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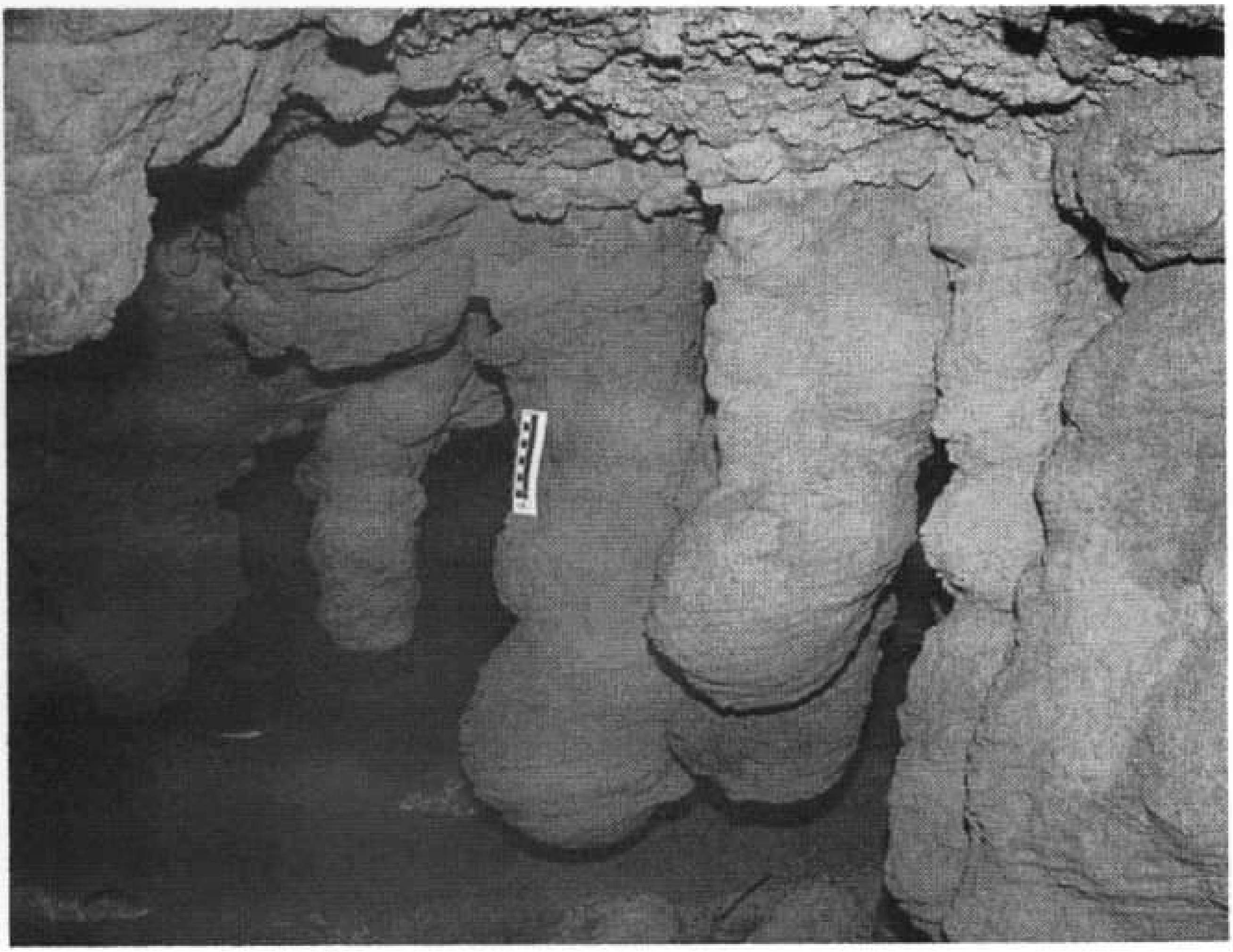
Helictite

Journal of Australasian Speleological Research



K.G. Grimes

Sand Speleothems, Loch Ard Gorge

Helictite

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Helictite was founded by Edward A. Lane and Aola M. Richards in 1962. It is intended to be wide ranging in scope from the scientific study of caves and their contents, to the history of caves and cave areas and the technical aspects of cave study and exploration. The territory covered is Australasia – Australia, New Zealand, the near Pacific Islands, Papua New Guinea and surrