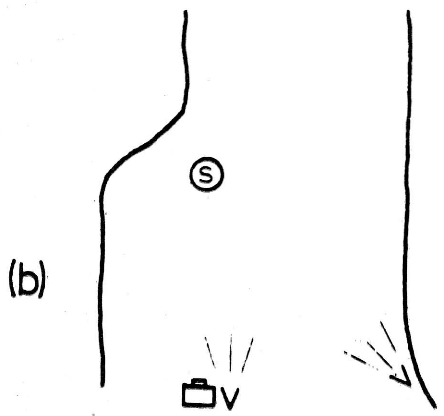
Each cave, each karst feature, each speleothem, requires individually tailored lighting for optimum results due to the limitations of the sensitive materials used and it is impossible to describe every possible situation. The discussions and their accompanying stylised plan diagrams provide a guide to the principles involved.

(a) Frontal lighting, on or near camera.



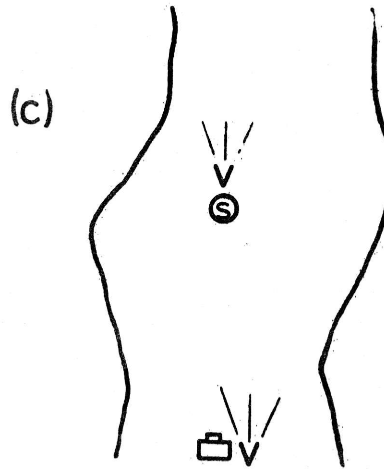
This is the most commonly used lighting in caves - it is the most convenient. Very low quality is achieved, as light reflected falls off with the square of the distance. One plane only (perpendicular to the lens axis) is correctly exposed, the foreground being overexposed and the background being underexposed, usually to a degree well outside the linear portion of the characteristic curve. In addition, as the axes of the lens and the flash cannot be the same and as a result a hard-edged, confusing shadow occurs below (usually) and to one side of the subject. Similar confusing shadows occur at every irregularity in the surrounds.

(b) Frontal lighting with fill-in.



This is a simple flash-on-camera set up, with a weaker light aimed in from 45° to decrease shadow density. With a little care in positioning the fill-in flash, additional exposure of the subject may be avoided. The fill-in flash should be weaker than the main flash (say, by two stops), and this can be achieved by using a weaker flash or moving it further away or by using a baffle (a piece of tissue, say) to cut down its output. This layout is a conservative approach, but it is very useful and reliable for medium distance work - i.e. 2-6m.

(c) Frontal light with background fill-in.



This unusual lay-out has few applications, but is presented here to introduce different concepts and is applicable where there is a single, simple form subject.

Illuminating the background with a light placed directly behind the subject is common in commercial photography, with oblique main lighting on the subject from the front. The effect is to give modelling to the subject which stands out in bold relief from the flat-lit background. One technique in formal wedding photography is to use a bare bulb (no reflector) in the background light, simultaneously vignetting the background and backlighting around the edge of the bridal veil. This technique can be easily applied to the rim lighting of speleothems.

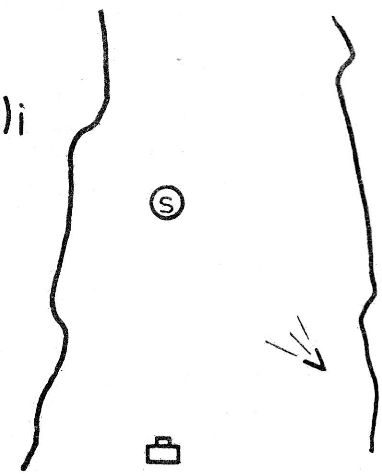
If the lights are positioned exactly as shown, with the main flash as close as possible to the lens, one has the basis for the little-known Martensen technique. The principle of this technique is to control lighting on the subject so that the contrast comes well within the straight-line portion of the characteristic curve, then to develop the negative to finality (gamma ∞), thus allowing the full tonal range of the subject to be contained within the limited range of the final print. The background light is positioned to produce the desired background tone. A longer than normal focal length lens is used to minimise the effect of the front light not being exactly on the lens axis. Tonal control is achieved by differential exposure of near and far parts of the subject, combined with differential reflection from oblique and perpendicular surfaces of the subject. (Using this process of developing to finality, and using the front light only, this technique can be used for showing weathering forms in rock, where depiction of contours is important.)

A disadvantage of this method is that the photographer must evolve his own individual approach to this technique, experimenting with exposure, film type and development. It would be extremely difficult to adapt to colour films. The other difficulty is that development to finality enhances grain clumping, and as large a camera format as possible must be used. Obviously, this esoteric technique is not suitable for inclusion in a roll of film containing varied subjects and contrasts.

A variation on this lighting is the use of an electric ringflash, which surrounds the lens and offers shadow-free lighting. This is of great value when photos need to be taken looking into a small, deep recess.

(d) Angle lighting.

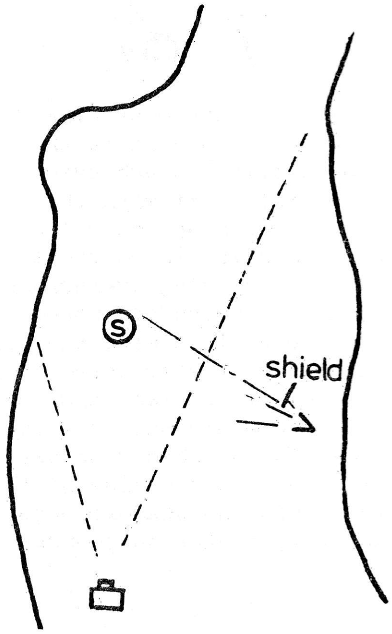
(d)i



This is the most commonly used lighting direction used in photography but only because the sun is rarely at lens level. In cave photography, it is the first variation tried when the flash is unshackled from the camera.

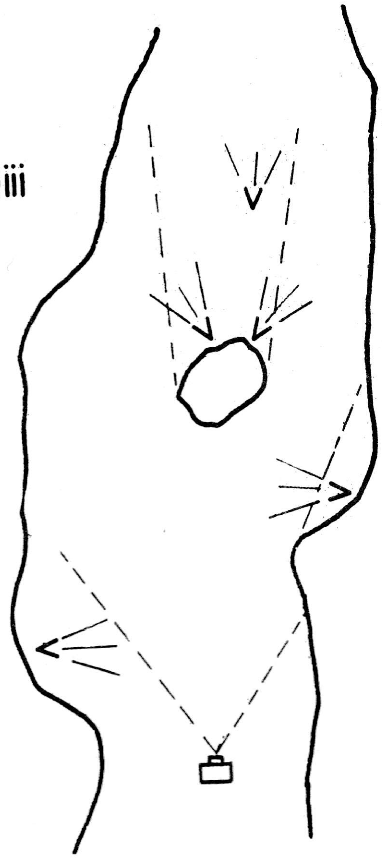
The effect of oblique lighting is to give modelling to the subject, i.e. to delineate contours, and also to provide a separation between subject and background. However, without modification the resultant shadows can be conflicting and confusing where the background is not a simple form. Where the subject is a single feature and the background is sufficiently distant, this lighting is very effective in recording the shape and contours against a black background, i.e. where the background lighting is well beyond the tonal range of the film. Sometimes this under-illumination of the background can be enhanced by shielding the light, (fig. d(ii))

(d)ii



To effectively illuminate the walls of a chamber in a multi-flash photograph, oblique lighting enhances the contours of the walls and other features, and can be used progressively over quite a long distance. The exposure control was detailed earlier; to simulate a single light source a lighting pattern similar to that in Fig d(iii) should be used.

It is important that the light source never be included within view of the lens, but there are sufficient shields in most caves to overcome this problem. It may be necessary to use an artificial shield (say (d)iii



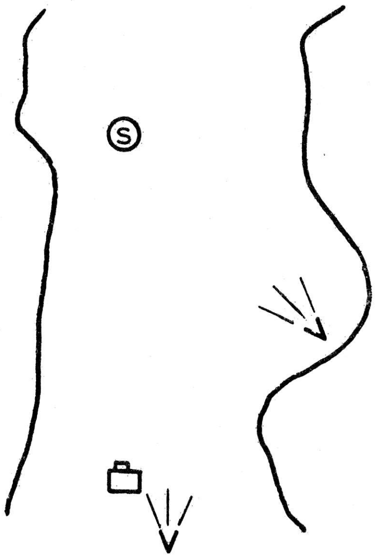
a black cloth) to prevent reflection from surfaces close to the flash causing distressing highlights.

It must be remembered that this is the general lighting for the whole area of the photo and it is best slightly underexposed using a stronger key lighting as detailed earlier. Also, each portion of the film area is exposed separately and may be done in sequence - there is no need to fire flashes simultaneously. Reciprocity failure is concerned with the duration of each flash - not the overall time required to effect sequential firing.

(e) Angle lighting with fill-in.

This is the basic lighting used in professional photography. It differs from (b) in that the oblique light is the key light on which exposure is based, while the light near the camera is arranged to underexpose by half a stop to serve as a shadow fill-in. This fill-in ratio ensures that shadow detail is recorded within the capability of the film; variation may be desired to give a more dramatic effect with underexposure for shadows to the extent of one or two stops. Closer coupling than half a stop would result in a two light-source effect - un-natural and confusing.

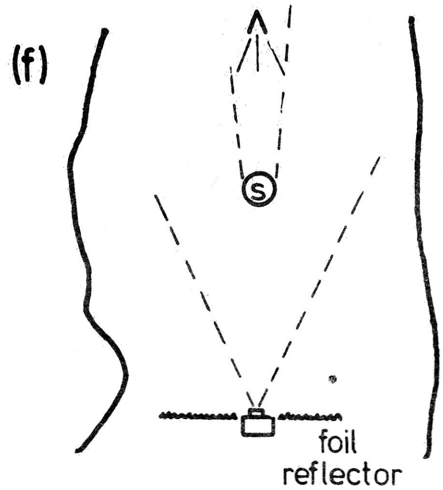
(e)



If the key subject is too large to be adequately covered by one flash, two or more flashes may be used, but it is important that the light appears to come from one source. This does not mean that light sources need be at the one point - it must merely seem to be so. Thus separated, parallel beams would appear to be from a source at infinity.

Similarly, it may not be possible to light the shadow area with one light unit; multiple lighting is acceptable so long as there is no conflict with the key lighting. Degrees of underexposure may be varied: in a long passage it would be desirable for shadow exposure to be progressively decreased with distance from the camera, re-inforcing the impression of distance. This progressive underexposure should not be confused with the normal fall-off due to distance from a single, powerful flash; the limited tonal response of any film, compounded by reciprocity departure makes the simple solution of a single light untenable.

(f) Backlighting.



In simple form with opaque subjects, backlighting merely provides a rim of light delineating the edge of the subject, the amount of reflected light from the surrounds being insufficient, within the tonal range of the film, to record other image detail.

With translucent subject material, however, backlighting comes into its own. Speleothems such as straws, small helictites, nests of oolites and thin shawls can be successfully and dramatically recorded, particularly when there is a surround of calcite surface reflecting light to record the shadow detail between the camera and subject. More control of shadow lighting can be achieved by using a foil reflector around the camera lens to reflect light back onto the subject.

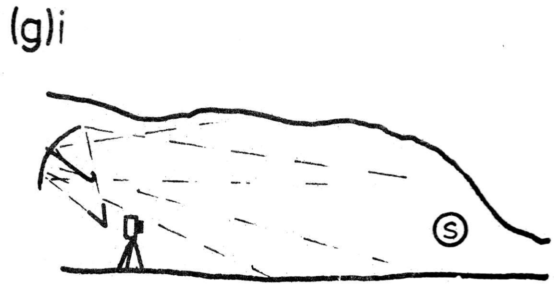
A useful guide to exposure is to open the lens two stops (i.e. halve the guide number).

(g) Diffuse sources.

All of the foregoing (a. to f.) are based on the use of small light-sources (flash-bulbs or tubes) in relatively small reflectors, giving strongly directional lighting. The extreme form is focussed point source lighting, which would give razor-sharp edged shadows, with little or no spillover of light into the shadows.

An alternative technique is broad or diffuse lighting. To use an analogy, the sun in a clear sky provides a point source of light, softened only by the atmosphere. A small translucent cloud interposed in front of the sun causes a softening of the light source. With total cloud cover the whole sky becomes the light source. This results in an even, hemispherical light source around the subject, offering no lighting tonal gradation, the only tonal gradation being provided by variation in absorption/ reflection of the subject. This principle can be applied in cave photography by using bounce or diffuse lighting.

Bounce lighting



Bounce lighting is well established in professional photography; a simple example is shown in Fig. g(i), where an electric flash is pointed into a large, white umbrella, which acts as a broad light source.

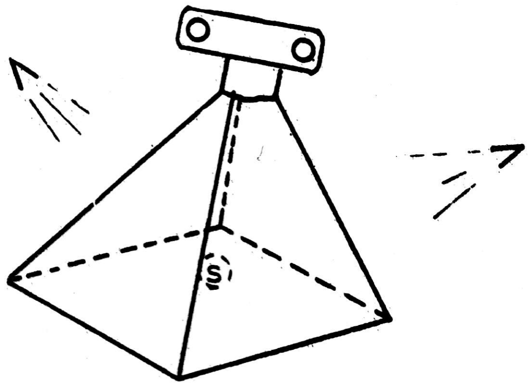
When applied to cave photography, it is often possible to find an alcove, completely covered with clean calcite which can serve in place of the umbrella. The use of a large sheet of metallic foil is possible.

One prime use of such a lighting form is in the oft-attempted, seldom-successful photo of a person in a squeeze. The usual faults in this type of photo are that the foreground is hopelessly overexposed, and there are conflicting shadows on and around the subject. These defects are overcome with bounce lighting due to the diffusion of the light, and the longer path-length of the light giving more even exposure to subject and fore- and background. As mentioned earlier, it is important that the light-source (i.e. reflector) must be above the line between the camera and subject.

In calculating the exposure, the distance from the flash to the reflector plus the distance from the reflector to the subject applies, i.e. the total light travel. Then, to allow for diffusion and absorption, the lens is opened one stop if a metallic foil is used, and two stops if clean calcite is used.

ii. Diffuse lighting

(g)ii



The principle of total cloud cover of the sky can be applied to cave photography by using a professional technique used for photographing polished metallic objects. Enclosing the subject in a translucent "tent". The "tent" may be cylindrical, pyramidical or whatever, the important feature being that the whole outside surface may be illuminated. The light is diffused on passing through the walls and shadows are essentially absent from the subject. This is of particular value when photographing biological specimens which often show multi-faceted reflective surfaces. High-powered flashes allow the lens to be stopped down for good depth of field and cause minimum discomfort to the subject.

It would be mechanically difficult to build a rig to cover all contingencies, but assuming that biological specimens are to be reproduced on a scale between 2:1 and 1:2 (which a 35mm SLR with bellows or extension tubes can cope with easily), then a pyramidical tent, the vertical axis of which is 20° from the vertical, as shown in Fig (g)ii, would suffice.

The camera is set in the apex with its lens axis at 20° to the vertical, the tent is about 100mm high, and two equal power flashes are aimed at opposite edges so that they each illuminate two sides. The flashes must be synchronised by use of a "splitter" or a light-controlled "slave" unit.

This section has been included as a hypothetical ideal; little work has been done on in-site biological photographs and problems such as how to provide sufficient light to focus the camera and how to photograph a lively specimen remain to be answered. Keen biologists should be able to work out their own strategies.

PHOTOGRAPHY OF CAVE WATER

A tonally correct image of water is generally not acceptable, as no image is produced, particularly if the water is still.

The surface of still water acts as a partial reflector; incident light (except for backlight is not reflected back to the camera, but light from objects beyond the water is reflected from the water surface to the camera with loss of intensity.

Thus, to satisfactorily record the presence of water, it is necessary to illuminate the surrounding area and to photograph its reflection in the water. To avoid confusion between the subject image and the reflected image, it is desirable to cause some movement in the water surface, thus affecting the clarity of the image.

The same principle applies to moving water; the surroundings must be illuminated to provide a reflected image. The nature of the reflected image allows the viewer, from experience, to determine whether it is random movement in a pool or stream movement.

Exposure time is critical in determining acceptability of the photograph. Images are consciously recognised when the exposure time exceeds 10ms; running water can only be recognised if it is seen for at least that long. Electronic flash exposure times are much shorter than this, resulting in the water having an unnatural frozen appearance. Flashbulbs, with a burn of 30ms, are more appropriate.

PROCESSING FOR QUALITY

There is an abundance of literature available on processing techniques, and each year since the inception of photography new, improved magic formulae have been developed. Any processing procedure is a compromise, and usually the film manufacturer's recommendations offer the best result if the same meticulous care is taken as is taken with exotic techniques.

With black and white emulsions, tne silver halides are reduced to silver by a reducing agent in basic solution. Different reductants, degrees of basicity, the presence of buffering agents, physical deposition of silver, variation and control of processing temperature, delay between exposing and processing, all affect the characteristics of the final image. With colour material, little variation from the manufacturer's system is permissible without massive changes in the end result.

It is not intended to discuss processing in detail, as there is no specific technique peculiar to cave photography. Owing to the greater difficulty in obtaining cave images compared to normal images, it is suggested that any experimentation not be done with cave photographs.

AESTHETICS

The "arty" side of cave photography is also beyond the scope of this article. Principles of composition and design are both well established and infinitely flexible. However, if the disipline of quality control is to be accepted, then it is usually sufficient to ask the following questions:

Why do I want to take this photo?

What exactly do I want and need to show?

How little can I include in the picture area to make the photo completely effective?

The composition usually falls into place once these questions are answered.

CONCLUSION

The late G.B. Shaw once wrote: "He (a well-known photographer) reminds me of the salmon, laying a million eggs in the hope that one will survive." This comment well applies to-day when we hear photograhers say: "Another one just in case." or, "I'll take a few and pick out the best one."

Once a decision has been made to take a photograph the rest is purely a mechanical operation. Assuming the camera lens is adequate, and given that the film has been reliably manufactured and will be correctly processed the one control we exercise is in exposing the film suitably for correct tonal rendition. This is the only graphic form capable of reproducing a continuous tone from pure white to total black, or, with colour, a continuous hue across the whole of the visible spectrum.

We fail in our use of the medium unless we can control it within its full capability.

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Windisch H.	"The Manual of Modern Photography".

DIGGING – Problems & Practice

Bryan Cleaver, Gerry and Jenny Hopkins

Where to dig?

Most of our experiences (good ones I mean) in digging have taken place at Bungonia so most of this article must be based on that area. One of the more obvious areas to dig is in dolines. There are usually obvious waterways down to the hole or doline and where they end is as good a site as any.

Usually the lowest area of the doline is the best place to dig. However it must be remembered that whatever caused the doline to collapse and choke with mud and boulders is still there so a fair amount of hard work will be involved in order to get the rubbish out and it still may only lead to a mud-filled cave. Finding a cave in these situations is much like finding chinks in armour-ie. LUCK. The best thing seems to be to dig down till something tells you to dig in some other direction eg. like following a rockface down and if it dips to one side then following that face. Otherwise the best places to look are probably where the trees are growing into the limestone and also other places where loose boulders and fill occur. The most important thing above all is to know your area well. Traversing on foot is the only way of finding possible new digs.

How to dig?

This mostly involves hard work. Equipment needed includes a small shovel. We have always steered clear of trenching tools as they tend to break easily. They cannot stand being used as levers and it is also easy to pinch your fingers. The best implement we have found is a small shovel the size of a trenching tool. A pick axe comes in handy, as does a crowbar but we have always found the smaller implements are easiest to use in confined places for obvious reasons. A strong bucket with a good rim around the top seems the best for hauling out dirt. We always cradle the bucket in a rope basket in case the handle breaks.

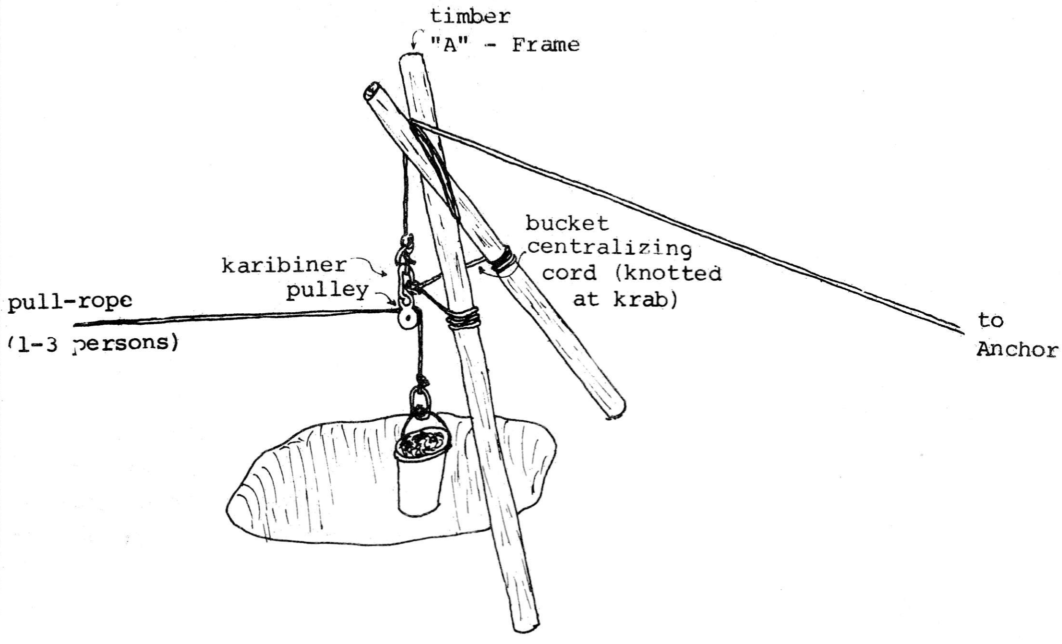
A good length of strong rope is also necessary for hauling the bucket. Caving lights etc, may be needed; just in case of a breakthrough. Any other equipment is specific to the job eg. in digging out the top tunnel in B15 we used a trowel and a caving helmet with the head-band removed.

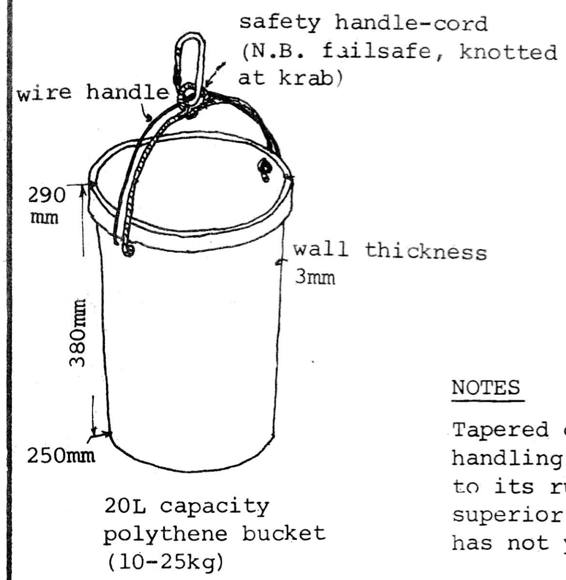
A shaduf was used by Mike Finger and Dave Stenson to dig the initial fill from B154 but eventually the mechanics of that system failed due to the depth.

Block and tackle is very useful for dragging large boulders out of holes. The problem being that it is hard to put the harness around the boulder such that it will not slip off during the lift. Tapes are probably the best to use in this situation although they are likely to become damaged.

In deep caves like B54 we have now found the best method of hauling dirt is to fix a pulley by tying it to an A-frame (Fig 1) over the centre of the hole. The bucket is pulled up via the pulley; the only problem being that once the bucket has reached the surface it has to be pulled to one side to be emptied. This is solved by attaching a rope to the bottom of the bucket. Mike Finger and Dave Stenson fixed a block and tackle system over B154 and the mechanical advantage allowed a comparitively weak person to haul up the bucket by holding on to the end of the

B.54 HAULAGE SYSTEM





NOTES

Tapered design of polythene bucket allows for easy handling of sticky clay. In this regard, and due to its rugged construction it has proved far superior to any other device used. Wire handle has not yet failed.

Haulage capacity exceeds digging capacity, even at the present depth of ∿ 15m. (Digging with pick and shovel).

For safety reasons a timber support should be placed approximately 2m from the bottom of the dig if digging is to be performed while haulage of dirt is taking place. A jumar or gibbs should also be added at the pulley if only one person is available for haulage duties.

K 27-5-80

rope and running down the hill. The disadvantage of this was that 3 people were involved- one to fill the bucket, one to haul the bucket to the surface and one to grab it on reaching the surface and pull it over the lip in order to empty it. In that situation the bucket was hung on a hook underneath the pulley and proved dangerous at times when it managed to come of the hook and fell back down. Luckily it made so much noise that the digger had a few seconds warning to protect himself. In shallow digs it is probably easier to pull the bucket out by hand rather than worry about the extra gear.

When the choise of where to dig is made, a site for the placement of the dirt should also be chosen. This is best located as far away from the hole as possible and in a place where it will not be washed back into the dig. For B60 we first built a wall of stone and the dirt was piled behind it. For B54 we have piled it over onto two sides, however we are rapidly running out of space. For B154 there was a convenient gully downslope of the dig which was used to take the dirt.

The most obvious thing about all of this is that you should not try to place the dirt in a place you may want to get at in the future ie. if the bottom is blocked it might be advantageous to try the sides of the doline. It is preferable to only have to move the dirt once.

Another essential consideration is to make the hole big enough at the beginning to allow room to work. This is not always possible but digging is easier if you can use a pick. It is also better to remove an loose earth banks and boulders so that they wont fall in later on.

One of the most dangerous things about digging is the possibility of removing a vital blockage at your feet that causes a cave in. This can be minimised by tying the digger to some stable rock or other belay. Having said this we have often dug without belay eg. Mendip Cave but the floor (or roof depending on how you look at it) was very stable and gave no signs of collapsing.

Odd things to do with digging!

One important thing is to try to stop water and dirt from entering the dig. This is sometimes impossible as in the case of B154 where half the weekends digging is always in removing the fill washed in with the last lot of rain. This fill is natural in origin and not the result of a badly located soil dump.

We have always found that when we are getting near to a find there seems to be pockets of very loose earth and air. Also we have found that while you are digging through plain earth fill there is little likelihood of finding anything. There has to be a lot of boulders before the chances of success are good. Having dug 40 tonne of earth, gravel and clay from B54 we dread to think of the size of the chock-stone we still have to come to.

The best sign of all is a breeze coming out of a hole that you have dug. The breeze in Solar Cave is infuriating in that you can feel it breathing over the top of a very large slab of lime-stone that will have to be removed, along with a large quantity of gravel, in order to gain access to the rest of the cave. Unfortunately, due to the large catchment area of the doline, the gravel that is removed is replaced almost immediately by fresh material.

Another problem of digging is finding diggers. We have tried many inducements which I am sad to report haven't worked. If anyone finds a way to enthuse labour let us know. Otherwise- GOOD DIGGING.

DOCUMENTATION

A HISTORY OF H.C.G. IN PRINT

Chris Dunne

Introduction

Being as it is, both sport and science, speleology is apt to suffer from a lack of care in the recording of its activities. Thus, there is a large turnover of individual knowledge which, however, is not always passed on. In the long run, the only knowledge passed on is what has been committed to print. Such is the case with HCG. Despite HCG's relatively long history as a club, and a large turnover of membership, we are, however, left with a relatively small legacy of printed history.

History

The club first appeared in print in 1960 as the Freelance Caving Group, although it had been active for a couple of years before this. It published several newsletters in quick succession, through 1960-61, under the title of "The Caverneer". Nos. 1 and 2 were never circulated beyond the meetings at which they were read. We have copies of nos. 3-5, and from comments in no. 5 it appears that there could have been at least one further issue.

In 1963, with what appears to have been a shake-up of its organisation, the club reappeared in print as the Highland Caving Group, with a new newsletter: "Calcite". Several issues, comprising Vol. 1, were published in quick succession. Vol. 2 didn't appear for a further twelve months, and then only to report the club's assistance in the recovery of the body of a rock-climber, killed in a fall at Bungonia in August 1964. Vol. 2 comprises three issues only, the numbering of which is confused: there are two issues numbered as Vol. 2 no. 1, whilst we have no Vol. 2 no. 2. In addition, several topical articles were published seperately, most notably, Blayne Pearcey's study of the Buckaroo area.

This period also saw HCG's admission, in December 1964, to the Australian Speleological Federation, and involvement, in May 1965, in another Bungonia fatality. This time it was one of the club's own members; John Bryant. This had a profound effect on the club, with many of the older members later drifting away to be replaced by a new group.

From 1966, Calcite adopted a numeric numbering beginning with no. 10, as the previously published Vols. 1 and 2 comprised nine issues. Again an attempt was made to publish regularly, this time om a bimonthly basis. However, this system broke down after Calcite 13, and after the sporadic issue of nos. 14-16, no. 17 didn't appear for some eighteen months until September 1969.

Meanwhile there had been further changes of membership, and finally the incorporation into HCG of the Wanderers Caving Group, from Canberra. In addition, three HCG members were now involved in ASF at executive level.

1970 saw the publication, beginning in

June, of a bimonthly internal "Newsletter", with Calcite being changed to a twice-yearly journal. There was talk of allowing Sydney Teachers College Caving Club to affiliate with HCG, whilst a Central Regional Council was formed in conjunction with Blue Mountains Speleo Club and Metropolitan Speleo Society. The four clubs mooted and co-hosted a very successful mini-Conference at Mudgee in October. A report on this was published seperately. Calcites 18 and19 appeared on schedule, but the late appearance and poor quality of Newsletter 5, in early 1971, marked the start of another publishing drought.

Meetings by now were being held in the field, and the membership had changed drastically from a few years before. Nothing appeared in print until the appearance in December 1972 of Calcite 20; a collection of trip reports spanning the previous two years, and largely written by Keith Oliver.

There appears to have been little or no participation in the December 1972 "NIBICON" conference in Sydney, and the club became polarised between its Canberra and Sydney memberships. Nothing was published till the surprise appearance in January 1976 of "Journal" no. 1, a collection of recently produced articles and maps, by a revived Sydney branch. This was followed in July by the reappearance of Calcite. Calcite 21 was produced as a publicity exercise by the Sydney branch, and was followed by Journal no. 2 in December, in time for the "CAVCONACT" conference in Canberra.

Having reasserted the club's existence, the two branches passed 1977 in a continued state of non-communication. Out of this emerged a new series of Calcites, published in Canberra through mid 1977, as Vol. 1 nos 1-3. After this the Canberra group seceeded to form the Capital Territory Caving Group, and Calcite was again shelved.

Finally, in July 1978, Calcite 25 appeared, promising once again, to be the beginning of a regular bi-monthly series. Calcite was given a new cover and, following preceedent, Canberra's three issues were counted as nos. 22-24.

A projected Journal no. 3 failed to appear as hoped within twelve to eighteen months of no. 2, but Calcite has continued to appear about three times a year, under the clubs policy of not publishing more often than material and practicality permit.

Listing of Publications

This listing includes all the seperatly published works attributable to the club to date. The listing is chronological, and authors or editors have been named where these are known.

"The Caverneer"

no. 1	1959-60	(tape only; lost)
2	1959-60	(hand written; lost)
3	Oct 1960	
4	May 1961	Blayne Pearcey
5	June 1961	" "
?		

"Calcite"

Vol.1 no.1	Mar 1963	Eddy Powell
2	Apr 1963	" "
3	May 1963	" "
4	Jun 1963	" "
5	Aug 1963	Evalt Crabb
6	Sep 1963	" "
Vol.2 no.1	Aug 1964	" "

"Buckaroo" 1964 Blayne Pearcey

"Tuglow Caves" 1964 Blayne Pearcey

"Foul Air in Caves" 1964 Evalt Crabb

"Annual Report' 1964 Evalt Crabb

"Water Tracing at Bungonia"1965 Jim Kerr

"Calcite"

Vol.2 no.2	Jan 1965	(printed as no.1) Evalt Crabb
3	Sep 1965	" "
no. 10	Jan 1966	" "
11	Apr 1966	" "
12	Jun 1966	" "
13	Aug 1966	" "
14	Jly 1967	" "
15	Oct 1967	" "
16	Feb 1968	" "
17	Sep 1969	Norm Poulter
18	Jun 1970	Bill Patrick

"Newsletter"

no. 1	Jun 1970	E.Crabb/K.Oliver
2	Jly 1970	" "
3	Oct 1970	" "
4	Dec 1970	" "

"Calcite"
no. 19 Dec 1970 Bill Patrick

"Report on the Mudgee Mini-Conference"
1970

"Newsletter"
no. 5 early 1971 K. Oliver

"Calcite"
no. 20 Dec 1972 Keith Oliver

"Journal"
no. 1 Jan 1976

"Calcite"
no. 21 Jly 1976 Tony Hele

"Journal"
no. 2 Dec 1976

"Calcite"

Vol.1 no.1	Apr 1977	Mike Webb
2	Jly 1977	" "

"Circular" Aug 1977 (Sydney)

"Calcite"
Vol.1 no.3 Sep 1977 Mike Webb

"Circular" Mar 1978 (Sydney)

"Calcite"

no. 25	Jly 1978	Steve Bunton
26	Spt 1978	Rik Tunney
27	Nov 1978	Steve Bunton
28	Feb 1979	Chris Dunne
29	Jun 1979	" "
30	Nov 1979	" "

Listing of Major Articles

This listing is chronological; authors are given where these are known. The source, where applicable, is also given.

Cave Mapping & Grille Cave Survey, Bungonia (Evalt Crabb) Cav. 3

The Bungonia Area & the Bungonia or Grille Cave (Evalt Crabb) Cal. 1/2

Caves at Buckaroo (Blayne Pearcey) -a brief summary Cal. 1/5

Trip Report: Bungonia, 15 Aug 1964 -report of rock-climbing fatality (Evalt Crabb) Cal. 2/1

"Buckaroo" -Report on the Exploration and Excavation of Limestone in the Parish of Bumbury, County of Phillip -a description & history of activity (Blayne Pearcey)

Tuglow Caves (Blayne Pearcey) - a description & history of activity

Foul Air in Caves (Evalt Crabb)

Report of the HCG fatality in Drum Cave, Bungonia on 22 May 1965; & following reports (Evalt Crabb) Cal. 2/3

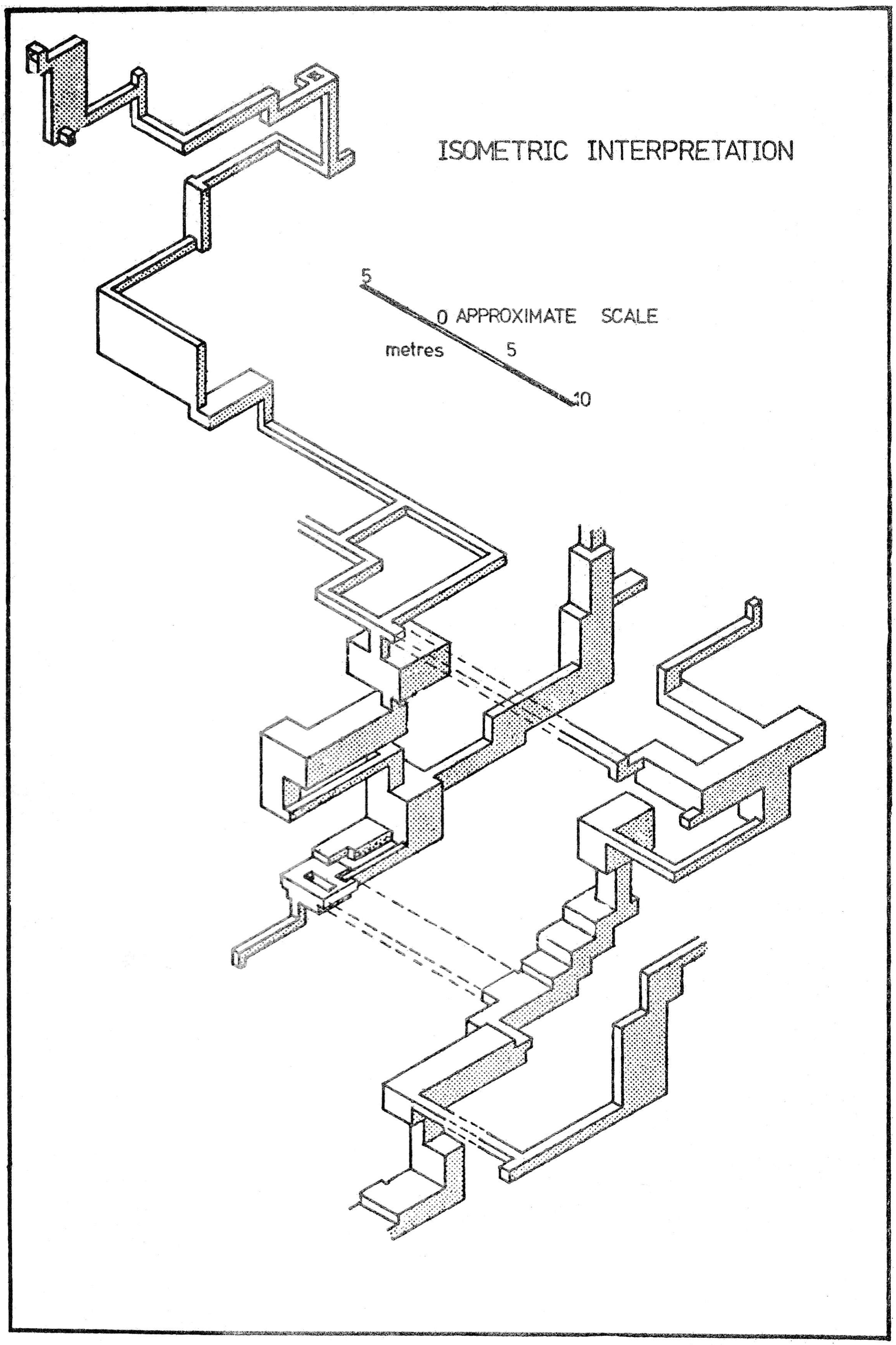
Summary of Exploration in the Mudgee District (Evalt Crabb) Cal. 10

From the above, it may be seen that the role of the Journal in presenting major articles has now left Calcite as a vehicle largely for trip reports and news.

ISOMETRIC PRESENTATION OF CAVE SURVEYS

Graeme Smith

This method of presenting a cave was first used in Australia by E.G. Anderson in "The Exploration and Speleogeography of Mammoth Cave, Jenolan" and has since been used by a number of authors including Bunton (1976). The isometric interpretation of Phoenix Cave was prepared from the maps appearing in the HCG Journal No. 2.


ISOMETRIC INTERPRETATION
5
0 APPROXIMATE SCALE
metres
5
10

The first step in the construction of such a diagram was to distort all the **passage shapes** and directions to three **perpendicular axis-** one vertical and the **other two** according to the trends of the **cave.** This is a critical stage and the **surveyor must be ruthless in corrupting his hitherto** accurate map. This is **critical** as any attempt to show too **much detail** will counter the initial **aim of simplifying the interpretation of the map.** Passages that are similar **in direction are all swung parallel as shown in fig 1.** Chambers are similarly distorted and "rectangularised".

Stage 2 is the drafting of a new plan and elevation based on the "new and improved" passage shapes and directions. Correlating heights with locations on the plan will reveal problems requiring further distortion of the truth. If a passage slopes it may be necessary to show this by a series of steps. This should be avoided as much as possible as it is slightly more confusing and looks messy.

The next stage is the construction of the isometric (using 30^{o} axis for the horizontal sections). This should be drawn accurately but you can afford to be quick and messy as you will have to draw it again anyway. IT IS VERY IMPORTANT THAT THE BEST VIEWING DIRECTION BE CHOSEN TO AVOID PASSAGES CONCEALING EACH OTHER. This will probably mean another compromise.

It will be obvious by now that some passages are hidden by chambers and vice-versa. The real distortion now begins. Pitches or passages may have to be lengthened so that the real connections are not confused as passage overlaps. Chambers may have to be changed in size or shape to show other parts of the cave. Finally, in the Phoenix Isometric I had to resort to an exploded view as I felt that to elongate the passages sufficiently to separate the different sections of the cave would be too much of a corruption.

Finally, it is time to draw the final draft, and then, to aid interpretation further, shading of the faces of one angle of viewing can be carried out. Hopefully the finished product will give give a good idea of the "nature" of the cave; something very hard to discover from normal orthographic views. Despite the gross corruptions I keep talking about, I feel that the view of Phoenix Cave presented here is more useful to cavers than the accurate map presented in Journal 2, although it is of less scientific value.

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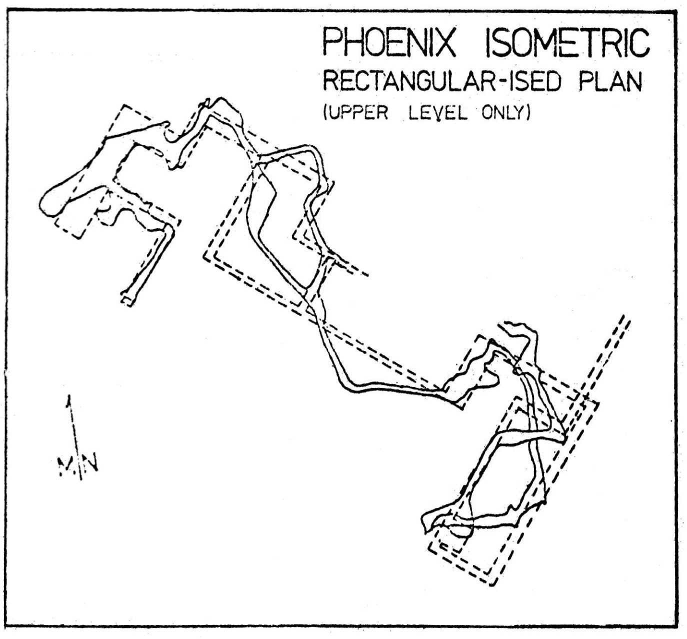

BIOLOGY

Broad Similarities in the Invertebrate Fauna in N.S.W. Caves

Graeme Smith

In preparation for a long - term study of the factors affecting the abundance and diversity of animals in the caves of NSW, systematic collection has been undertaken in a number of areas. Furthermore, a review of the literature and a comprehensive inspection of the Wombeyan Caves has revealed that each caving area has basic similarities with most other areas. This is not to say that unique species, endemic to a particular area, are not to be found. There are a number of such cases eg *Nicoletia* sp. from Bungonia (Smith 1976) and *Synotaxus* sp. from Jenolan (Gray 1973). However, if we examine the fauna at a generic level, similarities abound. Some groups occur within caves so regularly that it is possible to predict that they will be found in the areas from which they have not yet been recorded. It is usually only a case of persistant searching before it is found.

In the following article I have attempted to summarise the available data, only considering the genera that occur in two or more areas. The list will not be complete and I have no doubt that many of these genera will be found in areas not listed here. Where a record is not my own, it has been duly referenced. Specimens from my own collection have their specimen number recorded. Observations not supported by specimens are listed as GBS obs.

THE FAUNA

CLASS CRUSTACEA

SUPER-FAMILY ONISCOIDEA

Large pigmented slaters occur in the entrances to caves at Wombeyan and Bungonia (GBS obs and GBS 96 resp.). These are probably surface species sheltering in the cool, humid micro - climate found in the caves. The occurrence of such species is probably related to the presence of suitable surface conditions. NB It is impossible at this stage to know if these two species are generically related, however I have included them as I believe that records will be forthcoming from other areas.

Smaller, unpigmented slaters have been recorded from Wombeyan (GBS obs), Bungonia (GBS 49, 95, 96), Cooleman Plain (GBS 83) and Jaunter (GBS 134).

Hamilton-Smith (1967) reports that "... species of Oniscoidea have been collected from virtually every area in Australia, but again determinations are not available for this material. However, some specimens show evidence of troglobitic adaption." This lack of taxonomic knowledge makes discussion difficult. From my own observations I would expect to find these animals in any cave with persistent moisture. They are usually collected amongst rocks in damp areas or roaming over mud banks.

CLASS MYRIAPODA

ORDER DIPLOPODA (Millipedes)

Again Hamilton-Smith (1967) offers a good summary - "Millipedes have been collected from many areas in eastern Australia, but are not so far recorded from those of other parts of the continent. Many species, generally belonging to the Paradoxosomatidae, are found near entrances and are probably accidental or parietal. However, at least half a dozen undescribed species of the Sphaerotrichopidae are known from well within caves and are first or second level troglophiles." My own records show two basic types occur regularly. I have no identifications and so must refer to these as an "unpigmented spiny" type from deep within caves at Jaunter (GBS 135), Bungonia (GBS 94, 109) and Wombeyan (GBS obs), while the other group is more variable but all are pigmented with a circular body cross - section. I have specimens from Jaunter (GBS 136), Bungonia (GBS 31) and Cooleman Plain (GBS 90). Both types often occur in the same cave.

CLASS ARACHNIDA

ORDER OPILIONES

Family Triaenonychidae

Holonuncia cavernicola (Forster) Jenolan.

Holonuncia spp. Yarrangobilly, Tuglow, Wombeyan, Wyanbene, Isaacs Creek, Wee Jasper, Colong, Cliefden, Bungonia (all Hunt 1970), Jaunter (GBS 79, 81) and Cooleman Plains (GBS 78).

In his paper, Hunt (op cit) comments that "the genus has numerous surface representatives, including undescribed species from bushland in the suburbs of Sydney." These animals are regular and often conspicuous inhabitants of most caves. Adults are generally orange to light brown in colour while the juveniles often lack this pigment.

ORDER ARANEIDA

Family Gradungulidae

Gradungula sp nov. Jenolan, Cliefden, Yarrangobilly and surface localities (all Gray 1973). Gray (op cit) comments that this is a partially depigmented troglophile.

Family Amaurobiidae

Stiphidion facetum (Simon). Gray (1973) comments that this spider is common in south-eastern mainland and Tasmanian caves. Its web consists of a squat lampshade-like funnel attached between rocks or under wall overhangs. He records it from Jenolan, Bungonia, Colong, Wombeyan, Yarrangobilly, Wee Jasper and surface localities. It is usually found near the entrance (GBS obs).

Procambridgea cavernicola (Forster). Gray (1973) records this species as a depigmented troglophile in the Wombeyan and Wee Jasper caves.

Family Theridiidae

Achaearanea extrilidum (Keyserling). Kempsey, Yarrangobilly and surface localities (all Gray 1973).

Achaearanea spp. nov. (*properum* group) Windy Gap and Kempsey (both Gray 1973).

Achaearanea sp. Cooleman Plain (GBS 20).

Gray (1973) comments "the genus *Achaearanea* is a dominant surface group in Australia and cave records are usually referable to surface species; slight depigmentation is sometimes observed (eg. *A. extrilidum*)."

Icona sp.nov A. Windy Gap, Timor, Jenolan, Bungonia, Cooleman Plain, East Buchan (Vic), Murrindal (Vic), Nowa Nowa (Vic), Flinders Island (Tas) and Mole Creek (Tas) (all Gray 1973, but referred to as a genus near *Steatoda*).

Icona sp.nov B. Cliefden (Gray 1973).

Icona sp.nov C. Yarrangobilly (Gray 1973).

Icona sp. Jaunter (GBS 12, 15, 14, 24) This is probably sp nov A.

Recorded by Gray as nr *Steatoda*, this group of spiders has since been identified as belonging to the genus *Icona* (Gray pers comm). The genus is known from New Zealand and sub-Antarctic islands but in Australia it is only known from caves (Gray pers comm). Apart from specimens of sp nov A from Mole Creek all are depigmented, dark zone cavernicoles showing variable eye regression (Gray 1973).

Family Sparassidae

Heteropoda procera (Koch) '. Comboyne, Windy Gap, Kempsey and surface localities. Huntsman spiders often occur as unmodified troglophiles in caves (all Gray 1973).

Family Cycloctenidae

Cycloctenus abyssinus (Urquhart). Jenolan, Tuglow, Bungonia and surface localities (all Gray 1973).

Cycloctenus sp. nov A. Wyanbene (Gray 1973). A forest-litter hunting spider family. *Cycloctenus* records are of unmodified species (all Gray 1973).

Toxopsiella sp. nov A. Bungonia, Cliefden and surface localities. A genus of small hunting spiders (with strongly spined legs) which wander the cave walls and floor (all Gray 1973).

Family Mimetidae

Mimetus maculosis (Rainbow). Jenolan, Kempsey and surface localities (all Gray 1973).

Mimetus spp. Yarrangobilly, Bungonia, Indi (Vic), East Buchan(Vic) and Wombat Creek (Vic). These are ambushing spiders common in forest habitats and are often present in caves as unmodified troglophiles (all Gray 1973).

Family Uloboridae

Uloborus pantherinus (Keyserling). Jenolan, Bungonia and surface localities (all Gray 1973).

Family Theridiosomatidae

Gen nov sp nov A. Kempsey, Kunderang and Windy Gap (all Gray 1973).

Gen nov sp nov B. Abercrombie, Tuglow, Bungonia, Jenolan, Wombeyan and Glenelg River (Vic). Australian records of this family are mainly from caves but such species show few signs of cave modification (all Gray 1973).

ORDER ACARINA

Family Cillibidae

Uroobovella coprophila (Womersley). Wee Jasper, Wombeyan, Comboyne and Naracoorte (SA) (Hamilton-Smith 1967). Originally described as *Cillibia coprophila*, it has since been re-described as *Uroobovella* by Hirschmann and Zirngiebl-Nicol (1962). Hamilton-Smith (op cit) comments: "Although specimens are not to hand from other localities, this species occurs in most eastern Australian caves inhabited by the bat *Miniopterus schreibersii* (Kuhl) - probably a total of several hundred caves." Harris (1973) examines the ecology of this species from Carrai Bat Cave. This species has not been recorded from outside a cave

Family Leeuwenhoekidae

Neotrombidium gracilare (Womersley) Wombeyan, Cliefden and Wee Jasper (all Womersley 1963). Members of this family are generally parasitic upon arthropods in their larval stages but are free-living as adults. At present the larval-hosts of the Australian species are unknown (Hamilton-Smith 1966a).

ORDER PSEUDOSCORPIONIDEA

Family Chthoniidae

Sathrochthonius tuena (Chamberlain). Jenolan, Wombeyan (both Beier 1967) and possibly Wee Jasper (Beier 1968).

CLASS INSECTA

ORDER COLLEMBOLA

Family Sminthuridae

Many specimens are available yet few are identified. Jaunter (GBS 113), Bungonia (GBS 40, 121) and Wombeyan (GBS obs).

Family Poduridae

Hypogastura sp are recorded from Bungonia (Wellings 1972). Many other Podurids are to hand but are as yet unidentified.

ORDER ORTHOPTERA

Family Rhaphidophoridae

Cavernotettix montanus (Richards). Yarrangobilly and Cooleman Plain (Richards 1966).

Cavernotettix wyanbenensis (Richards). Wyanbene and Cheitmore (Richards 1966).

Cavernotettix sp (spp). Populations of cave crickets of this genus can be found at Jaunter, Jenolan, Wombeyan and Bungonia. They are as yet undescribed.

ORDER COLEOPTERA

Family Carabidae

Trechimorphus diemenensis (Bates). Bungonia, Jenolan and Murrindal (Vic) (Hamilton-Smith 1967).

Notospeophonus jasperensis jasperensis (Moore). Wee Jasper (Moore 1964).

Notospeophonus jasperensis vicinus (Moore). Bungonia (Moore 1964).

Notospeophonus spp. Cliefden, Timor and Wombeyan (Hamilton-Smith 1967).

Hamilton-Smith comments that it would seem that "forms comprising this genus have been confined to the cave environment in comparatively recent geological times. Specialisation is not strongly developed, and localisation of species is not strongly marked..."

Family Pselaphidae

Rybaxis sp. Wombeyan and Bungonia (Hamilton-Smith 1966b)

ORDER PSOCOPTERA

Family Psyllipsocidae

Psyllipsocus ramburi (Selys-Longchamp). Cliefden, Wee Jasper and Wombeyan (Smithers 1964). Also from caves in South Australia, Western Australia, Victoria and Queensland (Hamilton-Smith 1967). It is usually associated with bat guano.

ORDER LEPIDOPTERA

Family Tineidae

Monopsis spp. Wombeyan (Dew 1963). Hamilton-Smith (1967) comments: "the only form which appears to be truly cavernicolous is *Monopsis* sp (or spp?) found in almost all bat-inhabited caves of eastern Australia, where the larvae develop in heaps of guano."

DISCUSSION

The above list is summarised in Table 1.

Several genera stand out as being almost ubiquitous - *Holonuncia, Stiphidion, Icona,* Theridiosomatidae Gen nov., *Cavernotettix, Uroobovella,* and *Notospeophonus*. Other genera will become as significant as specimens already in hand are identified and/or described - eg. the millipedes, slaters and springtails. Yet even with the poor state of taxonomic knowledge it is obvious that the cavernicolous fauna of the caves of NSW is composed of a central core of common cave genera occurring in most areas and sharing their habitat with species that are not so widespread but are a feature of the area in which they occur. Such animals may be accidentals and reflect the surface fauna of a particular area, or a true cavernicole (troglophile) restricted to caves by present surface climatic conditions and reflecting the distribution of surface faunas in past climatic periods. The common cave genera have most likely evolved from widely distributed ancestors occupying the surface leaf litter environment at the time when the caves were open to colonisation. Hamilton-Smith (1967) discusses possible causes of secondary extinction of cavernicoles. These factors - flooding and dehydration - would have been felt in all areas in NSW at roughly the same time. Consequently any pre-adapted and wide-spread species would enter newly vacated caves in each area at the same time. Further climatic changes in each area would possibly result in the isolation of these species in the caves and thus they would evolve independently of related animals in caves in other areas.

TABLE 1

Genus	Number of area records in NSW
Holonuncia	12
Gradungula	3
Stiphidion	6
Procambridgea	2
Achaearanea	5
Icona	8
Heteropoda	3
Cycloctenus	4
Toxopsiella	2
Mimetus	4
Uloborus	2
Theridiosomatidae Gen nov	8
Uroobovella	3+
Neotrombidium	3
Sathrochthonius	2 or 3
Cavernotettix	8
Trechimorphus	2
Notospeophonus	5
Rybaxis	2
Psyllipsocus	3
Monopsis	1+

This isolation and selection process will eventually result in the formation of new genera, however, in NSW the time available for development of new genera has been insufficient due to the extinction of earlier colonising forms by the adverse and fluctuating climatic conditions.

Lastly, if we accept that all these closely related animals colonised the caves at approximately the same time we must then explain why animals of one area show greater degrees of speciation than related animals from other areas. For example, the genus *Icona* is found in most areas from Windy Gap to Mole Creek (Tas). In the majority of areas the spider can be assigned to sp A but at Yarrangobilly there is a different species (sp C) and at Cliefden a further distinct species (sp B). This could be due to different rates of evolution brought about by higher selection pressures such as poorer food or competition from other animals (eg. predation).

Many questions are still unanswered but there is a definite pattern emerging. It is vital to our understanding of the evolution of our fauna that detailed collections are made in many of the lesser-known areas (such as Jaunter) and that material already in hand in museum or private collections is identified or described and that this information is published.

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A Comparison of Cave and Doline Fauna

Stephen Bunton

Introduction

Since its discovery in 1974 Phoenix Cave has attracted the attention of the members of the Highland Caving Group. This study was undertaken in order to determine how much of the cave fauna is derived directly from the surface and how much is apparently isolated within the cave. This survey is by no means exhaustive yet it shows the distinct differences between the hypogean and doline epigean fauna of Phoenix Cave.

Only ground dwelling organisms were the subject of investigation since the cave environment is analogous to the forest floor on the surface. However the following factors modify the environment of the cave-

i) there is no light

ii) there is no vegetation growing within the cave, because there is no light

iii) the soil is less well developed because of the lack of biological activity

iv) organic debris decreases in quantity from the surface with depth and is only replenished from the top and not over the whole surface area of sediment in the cave

v) there is no algal or other light dependent mechanisms operating within the cave to break down the organic debris.

A comparison of the two environments may be made from an evolutionary point of view. Our current theory of evolution stresses selection against those animals not suited to an environment and thus they do not survive. The cave environment acts as a harsh selector and very few animals are able to live there.

Methods

Phoenix Cave was well suited to such an investigation for several reasons

i) It was a newly discovered cave and as near as possible to its natural state. Full history of its excavation and exploration is available as a guide to man's influence and interference.

ii) It was known to be biologically active.

iii) It's catchment area is away from the usual path of traffic and thus surface features are also close to their natural state.

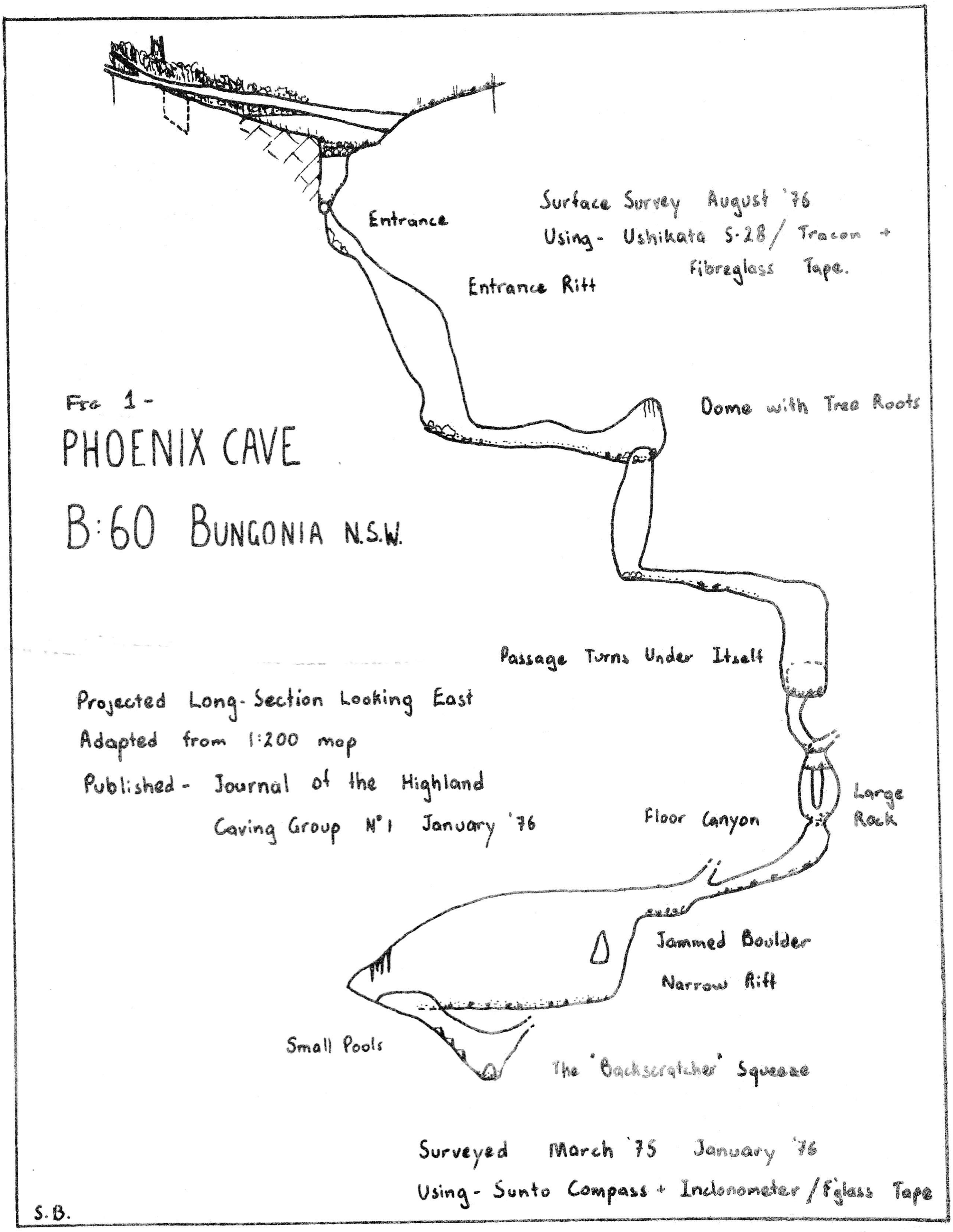
iv) It does not contain a bat colony and thus differs in its ecology from most caves that have been studied by biospeleologists in the past.

The sampling was made on two weekends and does not represent a long term study(ie 24-25 July & 7-8 August 1976).

A grade 5 survey was available and the cave was sampled for animals throughout. Any relevant features of the cave were noted. The surface area to be studied was surveyed and a map of an area 15m x 15m surrounding the entrance was produced. This area was sampled at several sites to obtain a transect of the area. The sample sites were chosen in order to cover the broad spectrum of leaf litter and vegetation types.

Description of the Environments

The cave is basically a narrow, winding passage which descends steeply and occasionally, near vertically to a depth of 70m. It descends without any long vertical drops and in all places where the floor is sufficiently level some sediment has collected This sediment consists of cave and surface breakdown material. Many piles of



cobbles, and smaller pebbles exist, indicating the volume and flow of flood waters. The sediment is structured as a sorted area of rock particles with size decreasing with depth. This is because smaller particles can fall through the voids between the larger rocks. Microscopic examination of the soil revealed that small particles of vegetation were common within the soil.

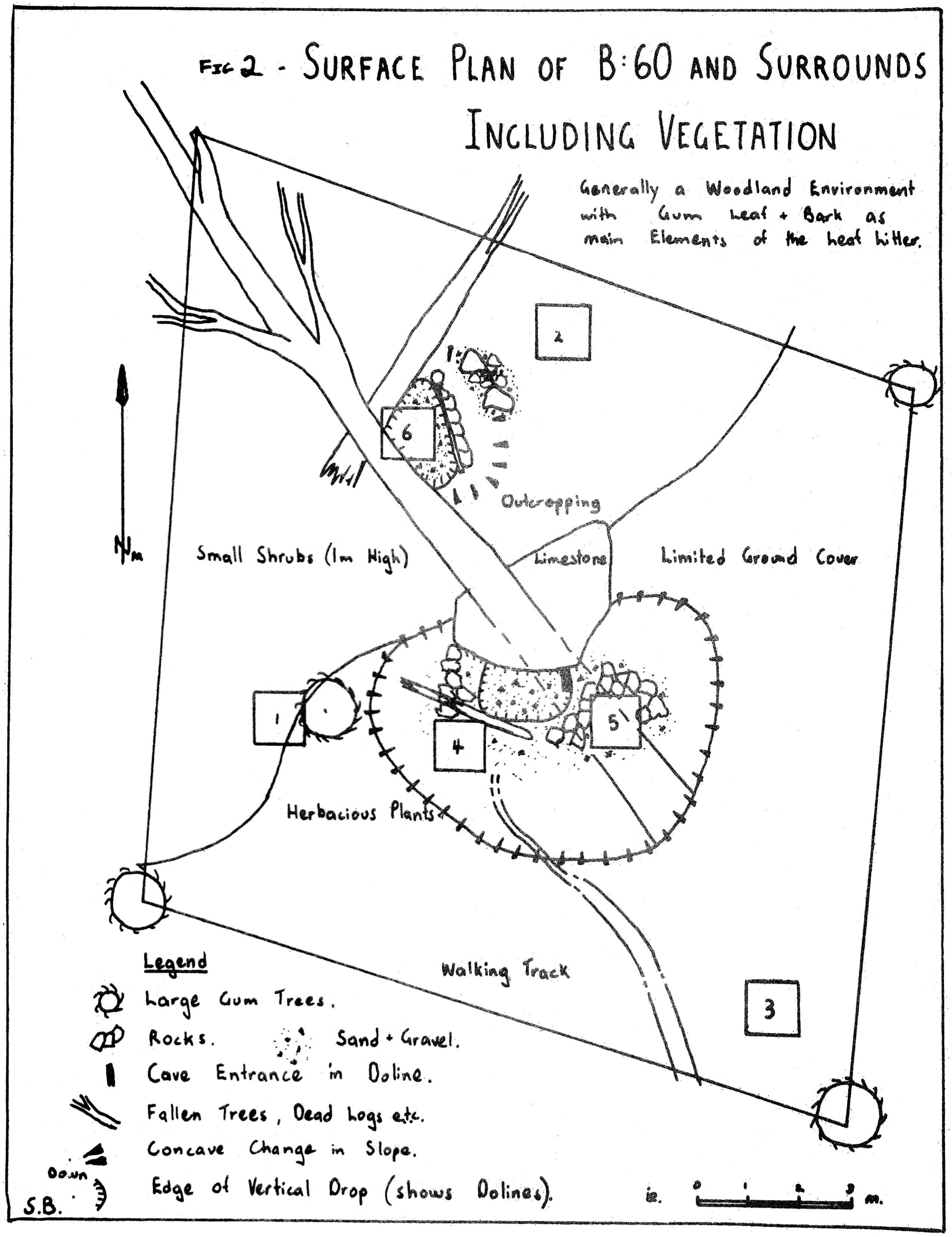


FIG 2 - SURFACE PLAN OF B:60 AND SURROUNDS INCLUDING VEGETATION

Around the entrance sections there is visable much large washed-in debri, consisting of grass, leaves, twigs and pieces of bark. The base of the entrance rift is partially lit by reflected sunlight but the cave soon becomes aphotic. Further down the cave the effect of the surface climate on temperature and air movement decreases until the cave approaches a state of constant temperature and humidity. Other caves in the Bungonia Caves Reserve approximate 17.75°C and 98% humidity (Wellings 1972 in Ellis R. ed). The lower levels of the cave are subject to fluctuating high levels of carbon dioxide.

Within the larger doline of the cave are two smaller pit-like dolines, both of which have been excavated and the fill placed beside them. Only one of these has yielded a cave (B.60). The surrounding vegetation is dry schlerophyll woodland (Whaite J.L. 1972 in Ellis R. ed) with a thick leaf litter consisting of bark, dead branches and leaves. The soil is thin and just covers the limestone bedrock. Imbedded in the soil are numerous ironstone rocks (Jennings J.N. et al 1972 in Ellis R. ed). Some bedrock outcrops but most is covered with soil and small shrubs. Six sites were sampled within the doline and are described as follows-

1. A region of dark, humic soil, several rocks and a cover of shrubs to 1m in height. The ground is steeply sloping, very moist and partially shaded by an adjacent tree.

2. Similar in soil and vegetation to 1, but the ground is more level and drier. It is also shaded by trees.

3. A dry, open area with little shade and many rocks within the soil, which is also dry. The ground cover is sparse and stunted.

4. A very moist area due to low elevation and excessive shade. There is much silt in the soil and the ground is covered by very 'juicy' herbaceous plants of low height.

5. This region is where the rock and soil from the cave excavation was placed. It has since been colonised by herbaceous plants as in site 4 but is even more shaded due to a large log overhead.

6. A silt filled doline with no vegetation.

Results

1. The Cave

The distribution and abundance of those animals found in the cave is shown in figure 3. Descriptions are as follows:-

Class Crustacea

Order ISOPODA

One type of slater being almost completely white with only a dark dorsal stripe.

Class Arachnida

Order OPILIONES

Holonuncia sp. Specimen 5mm in length. Large, strong pedipalps and long legs. Very small eyes. Orange colour. Predatory. A second individual, 2mm and white with small eyes.

Order ARANEAE

A small dark spider. Predatory but did not appear to be morphologically modified. Probably feeds on accidentals (Harris 1975).

Class Myriapoda

Order DIPLOPODA

Only the remains of exoskeletons were found. On previous occasions many specimens have been sighted.

Order SYMPHYLA

A colourless animal of little known status and classification. Only one specimen was found but others have previously been recorded (G.B.Smith pers comm). A sample was not collected for identification since their establishment is unknown. A similar specimen was found on the surface. Vegetable feeder, with flexible, long antennae.

Class Insecta

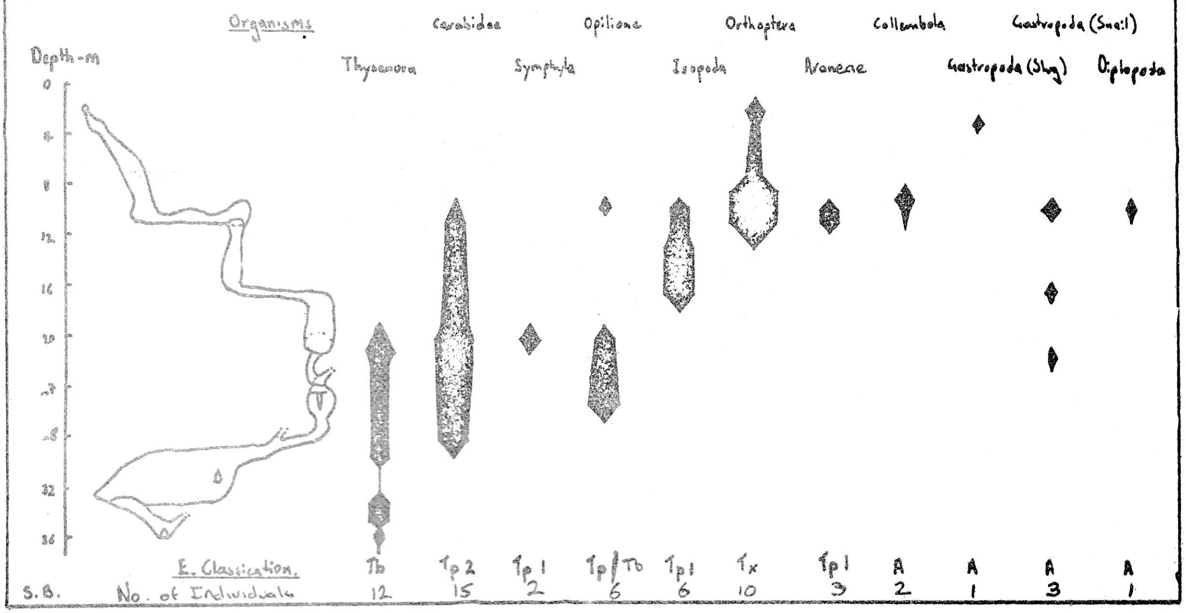
Order COLLEMBOLA

Family Entomobryidae. Similar to surface specimens. No modification. Fungiphile.

Order THYSANURA

Nicoletia sp nov. (Smith 1976). An eyeless silverfish with extremely long appendages. Probably vegetable feeder.

FIG 3 - DISTRIBUTION AND ABUNDANCE OF THE CAVERNICOLOUS FAUNA OF PHOENIX CAVE B:60 SHOWING ECOLOGICAL CLASSIFICATION.



Order ORTHOPTERA

Cavernotettix sp. Wingless cave cricket or weta. Migrate in and out of the cave daily (Harris 1975). Many small specimens were found inside the entrance and assumed to be juvenilles.

Order COLEOPTERA

Family Carabidae. Black in colour and scavenge on organic debris. Eyes present. Prominent labial and maxillary palps. Long antennae. Both Notospeophonus jasperensis and Trechimorphus diamenensis are known to occur in the Bungonia Caves (Wellings 1972 in Ellis R. ed).

Class Gastropoda

Shells of carnivorous snails were found within the soil. No living specimens were seen.

A slug was also seen.

No bats inhabit this cave, consequently no guano mites occur. Other caves at Bungonia have much fungi and many fungiphiles. The comparitively recent discovery of Phoenix Cave and its low level of people traffic would account for the lack of fungi and fungiphiles usually transported into the cave on the clothing of speleologists.

2. The Surface (See Table 1)

Classification of all animals is needed, however, descriptions are more brief than those for the underground specimens. It is presumed that the animals sampled and recorded fill the same ecological niche as is shown by Besley(1976). Note is made when specimens appear similar to those in other areas or underground. Some idea of relative numbers is given as such:-

+ one or two animals
++ three or four animals
+++ more than four animals

Table 1 - Surface fauna.

Animal	Site 1	2	3	4	5	6
O. Homoptera Plant bugs	+++	+++	+++	++	+++	-
O. Diptera Flies & larvae	++	++	++	-	++	-
O. Coleoptera Rove Beetles	+++	+++	+++	-	++	-
O. Hymenoptera Ants	++	++	+++	+	++	-
O. Lepidoptera Caterpillar	+	-	-	-	-	-
O. Orthoptera Cave cricket	-	-	-	++	-	-
O. Collembola Springtails	+++	+++	++	+	++	++
O. Blattedea Cockroach	-	-	+++	-	-	-
O. Acarina Mite spp.	+++	++	+++	+++	+++	-
O. Araneae Spider spp.	+	++	+	-	+	+
O. Isopoda Slaters	+++	+++	-	-	++	-
O. Amphipodà Land-shrimps (Cave prawns)	+	+	+	-	+++	++
Cl. Symphyla	+	+	+	-	-	-
Cl. Oligochaeta Worm	+	-	-	-	-	-
Cl. Chilopoda Centipede, 2 spp.	-	-	++	-	-	-
Cl. Diploda Millipede	-	-	+	-	-	-
Cl. Nematoda	-	-	+++	-	-	-
Cl. Gastropoda Slug	-	-	+	-	-	-
Snail shells	-	-	+	-	-	-

Discussion

Although the comparison is between two differing environments of particular characteristics, these two environments differ within themselves in the various component factors. Within the cave the characteristic sediment floor is only found where the ground is level and the areas between this are bare rock. On the surface the ground cover and moisture differ.

In general the animals outside the cave are:-

i) More diverse in morphology and function.

ii) Contain more different species within each taxa and also within each ecological niche, eg. Acarina and Homoptera.

iii) They are believed to be slower moving if predators.

iv) More subject to hiding themselves and burrowing in the leaf litter.

v) Fit directly into a complete food chain (as proposed by Besley 1976) and are capable of eating plant material directly eg. Acarina.

vi) They are smaller in size.

Distribution and abundance of surface organisms is modified by a cyclic effect of surface factors in the environment.

vegetation → shade → moisture → vegetation

soil → vegetation → soil

Surface environments select against those animals which cannot survive as well in each micro-habitat thus creating the abundance phenomenon observed.

It is fairly easy to ascertain the feeding habits of the cave-dwellers. In fact, food plays a dominant role in the position of the animals within the cave. New food reserves only enter from the top of the cave (Culver 1970) and decay as they are washed to depth. Both the Thysanura and Symphyla consume decayed vegetable matter (Besley & Meyer 1973). The carabid beetles are also scavengers. The opiliones are predatory on any other cave-dwellers and the isopods are scavengers although at lesser depths.

It does seem though that the snail cannot get food at the depth at which it was found and thus I believe, the shell which would decay very slowly stood more chance of being washed to depth than other accidentals. No live snails were found. The slug, diplopod and collembola also seem to have no life support in the cave environment. The spider however does have food sources near the entrance but lack of light would make predation difficult.

Cave animals have, in the past, been classified according to ecological status by a method described traditionally as the 'Schiner-Racovitza System' (Hamilton- Smith 1968). However this system has been modified (Hamilton-Smith 1967) to more accurately interpret the relationships of the Australian cave fauna. The present system is:-

Trogloxenes (Tx)- those animals which spend part of their life inside a cave.

Troglophiles- 1st level (Tp1) - those animals capable of living in a cave but are also found on the surface.
- 2nd level (Tp2) - those animals capable of living in a cave without morphological adaptations to do so, but are not found on the surface.

Troglobites (Tb) - those animals not found on the surface and having adaptations to cave environments eg. reduced eyes or loss of pigment.

The ecological classification of those animals recorded can be obtained from consideration of :-

i) The food sources they use.
ii) The position within the cave.

Harris (1975) adds a catagory viz. Accidentals (Acc). This covers those animals which for example are washed in.

The ecological classification is recorded in Table 2 . For those animals

Table 2 - Proposed Classification of Cave Fauna

Animal	Class	Reason
<u>Nicoletia</u>	Tb	- None found outside and it has morphological modifications.
Carabidae	Tp2	- None found outside but no modifications.
Symphyla	Tp1	- Also found outside.
Opilione	Tp2/Tb	- Not found outside and possibly possessing modifications.
Isopoda	Tp1	- Also found outside.
<u>Cavernotettix</u>	Tx	- Found outside and when found inside it is not a component of the soil fauna but perches high on the wall ie., using the cave for shelter.
Araneae	Tp1	- Apparently capable of predating successfully.
Other animals		- Considered as accidentals.

in the dark zone there is a need to use morphological characteristics to determine the status of each animal.

These findings agree with the descriptions offered by Hamilton-Smith (1967), except for the opilione. He classifies opiliones as Tp2 but the reduced eyes must be considered a morphological adaptation and thus this animal should be considered a troglobite.

Of interest to this study is the fact that although the cave is 70m deep only the top 40m is populated. This could be due to the high concentration of carbon dioxide, which may fluctuate daily. It seems unlikely that the metabolism of such small animals can support diurnal migrations up and down the cave and thus populations have a lower limit imposed on them.

Although the cave does exert some rigid evolutionary pressures on its inhabitants, there are some which it does not impose. Such pressures, which on the surface, have made animals

i) more cryptic and tending to burrow
ii) only able to reach small sizes and
iii) slower moving predators

must be due to the influence of predators and their importance. The cave has promoted a sense of complacency amoungst the animals which:-

i) freely roam in the open passage and
ii) grow to larger size.

Predators on the other hand are larger and swifter moving.

In general the cave-dwellers:-

i) have long sensory appendages,ie. antennae, labial or maxillary palps cerci or all of these.
ii) grow to larger size since it is not so necessary to crawl into small cracks and also there is no vegetation to crawl through.

It must be noted, however the cave dwellers have good responses to touch stimuli. An experiment simulating the touch of a predator by the touch of a finger sent the animals scurrying rapidly away.

Summary

Although the two environments compared are analogous, they are both different enough to contain differing fauna. Not only does the fauna appear different but different animals fill the same roles in each environment. Underground only some of the available niches are filled.

However, evolutionary pressures in the cave environment have caused the (different) animals found there to even behave differently. Once they have shown they can exist in a cave environment, they become characterised (over time) by specialisations such as loss of eyes or pigment, more sensitive antennae and different behavioural responses.

Neither the nature, advantage or mechanism of these characteristics is known. All we know is that they are the result of different evolutionary pressures.

Conservation

The greatest care must be maintained when visiting Phoenix Cave since there is no 'off the beaten track' which Wellings (op cit) feels necessary to preserve the animal populations in the caves.

Many animals were not collected as specimens, indeed only one animal from each species was collected, sometimes none, as the establishment of the populations in the cave is poorly understood.

Acknowledgements

I would like to thank Graeme Smith for his assistance on the two sampling weekends (7-8 and 14-15 August, 1976).

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CAVE & AREA DESCRIPTIONS

CLIFF CAVE - Cooleman Plain (including a new extension)

Graeme Smith

(see page 40)

The entrance is located several metres up a talus slope above and to the left of the resurgence, which lies at the base of a prominent cliff - hence the name.

A 5 metre drop to a rocky floor is followed by an easy climb (1.5m) onto collapse blocks. A further 1.5m drop finds the downstream end of the small stream in the main passage. (N.B. Heavy rain had fallen on the previous two days) The water flow in this passage was probably less than 1% of the flow from the resurgence. The water sank into gravel.

A short, high level passage enters from an aven at the sharp left hand bend a few metres upstream. Continuing upstream through a pool and around right then left hand bends, the passage maintains its vadose canyon form. Some collapse occurs on this left-hand bend with a boulder jamming high in the passage, with another on the streambed. At this point the passage begins to change in nature. The floor begins to rise; the water flowing over the surface of clean rock. An S-bend at floor level leads to another westerly trend in the passage with another large boulder jammed in the passage. Up the slope a small passage can be found on the left. Some of the water was sinking here. Another passage enters from the left, this time with water flowing from out of it. This passage connects (by voice and light) to the previous passage.

Back in the main passage the cave floor is a cemented talus slope. This breakdown continues high into the roof. At the "end" of the main passage a tight squeeze leads to a 3 metre drop into a pool. From this pool a passage extends back towards the entrance paralleling the main passage. No way on could be found.

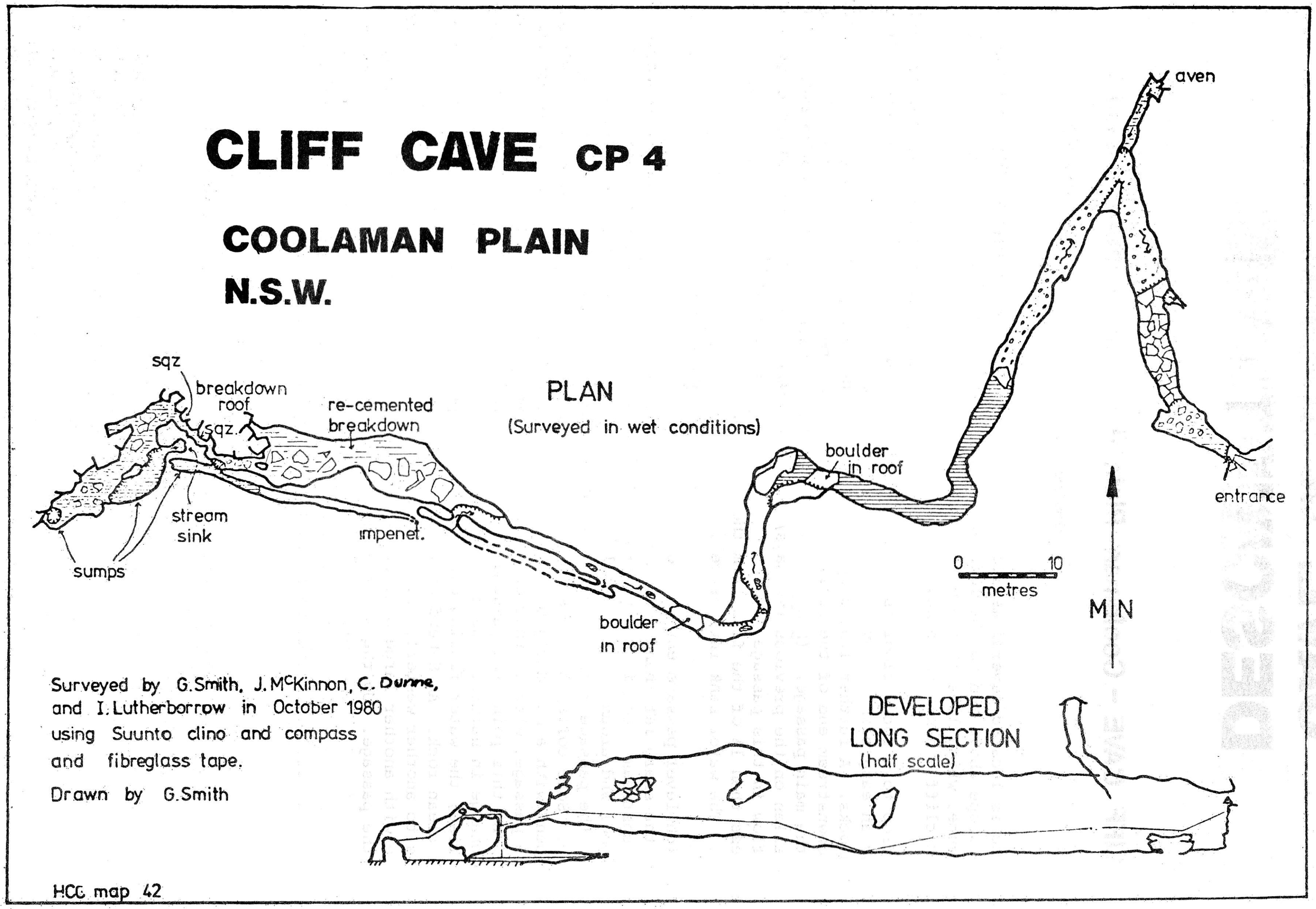
New Extension

This was discovered by Ian Lutherborrow when he removed some loose rocks above the 3 metre drop mentioned before. He then squeezed up higher through the rockpile and into a tight passage with a further difficult squeeze. The passage then opened up into a small chamber with a muddy floor. A slope on the left leads to a deep pool that sinks down an impenetrable hole. Again, at the level of which this chamber is entered, a traverse leads into a second section of the chamber. On the right is a muddy hole leading to water, while to the left is the same pool mentioned before in this chamber. A traverse above this pool is possible. No way on could be found.

FRUSTRATION CAVE EXTENSION - Cooleman Plain

Graeme Smith

During the Easter weekend 1979 HCG and SUSS combined on a trip to Cooleman. During that weekend Guy Cox and Bruce Welch (from SUSS) succeeded in re-pushing the upstream end of New Year Cave and reported a great deal of passage which should be getting close to Frustration Cave. Bruce comments that they had pushed up another branch to the left of the passage carrying the stream. Next day Tony White pushed the upstream sump in Frustration Cave only to find himself in a small air-bell with somewhat poor air and so rapidly he retreated. The


CLIFF CAVE CP 4
COOLAMAN PLAIN
N.S.W.
PLAN
(Surveyed in wet conditions)
aven
entrance
boulder in roof
boulder in roof
sqz
breakdown roof
sqz.
re-cemented breakdown
stream sink
sumps
impenet.
0 10
metres
M N
DEVELOPED LONG SECTION
(half scale)
Surveyed by G.Smith, J.McKinnon, C. Dunne, and I. Lutherborrow in October 1980 using Suunto clino and compass and fibreglass tape.
Drawn by G.Smith
HCG map 42

following day Janine McKinnon and myself pushed downstream in Frustration Cave and succeeded in passing the downstream "sump". This was only a tight duck to the right (see map). Beyond it was possible to remove some rock obstacles and push through a very tight section and into another squeeze to the left. Several ways through this section look possible, however only the dotted route shown on the map should be trusted.

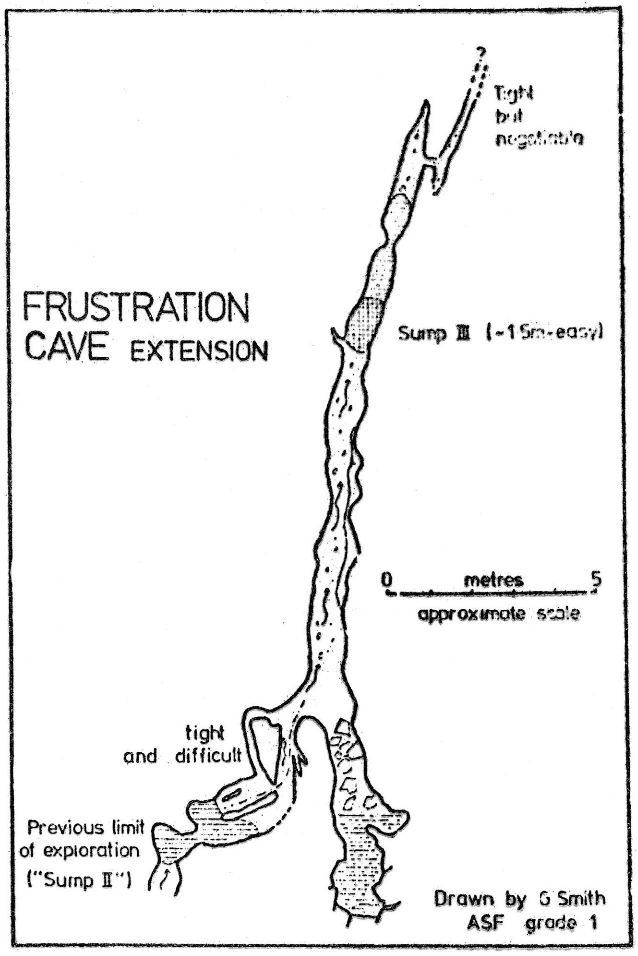
Beyond here was about 10-15m of larger passage (1.2m high) leading down to a further sump. By pushing into the water feet first it was possible to estimate that the roof begins to turn up again about 1m down and 1.3m into the water. The roof continues to rise for about another metre but no airspace could be felt so we did not try to push through.

During Easter 1981 we returned to Frustration Cave to push the sump. Ian Lutherborrow, Janine McKinnon and myself quickly moved through to sump II, which again was open due to the local drought conditions. I was the only one to get through the squeeze on the other side of the sump.

With the aid of a face mask, the sump dive was easy on the way through - the surface of the pool on the other side being visible about 2m ahead. I quickly returned through the sump and yelled back to the others that I was going on. The sump was now very silty and visibility zero, but the sump is smooth sided and crawl size so presents no problems.

On the other side the passage continues in the same vein as between sumps I and II. It is strongly joint controlled. After a short side step to the right it heads off along a horizontal, clean, vertical lens-shaped pressure tube. At this point I returned to the others as my light was causing concern.

The potential for further extension is obvious and should be investigated when dry weather permits.



TWO CAVES IN THE WARRUMBUNGLES

Jenny Lette

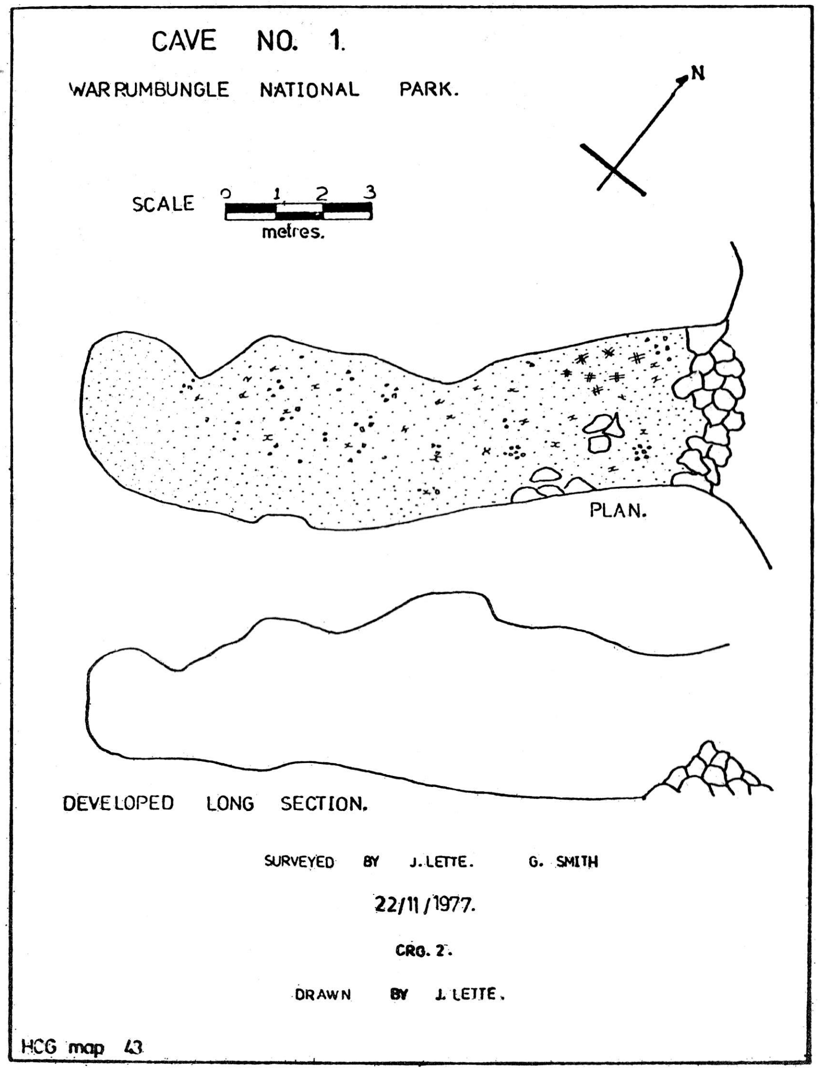
The hardest aspect of these caves was in finding them. We obtained a rough idea from the Rangers as well as the necessary permission to leave the marked trails. At first we followed the Belougery Split Rock trail, until we found a dry creek bed between the two peaks. Here we left the main trail and scrambled down the steep scree slope to the top of a cliff. We traversed along the top to the west to where we could descend. Once we were down this, the caves were found back up to the right in the base of the cliffs.

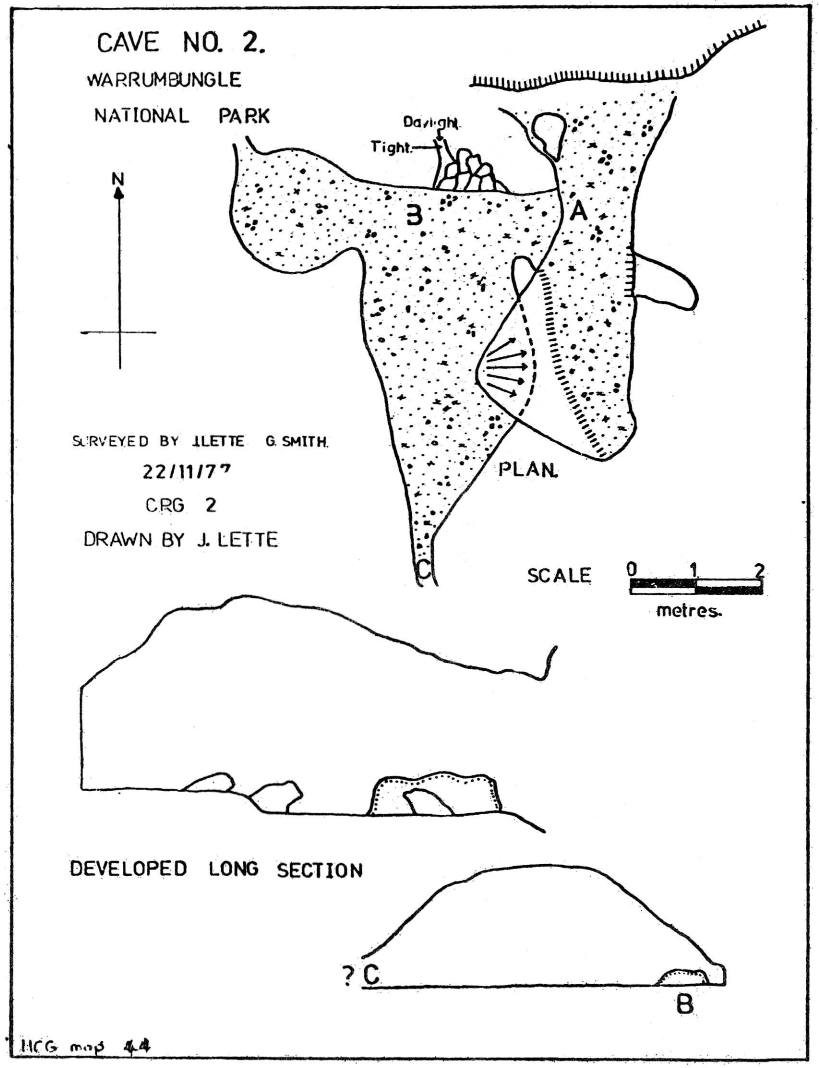
The nearer of the two caves was the smaller. The other lay 20 metres to the east and was slightly more complex.

Cave No. 1 (See map page 42)

This is entered over the top of a small rockpile and is about 13m long, the roof height is about 3-4m throughout and its width is about 3-4m throughout.

The cave is formed in what we believe is volcanic rock. The floor was covered in


CAVE NO. 1.
WARRUMBUNGLE NATIONAL PARK.
N
SCALE 0 1 2 3
metres.
PLAN.
DEVELOPED LONG SECTION.
SURVEYED BY J. LETTE. G. SMITH
22/11/1977.
CRG. 2.
DRAWN BY J. LETTE.
HCG map 43


CAVE NO. 2.
WARRUMBUNGLE
NATIONAL PARK
Daylight
Tight
N
B
A
SURVEYED BY J.LETTE G. SMITH.
22/11/77
CRG 2
DRAWN BY J. LETTE
PLAN.
C
SCALE 0 1 2
metres.
DEVELOPED LONG SECTION
?C
B
HCG map 44

dust, sand, gravel and a large amount of fa[illegible] This cave is obviously used by many animals as indicated by the massive accumulation of droppings. Swallows were the only active inhabitants at that time.

Cave No. 2

This cave, although similar in nature to the first, is more complex. The floor was of the same composition and just as dry. We had no torch so that exploration was limited as indicated by the question marks on the map.

The main chamber is large and spacious and there is a low crawl on the right near the entrance. This leads to the second major section which runs parallel to the main chamber. A low circular alcove further to the right was not fully explored.

The Surveys

North was approximated by using the sun as a guide, and attempting to estimate angles in the cave with respect to a sight from the entrance. Distances were paced and this pacing calibrated later.

Conservation

These caves should obviously be conserved because of the large number of birds and mammals that shelter in the cave. Conservation should not be at all difficult as they would only be found by someone actually looking for them and they offer little of interest to attract such determined visitors

I would like to express my thanks to the Rangers who were helpful and interested during our stay.

MUDGEE An Overview

Peter Dykes

Introduction

The limestone around the township of Mudgee has been of particular interest to the Highland Caving Group for the best part of the last 20 years.

Most interest has been mainly centred on the Buckaroo outcrop, east of Mudgee. However, other outcrop at Lawsons Creek and Mt. Frome have occasionally been visited.

This report is meant to conclude the more recent investigations by H.C.G., as well as offering an overall documentation of the limestone in the vicinity of Mudgee.

History

Limestone was first reported to exist in the area over 100 years ago and has been quarried at various times since then, in a number of places, mainly for lime and road base.

The usual run of stories have been associated with the area, i,e, bottomless pits, caves devouring farm implements and stock etc.

The first detailed report on the limestone at Mudgee, appeared in 1919 with publication of Carne & Jones' "Limestone Deposits of N.S.W." Carne and Jones reported in detail on most of the outcrops in the area.

The history of Highland Caving Group's activities at Mudgee extends back to the very early days of the club. During the first two years of the 1960's the club ran mainly familiarisation trips to the area, concentrating on finding the limestone outcrops reported in Carne and Jones.

During one of these visits, a radio interview with a Mrs. Archer, the owner of Buckaroo property, was heard. Mrs. Archer reported that there were caves on her property which had never been fully explored. After seeking permission, 13 members of H.C.G. visited Buckaroo in June 1963. This visit was followed by a further 4 trips, which all yielded very little.

It was found that the outcrop that Carne and Jones referred to as "Buckaroo" is approximately 3½-4 kilometres to the south of what is presently known as Buckaroo. It would seem that Carne and Jones made a mistake in their nomenclature, as local townspeople have stated that the outcrop on Mrs. Archer's property has always been referred to as Buckaroo.

Blayne Pearcey, a fairly active member of H.C.G. at the time, produced a report on the limestone at Buckaroo in April 1964. This report was a milestone in the history of H.C.G.'s activities at Mudgee. To date, it is still the most definitive document on the Buckaroo limestone and is reprinted in appendix A of this article.

At the same time that H.C.G. was becoming interested in the area, the Newcastle Technical and University College Speleological Society (N.T.U.C.S.S.) was responsible for the excavation and exploration of the "Fence Line Hole" (MU.5). What work they did do has largely been lost as the club became defunct in the late sixties and the society's records appear to have never been deposited with the Australian Speleological Federation's librarian.

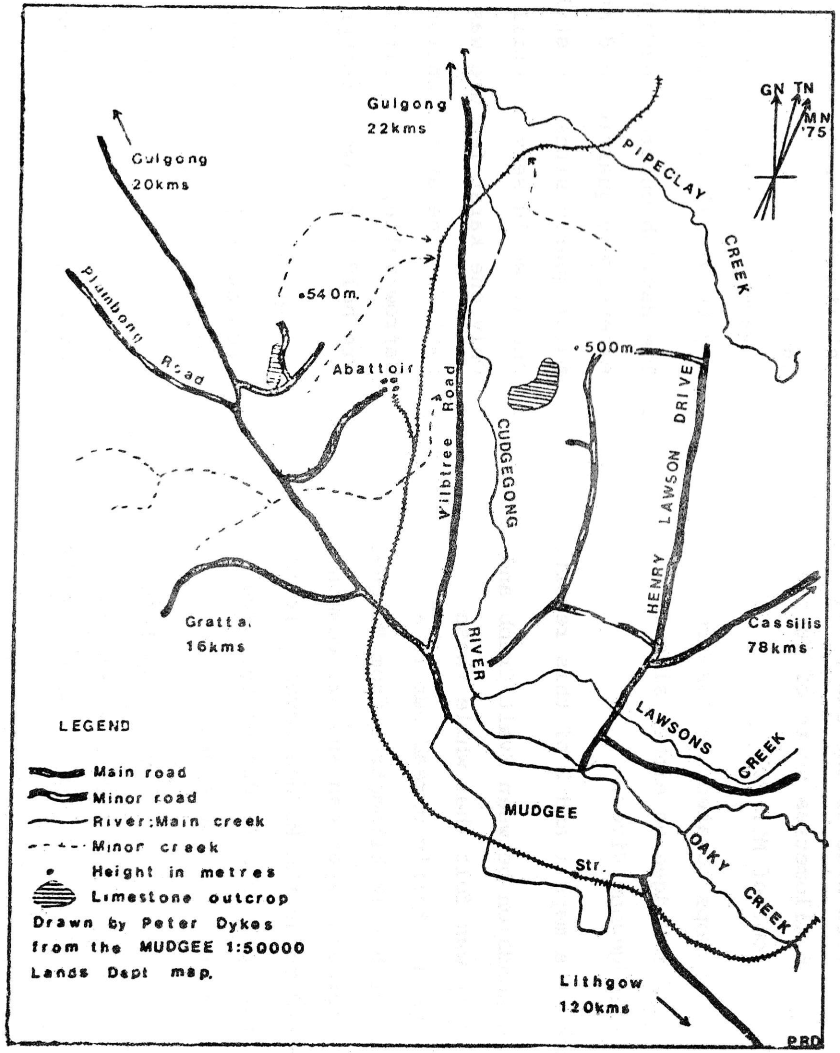
With the lack of substantial cave development being found, interest in the Mudgee district shifted south to Apple Tree Flat and Cudgegong areas, and finally waned until the end of the sixties, when it was proposed to hold a Mini Conference at Mudgee.

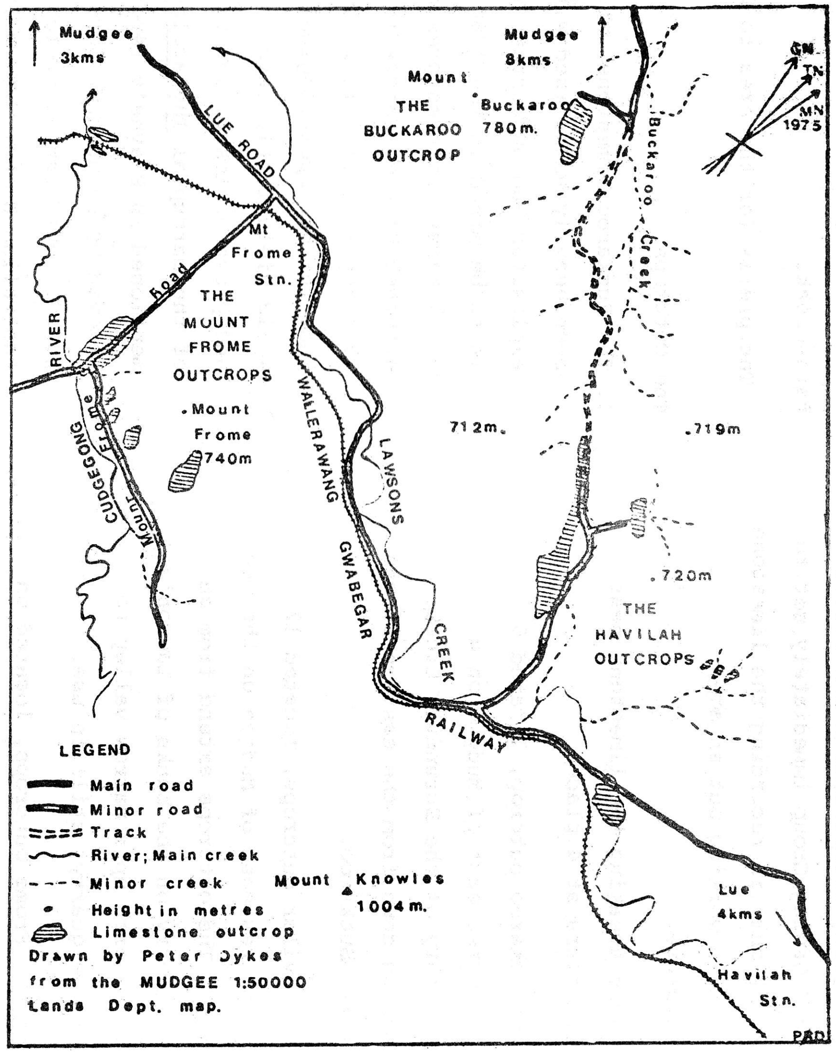
The 1970 Mudgee Mini Conference, sponsored by Highland Caving Group, Blue Mountains Speleological Club and the Metropolitan Speleological Society began a new wave of exploration in the Mudgee district. After the initial emphasis that the Mini Conference spurred, interest again shifted from the limestone immediately around Mudgee to the more profitable cave areas south of Mudgee. Most of the early part of the decade was spent exploring Apple Tree Flat, Queen's Pinch and Capertree Valley areas. Not until 1977 was much interest again shown in the area.

Due largely to the efforts of Evalt Crabb and a new generation of cavers in H.C.G., the period 1977 onwards saw the whole of the Mudgee district being progressively revisited and documentated. Buckaroo and the other outcrops in the immediate vicinity of Mudgee became the centre of exploration and this report is largely the result of these efforts.

Area Nomenclature

One of the first problems, and possibly the major problem that was encounted in 1977, was that there existed no clear or precise area nomenclature/s for any of the limestone found between Lithgow and Mudgee. What this meant is that any cave or karst feature found could not be adequately and accurately recorded in the


Gulgong
22kms
Gulgong
20kms
Plumbong Road
.540m.
Abattoir
.500m.
PIPECLAY CREEK
GN TN MN '75
Wilbtree Road
CUDGEGONG RIVER
HENRY LAWSON DRIVE
Gratta.
16kms
Cassilis
78kms
LAWSONS CREEK
MUDGEE
Str.
OAKY CREEK
Lithgow
120kms
LEGEND
Main road
Minor road
River;Main creek
Minor creek
Height in metres
Limestone outcrop
Drawn by Peter Dykes
from the MUDGEE 1:50000
Lands Dept map.
PRD


Mudgee
3kms
LUE ROAD
Mt
Frome
Stn.
Road
THE
MOUNT
FROME
OUTCROPS
RIVER
CUDGEGONG
Mount Frome
.Mount
Frome
740m
WALLERAWANG
GWABEGAR
RAILWAY
LAWSONS
CREEK
Mudgee
8kms
Mount
Buckaroo
780m.
THE
BUCKAROO
OUTCROP
Buckaroo Creek
GN. TN MN 1975
712m.
.719m
.720m
THE
HAVILAH
OUTCROPS
Lue
4kms
Havilah
Stn.
LEGEND
Main road
Minor road
Track
River; Main creek
Minor creek
Height in metres
Limestone outcrop
Mount Knowles
1004m.
Drawn by Peter Dykes
from the MUDGEE 1:50000
Lands Dept. map.
PRD

speleological documentation for N.S.W. Highland Caving Group immediately set to work, not only in recording the limestone, but also in working out an area nomenclature.

Broadly speaking the limestone near Mudgee occurs at 4 places:

1. The Buckaroo outcrop, located 6 kilometres east of Mudgee on a tributary of the Eurundury Creek, running down from the eastern slopes of Mt. Buckaroo.
2. The Havilar outcrops, located 12 kilometres east of Mudgee on the Lue Road. The outcrops extend from an old quarry on the banks of Lawson's Creek north up a narrow valley to a large quarry, still in use.
3. The Mt. Frome outcrops, located on the eastern side of the Cudgegong River, 6 kilometres south of Mudgee, at the foot of Mt. Frome.
4. Two outcrops located 5 kilometres north of Mudgee on either side of the Cudgegong River.

See area maps 1 and 2 of this report.

In discussion between Evalt Crabb and myself it was felt that while these outcrops are fairly spread out in a radius of 5 - 12 kilometres from Mudgee, they represent what can and are commonly referred to as the Mudgee Caves. It is therefore proposed to define the area nomenclature for Mudgee as:

"All limestone drained by the eastern tributaries of the Cudgegong River, including the Eurundury Creek, up to the junction of Lawson Creek and the Cudgegong River and as far up Lawson Creek as the junction of Lawson Creek and Bara Creek."

The prefix for the area to be: MU

The Outcrops

1. The Buckaroo limestone outcrop has been heavily vandalised with explosives and on current information is to be mined in the 1980's. There are 5 karst features present today, although Blayne Pearcey in April 1964 reported 11. It would appear that further speleological work would yield little cave development and prove useless. The skeleton of the marsupial *Thylacoleo carnifex* mentioned in Blayne's report was removed by an unknown person/s before H.C.G. could remove it for the Australian Museum. This is very unfortunate vandalism as the skeleton was quite a significant discovery. However, it could prove that Buckaroo may be of palaeontological significance.
2. The Havilah outcrops have been extensively quarried and at least 6 major quarry sites can still be seen, one it would seem is still in use. Only one karst feature was found, a small doline at the entrance to a narrow valley. Very little prospects are held for cave development.
3. The Mt. Frome outcrops again have been extensively quarried. One quarry would measure 100 metres by 30 metres by 15 metres. Three features were found, all very small caves. Again there appears little prospect for cave development.

4. The two limestone outcrops north of Mudgee are located either side of the Cudgegong River. There is very little surface exposure of the outcrops and absolutely no prospects for cave development being found.

Geology

All of the limestone around Mudgee appears as small outcrops or lens, and the total amount of limestone is quite misleading because of this. In fact limestone has been found up to a depth of 200 metres below Mudgee; most of the Cudgegong River flood plain has between 150 metres and 200 metres of limestone, covered only by alluvial deposits.

The limestone that does show above the surface is nearly all to be found in the mountain range east of Mudgee. All of it is of Silurian age, and most of it is intercalated with clay shales and/or sandstone (a pipe clay quarry is still in operation about 500 metres north of Buckaroo outcrop, and examination of the quarries at Mt. Frome shows fairly easily the clay shales intercalated in the limestone).

At the Havilah outcrop dolomite is also present as "irregularly defined beds, lenticular in shape with one prominent bed up to 20 metres in thickness".
The dolomite appears a dark blue grey in colour, with brownish streaks and is fine to coarsely crystalline in texture.

Most of the limestone is light to dark grey in colour and compact to finely crystalline in texture. At every major outcrop abandoned quarries can be seen. One is still in operation.

The limestone appears to have been mined for road base and lime. At the Havilah outcrops dolomite and limestone were mined for use by H.S.C. Hoskins Ltd. for their ironworks at Lithgow during the period at the turn of the century.

Metropolitan Lime Company also set up kilns and produced lime from the Havilah deposits during the first few decades of this century. All this mining development has now ceased, except for a small operation at the Havilah outcrop. However, there are proposals to mine the Buckaroo limestone for use in the coal mines at Lithgow and Ulan. Whether these proposals are realised remains to be seen.

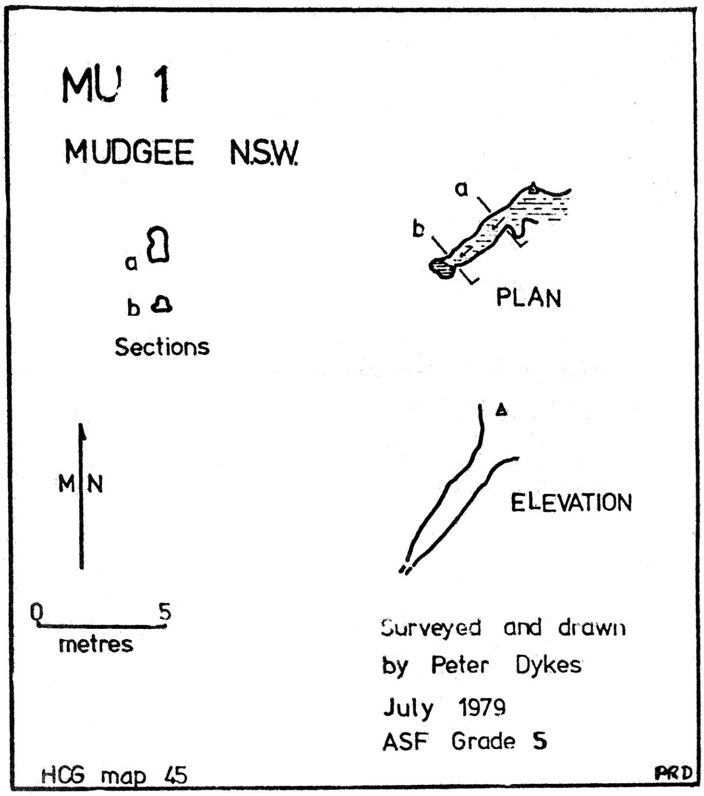
Throughout most of the area, fossils can be found. Although the small exposure where the railway line crosses the Cudgegong River east of Mudgee provides the best examples.

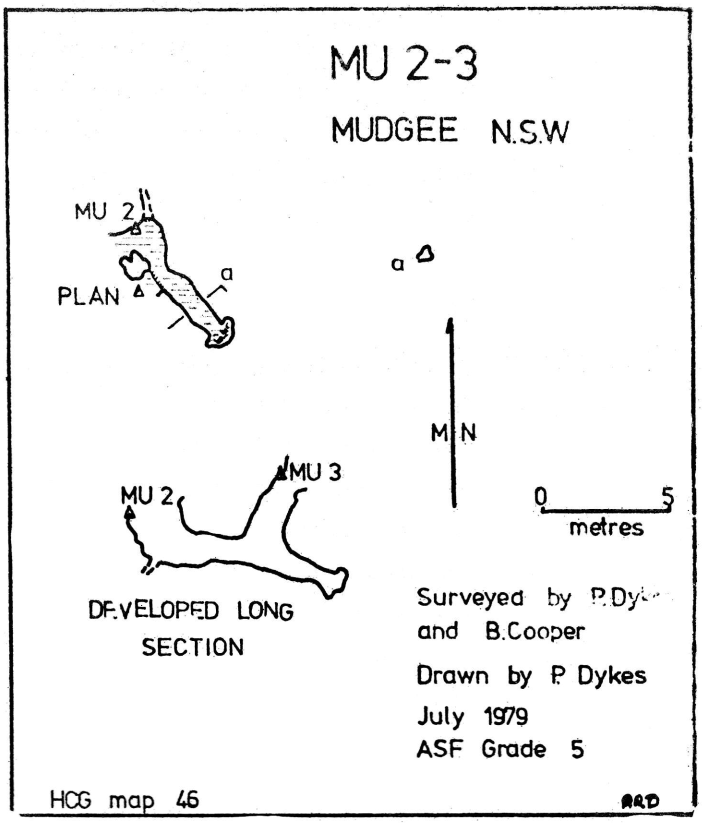
Caves

The following tags have been placed:

Buckaroo Outcrop

MU1. Cave; Located on the western side of the old quarry. Previously referred to by Blayne Pearcey in his report as M.1. Originally observed as a small enclosure with a pool. In July 1979, a cave of 6 metres was entered and surveyed when the water level had dropped considerably (T.R. P. Dykes 14-15/7/79). The cave consisted of a 6 metre passage, a little larger than body size, dropping at an angle of 36° into a small pool. Further entry seemed impassable.

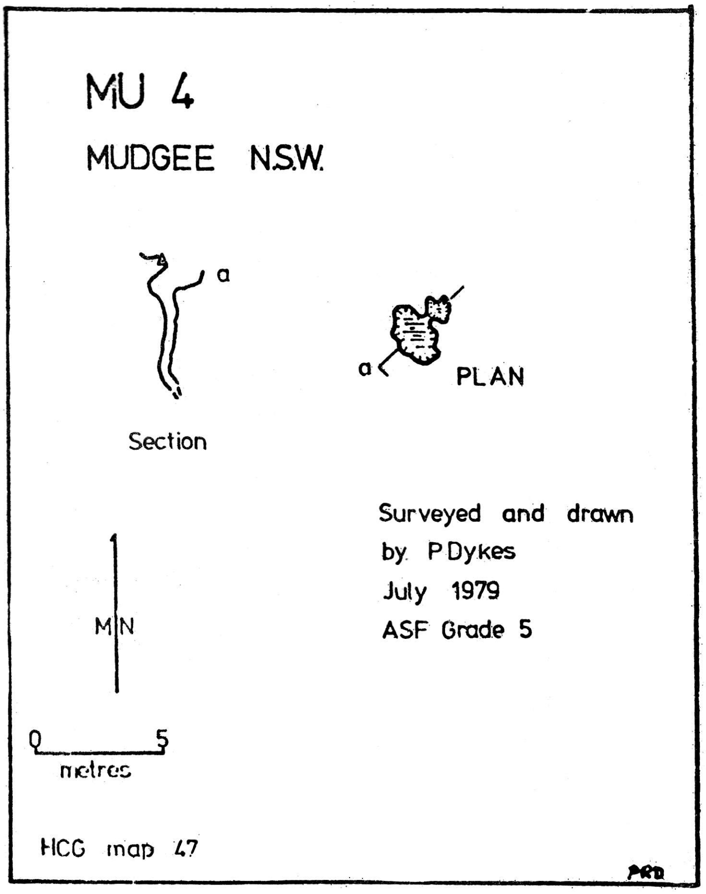




MU.2 Cave: Located on the eastern side of the quarry. Previously referred to by Blayne Pearcey in his report as M.2. The cave drops into a passage about 6 metres long running south. A second entrance is located 2 metres away. It was in this cave that the skeleton of Thylacoleo carnifex was found.

MU.3 Cave; Second entrance to MU.2.

MU.4 Doline/Shaft; Located about 150 metres west of the quarry in the adjoining paddock. The area is covered by native forest and the doline may prove hard to find. The shaft is located on the southern side of a doline 3-4 metres in diameter. The shaft drops 5 metres, ending in a very tight squeeze.



MU.5 Doline/Shaft; Located at the northern edge of the outcrop, near the fence line. Previously referred to by Blayne Pearcey as M.4 and has been named the "Fence Line Hole". Evalt Crabb has stated that the doline was dug out by Newcastle Technical and University College Speleological Society in 1963. It was then reported as a vertical shaft 6 - 8 metres deep (tight squeeze for most of the way) ending with a running stream at the bottom. The entrance has since been covered by chicken wire and on removal in July 1979 was found to have been blasted in (T.R. P. Dykes 14-15/7/79).

NOTE: With the execption of M.9 and M. 10 all other entrances, dolines etc, mentioned by Blayne Pearcey in his report have been blasted beyond recognition. It was not considered necessary to tag M.9 and M.10 as they refer to general areas where sinking and resurging occur in tne creek bed.

Havilah Outcrops:

MU.6 Doline; Locatea about 30 metres west of the track leading up into a narrow valley north of the Lue Road. The doline is on the eastern side at the entrance to the valley. A small gully leads into the doline.

Mt. Frome Outcrops:

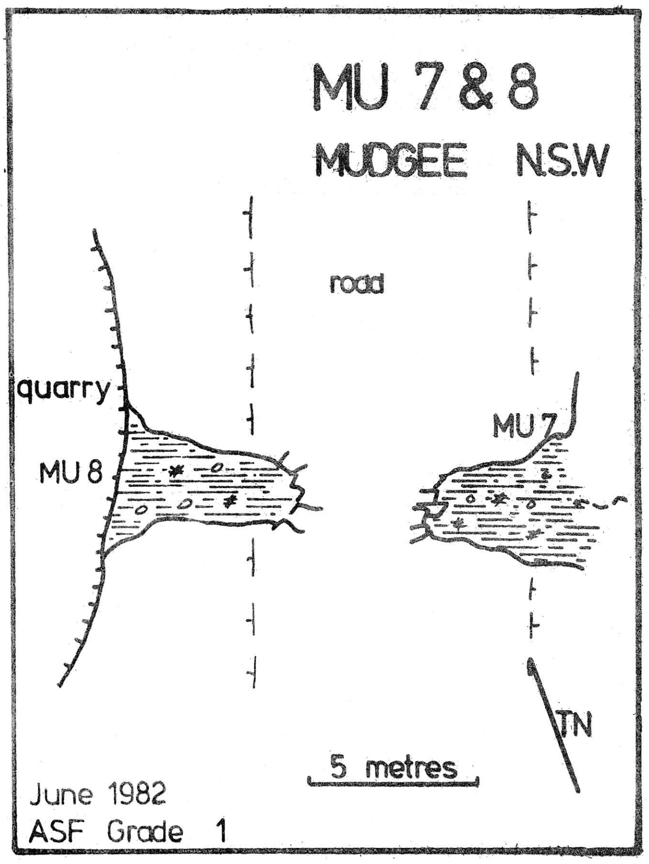
MU.7 Doline/Cave; Located on the eastern side of the road running along the foot of Mt. Frome just before it crosses the Cudgegong River. The cave is silted up and would seem to have run under the road towards a quarry which is now used as a tip.

MU.8 Cave; Located in a quarry, now used as a tip, on the western side of the Mt. Frome Road just before it crosses the Cudgegong River. Appears to be the other entrance to MU.7. The cave has been heavily silted up and has a concrete colvent placed in the entrance as well as a lot of rubbish.

MU.9 Cave; Located in a large quarry at the northern end of the Mt. Frome outcrops. The cave is about 2 metres long by 2 metres high. The cave is in reality a cavity in the wall of the quarry.

Conclusion

Mudgee today offers very little in terms of caves. Much of the surface exposure of limestone has been quarried or blasted. Yet it is doubtful whether in fact there was any cave development in the first place.



Most of the limestone is not massive but intercalated with clayshales and sandstones. Any cave development that may have occurred in the past is more than likely to be silted up. Further, a great deal of the limestone does not show much relief and occurs only in small outcrops or in a series of small outcrops. All this means is that the chances of cave development being found are very slim.

Perhaps only in the palaeontological area is Mudgee worth looking at. This field has not been fully investigated and MU.2 may be worthy of further work.

In conclusion, whilst the limestone, and the caves offer very little, the vineyards are close by, the wine is excellent and the natives tame and hospitable. The area is certainly worth a visit if only to replenish your depleted wine stock.

Acknowledgements

I am in debt to Evalt Crabb who supplied me with much of the historical background to this article as well as being my "guide" to the limestone in the area. Without his assistance and the help of other members of H.C.G. I would never have been able to finish this report.

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Appendix A.

Report on Exploration and Excavation of Limestone in Parish Bumberra (Portions 110,102,113) - County of Phillip - Blayne Pearcey, April, 1964

Introduction

During the past 18 months, the Highland Caving Group has undertaken the excavation of the above outcrop of limestone.

Approximately 6 months of field work was carried out in the area, and the remaining time has been spent in reviewing the results of the above.

The following report, although by no means complete in its conclusion, does offer a reasonable idea as to the characteristics of the area. Further work is necessary in the area and this will be carried out as and when time permits.

History

This area has been popularly known as "Buckaroo", however, although the outcrop is located to the north east of the range of mountains of which Mt. Buckaroo is the main peak, the "Buckaroo" referred to by Carne and Jones in their "Limestone Deposits of N.S.W." is located some 250-300 chains to the south east. Early photographs published by C. & J. do, however, bear a striking resemblance to the outcrop with which we are concerned, therefore it could be that a slight mix-up has occurred here, or possibly that this area was also known as "Buckaroo".

The presence of limestone was first noted here over 100 years ago. Following this discovery, iime was burnt for some time, a total of approximately 100 tons being removed. The area was also mined for pipe-clay, silica and talc, and this is still carried out occasionally by amateurs.

From a very early stage, it was reported that there were caves in this block of limestone and several reports have been found, giving an overall impression that far greater romanticism exists than truth. Some of the more exciting ones give details of how farmers have lost implements to the dark abyss of the underground and how the cave entrances were finally filled in at great expense by an owner who feared that his children might become lost in the long passages.

Apart from some previous excavation by the Newcastle Technical and University College Speleo Society, the area was virtually untouched by speleos. It is understood that certain other groups had visited the region, but from local reports, itappears that they had shown little interest in the region. It was however, battle-scarred from the previous attempts to quarry the limestone.

Description

This area is located approximately 4½ miles N.E. of Mudgee (6 miles via the Cooyal Road) on private property owned originally by Mrs. M. Archer to whom the Group is indebeted for allowing entry into the region. The limestone extends in a N.W. direction for a distance of 50 chains in a series of disconnected outcrops, approximately 6 chains wide. The limestone occurs as massive beds intercalated with clayshales. A great deal of overburden, quite often interspersed with pipe-clay is present.

The limestone is predominantly grey in colour but variations of from light red to pink have also been noted. The texture ranges from compact to finely crystalline.

The limestone is of Silurean origin, and is nearly vertical in bedding. A definite strike occurs along a bearing of 85^{o} and it is along this that most of the surface activity appears. The dip is not determinable.

The surface of the main outcrop is

riddled with holes ranging in size from 3" up to 18". Most of these have been filled up, either by siltation of by property owners. The area is also rich in fossils not all of marine origin.

The area nestles at the foot of a low range of mountains up to 2000' above sea level. This range is approximately 400 yards to the south of the outcrop. A small creek (non perrennial) rises in these mountains, and this is the only visible surface drainage feature of the area. This travels approximately 1500' along the plain before soaking into the ground, depending on the amount of rainfall at one of several gravel filled hollows.

This water has been traced and reappears at two places. One of these is "M1", a spring which was blasted open prior to our arrival in the area. As a result of this blasting, M1 now empties into the basin of the quarry. The other is what is now considered to be the main efflux of the system, M9, which is situated about ½ mile away to the north.

It can be seen that the catchment area is quite large for such an apparently small surface area of limestone, and it is therefore to be expected that a considerable flow of water would be noted from these effluxes. Such is not the case. Rather, it would appear that there is a time lapse between the water disappearing at the insurgence, and its reappearance at the resurgence. This time lapse is in the order of a week or so, depending on the amount of rain which has previously fallen.

There are numerous other outcrops in the area, some of which, such as Mt. Frome are at present being worked commercially. All of these outcrops are of the same age as this one.

The limestone in the area is of very high quality. The following are from assay charts for two samples in the area covered by this report:

Calcium Carbonate	96.92	96.75
Magnesium Carbonate	2.59	2.08
Manganese Carbonate	....	0.02
Ferric Oxide & Alumina	0.36	0.26
Phosphoric Anhydride	0.05	....
Gangue	0.31	1.00
Organic Matter	....	trace
Moisture (H_2O)	....	....
Total	100.23	100.11

Although nothing has been done in our survey to ascertain the depth of the limestone in this area, local reports state that depths of 500 to 650 feet of limestone have been commonly encountered in the process of drilling for water in this area. Reports also state that the water which has been struck has been always at the base of the limestone block.

Discussion

From the foregoing it would seem feasible to state that the likelihood of there being caves in this area is very remote. For a start it would seem reasonable to think that water would be struck in the limestone block itself when drilling. Instead the water which has been found appears to be of artesian origin being held under the limestone block in the clay base soil.

However, caves, or rather positive indications of the existence of caves have been encountered, therefore it is necessary to consider further the peculiarities of this region. In many respects the region resembles the Dip Cave region of Wee Jasper. With this line of reasoning, it does not seem unreasonable to think that such activity which has taken place could have been due entirely to the percolation of water below the surface rather than as a result of water being fed in from the surface.

Examination of the area shows that the activity which has taken place, however, has been either slow over an extremely long time, or very severe over a short period of time. This is shown by the extensive fluting by water action in some shafts. However, in view of the fact that the rainfall in this area is at present and has in the past several thousand years at least, been only in the order of 25-25 inches per annum, it seems rather hard to explain either of the above theories.

We must, therefore hypothesise that the activity which has occurred is of a very ancient origin and therefore, presuming that it stopped when the rainfall or water available for the action ceased, there would be no likelihood of finding anything of value for tourism.

Nature might, however, be very kind and provide an extensive underground water system, although, if we wish to retain our thinking within bounds of reality, we must almost entirely discount this possibility. Nevertheless, it seems only reasonable that we must at least acknowledge that such a system did exist in the past, otherwise we would not have the extensive activity that is apparent today.

Outline of Work Undertaken

In view of the fact that there was no apparent entrances to any caves in this area, it was decided that considerable excavation should be undertaken. Excavation was first commenced at the entrance known as M.2. This was the point at which N.T.U.C.S.S. had previously attempted to gain entry. The line of digging chosen by H.C.G. was in a different direction to that of N.T.U.C.S.S., the main reason being that it was impractical to continue digging in the same place due to rock and water. Approximately 30 cubic yards of soil and debris were removed and a total of 220 man hours were expended in doing this work.

As a protection against the work at M.2 proving to be unsuccessful, work was undertaken at another point, M.3. Work was also started at M.6 and M.5, M.7 and M.8.

Surface blastering was used in an attempt to move away unwanted material at M.3 and M.6. This operation was successful at M.3, but not of any value at M.6 due to the rock being too thick.

A programme of mapping was also undertaken and this proved to be of benefit in the training of personnel in the techniques used in surface mapping.

Much of the work undertaken was interrupted by inclement weather which resulted in the complete programme of work as originally planned being altered to allow it to fit in with the available time.

As it was though, that M.1 may have a syphon at the end of the water passage 300 gallons of water was emptied from it. This gallant effort proved to be unsuccessful, but it did prove that the spring refills very quickly, and that the floor is heavily silted.

NTUCSS also specialised in working at their "Fence - Line Hole" or our M.4. As far as is known, they have stopped working here.

Results of Work Undertaken

The work which was commenced at M.2 was halted due to lack of time, and also as there appeared to be a better chance of success at M.3. However, before doing this, a depth of approximately 10 feet had been reached and the digging had commenced to throw out some of the original cave silt, it being easily recognisable as it differed in colour from the other debris and soil. At the final stages of the digging here, it was found that we were now in a narrow pipe, which had a small stream of water flowing through it.

M.3 proved to be much more difficult to excavate, once the easier top soil had been removed. The digging revealed a well worn water fluting surrounding the entrance. Work was halted, however, by a solid bridge of rock across the small passage in which the party was digging, temporarily until blasting was available. With local assistance so readily given by the Mudgee and District Development Association, the blasting was accomplished very efficiently. Unfortunately the party had to return to Sydney before any clearing of the blasting rubble could be done. Because of this, it was about a month before the full results of the work in this spot were known. On the 11th August 1963, a member of H.C.G. was successful in gaining partial entry into the system through M.3. It was found that the system in this place was filled to a considerable depth with water. No further exploration could be obtained due to the conditions of the passage.

M.4 was worked mainly by NTUCSS and full results of the work in this area are not known. It appears, however, that a certain amount of success should be enjoyed, as although there is no visible limestone on the surface here, the region has a remarkable affinity to the Wee Jasper region, in particular around the Dip Cave. As it is known that the limestone in the Buckaroo region extends underground for at least 5 miles to the north, and indefinitely to the south, there is a good chance of success in gaining entry at this point.

M.5 received only minor attention, but as it was considered that a major blast would be needed to remove the rock from around a small pipe, and as this was not considered desirable, little progress was made in this region. M.6 was also very much in this same position, but as they are both very close together to the first point of entry, it is considered that at the best, they would also lead into the same water filled cavern.

M.7 was discovered by the property owner and the author during the latter's holiday visit on 11th August 1963. It was then recognised as being the hole down which the legendary farm implements were lost. Minor excavation of the thin fluted rock surrounding the hole revealed that the pipe led down to water also, and that it was a much more suitable hole with which to gain possible tourist entry to the system. M.8 was found nearby (see Fig.1) and this is a very large pipe, being 18" in diameter. As it was filled with debris. and as time was short, it was decided that nothing could be done at this stage to remove the debris and open it up. It is reasonably definite that this hole extends down to the same water encountered at M.7, as some plants were pulled out of the soft soil whose roots were very wet.

The main efflux, M.9 was visited by the author and found to be quite a surprising feature. There is no visible limestone, although it is known that limestone exists approximately 6 feet below the surface, and the only surface rock is a common sandstone. It is not thought that any benefit would be derived from excavation here, as it is more than likely that this is also a pressure spring, similar to M.1

An interesting discovery in M.2 was a skeleton. This was located in the roof of the first chamber. It has been suggested that the skeleton may be that of the extinct Australian marsupial Thylacoleo carnifex. Positive identification however, is still forthcoming. An illustration appears at Plate 1.

Conclusions

As most of the work done in this area was not only to try and locate supposed caves, but also to locate caves which might have had some tourist benefit, much of the work was aimed at not necessarily finding the best trog-like entry, but the best tourist type entry, or possible entrance. Although this did not hamper the work carried out, it did limit to a considerable extent the scope of the work which could be carried out.

As a result, most of the points which were excavated were in the visible and known limestone outcrop or in the vicinity of the outcrop, rather than in theorectically feasible soil covered areas adjacent. As it is known that limestone extends in depth down to 600 feet in places, the above reasoning should not be taken as being disappointing.

Due also to the conglomerate nature of the surrounding soil, one line of thought which gained reasonable following was that the region might be too close to the actual edge of the limestone belt to have allowed recent, extensive and plentiful activity to have taken place. A similar line of thought also theorised that the limestone block may have very little activity due to the low rainfall of this area for the past few thousand years, and that any activity which had taken place would be so ancient as to have been naturally destroyed. Certainly there are several signs on the surface, such as the accumulation of breccia, which tends to lend weight to this speculation.

The main conclusion, therefore, was that in this particular region, no worthwhile tourist-like caves would be found, although the possibility of finding good caves was not altogether non-existent. It is thought that any caves which would be found here would require such extensive modification as to be inhibitive, financially to tourist development.

In view of the fact that there are other known caves in the region as well as a lot of unexplored limestone, it is recommended that these areas be investigated in the first instance before much further work is put into this region.

Table of Areas Investigated at Buckaroo.

The holes which have been investigated and which may show some promise are listed below. Appendix "B" (Fig.1) should be consulted in conjunction with this table to ascertain the position of these datum points.

M.1 Efflux - blasted.

M.2 Possible entrance. Now excavated to a depth of 10 feet.

M.3 An actual entrance via tight muddy squeeze. Shows some promise as the only feasible place through which tourists could enter. Blasting carried out here was successful.

M.4 NTUCSS's "Fence Line Hole".

M.5 Another possible entrance in the same line as M.3 and situated in a likely sink.

M.6 Was blasted. Thought to be a point of entry, but does not look likely.

M.7 2nd point of entry. Needs blasting or further excavation. Looks to be similar pattern to M.3, so could also respond to blasting.

M.8 Close to M.7 Looks to be the logical

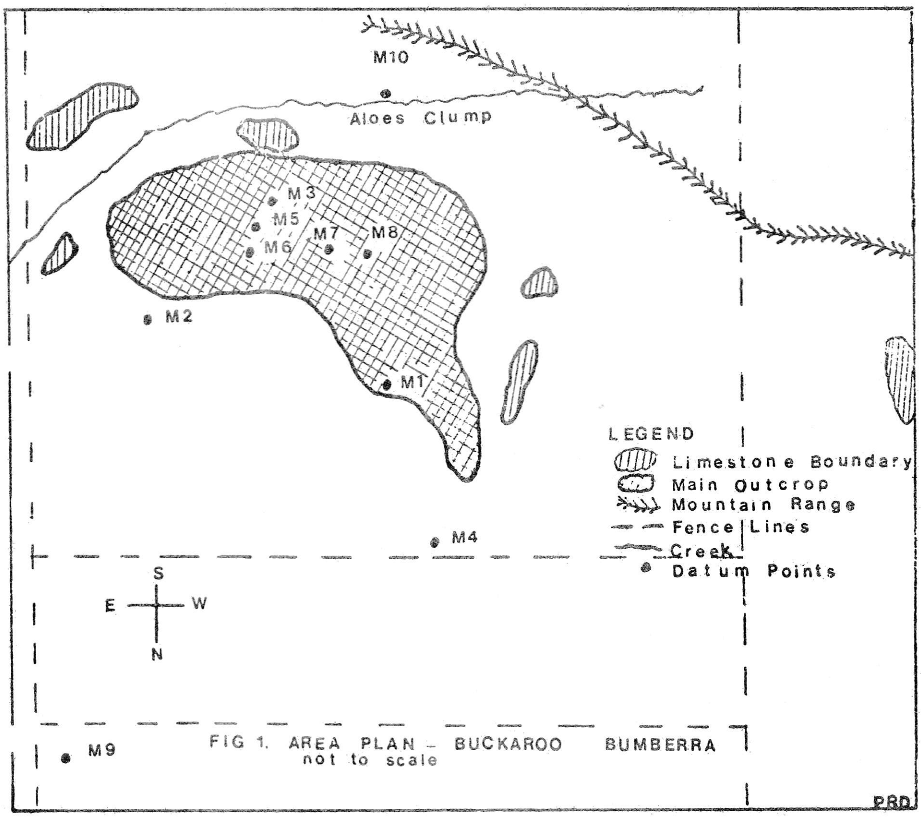

FIG 1. AREA PLAN - BUCKAROO BUMBERRA
not to scale

B. PEARCEY

straight through entrance to the system and it could be if it were possible to easy clear debris out. This is a straight down swallet.

M.9 This is apparently the main efflux to the system, situated approx. 3/4 mile to the south of the system.

M.10 This appears to be the main influx to the system located near an aloes clump.

M.11 Another efflux located about 200 yards to the north of M.9. It is not known whether or not this serves the same system, but it is worthy of consideration if further work is done in this area.

References:

Carne, J.E. & Jones, L.F. The Limestone Deposits of N.S.W. 1919 Mineral Resources Series No. 25 N.S.W. Dept. of Mines, Syd p.p. 304-307.

Appendix "B"

Abstract of Notes on Mudgee Limestone from the "Limestone Deposits of New South Wales" 1919 Mineral Resources Series No. 25. N.S.W. Dept. of Mines. Sydney. By J.E. Carne & L.J. Jones.

Abstractor - Peter Dykes.

County - Phillip
Parish - Boogledie
Portions 54 & 134 p.p. 304

Situated about 7 miles east of Mudgee and 1 3/4 miles north of Wall's Siding on the Mudgee - Sydney Railway.

Deposit of dolomite with some limestone, on the same line of strike as the beds at the Havilah Quarry. Total length of the exposure 25 chains with a width averaging 2-3 chains.

Strike N.45°W dip not determinable, but associated clay-shales and quartizites dip W.45°S. at 43 degrees.

Outcrop not very prominent, rarely projecting above general surface level. It is currently being worked for B.H.P. Steel Works at Newcastle.

Parish - Bumberra
Portions 110, 102 & 113 p.p. 304

Situated 4½ miles north west of Mudgee.

Exposure about 50 chains long by 6 chains wide starting in portion 110 and ending in portion 113. Limestone occurs in massive beds intercalated with clayshales and in places a good deal of overburden is present. A few small quarries are open and the stone is occasionally burnt for lime.

Portion 58 p.p. 305

Situated 2½ miles east of Mudgee

Limestone located on northern bank of the Cudgegong River on either side of the railway line. The outcrop is small and contains numerous fossils, chiefly corals.

Portion 83 p.p. 306

Limestone reported close to the Cudgegong River about 1 3/4 miles south-east of the Murra Railway Station.

Portions 52,73,51,50,49,48,70 & 57

Portion 54 Parish - Derale p.p. 305

"Mt. Frome"

Situated 4 to 5 miles east-south-east of Mudgee.

Numerous outcrops of limestone occur on the southern and south-western slopes of Mt. Frome and extend south to within a few chains of the Cudgegong River. These beds probably represent the northerly extension of the Queens Pinch Belt.

Strike N.20°W. dip 20°S at 48 degrees.

The limestone occurs in fairly massive beds intercalated with clayshales and fine-grained sandstones. The outcrops are not prominent, the limestone rarely projects above the general surface level.

Parish - Derale

Portion 58 p.p. 306

"Havilah"

Situated about 9 miles east of Mudgee.

Quarry operations have revealed a belt of limestone with intercalated dolomitic beds 6½ chains wide striking N.50°W., and dipping vertically.

The dolomite occurs as irregularly defined beds, lenticular in shape, with one prominent bed of up to 60 feet in thickness. Owing to the nature of the beds, it is impossible to say how far these beds extend. The quarry workings show that some of the dolomitic beds thin and finally pinch out, but the outcrop on the northern side of the road would seem to indicate that lenticular beds might be expected throughout the entire length of the deposits. The limestone is typically light grey to whitish in colour and compact to finely crystalline in texture. The dolomite is dark-blue grey in colour, with brownish streaks and is fine to coursely crystalline in texture.

The deposit has been mined for limestone and dolomite by G.&.C. Hoskins Ltd. for their ironworks at Lithgow.

Limekilns, built on the principle of brick kilns, have recently been erected and lime is now being produced by the Metropolitan Lime Company.

On the south side of Lawsons Creek 14 chains west of the Havilah quarry is a small exposure of magnesian limestone.

About 1 mile north of the Havilah quarry near the north-west corner of portion 58, three small outcrops of limestone occur on the southern slope of a high ridge. The stone is white and pink in colour, compact in texture.

Portions 52,39,44 & 37
Portion 152 Parish - Boogledie p.p. 307

"Buckaroo"

Situated about 7 miles east of Mudgee and 1 mile north of the Sydney-Mudgee Railway Line.

Limestone associated with altered clayshales and tuffaceous sandstones outcrop on the eastern slope of a high ridge close to Buckaroo Road, in portion 37. The outcrop can be traced more or less continuously in a northwesterly direction through portions 52, 39 & 44 Parish of Derale and terminates in portion 152 Parish Boogledie - a total length of 85 chains.

Associated with the limestone are a number of intercalated lenticular beds of dolomite.

The limestone is grey, light to dark in colour, compact to finely crystalline in texture. The dolomite is generally darker in colour than the limestone and characterised by brownish streaks and spots, the texture is finely crystalline.

Twelve chains east of the main belt in the north-east corner of portion 152 is a small exposure of limestone 3 chains long by 1½ chains wide.

Parish - Burundury
Reserve 29 & 187 p.p. 309

Situated about 8½ miles north-north-east of Mudgee.

Small outcrop of limestone occurs on reserves 29 and 187 close to the Cassilis Road. Two small exposures, on the same line of strike, 7½ chains apart. The limestone is grey to dirty white in colour and coarsely crystalline in texture. Thin dolomite beds occur.

Parish - Munna
Portions 6 & 7 p.p. 338

Situated about 4 miles north-west of Mudgee.

Limestone outcrops on a prominent ridge about 25 chains east of the Cullenbone Road, near the eastern boundary of portion 7 and extends N.45^{o}W. for a distance of 5 chains.

The limestone is dark blue grey in colour with veins of white calcite. Texture is finely crystalline.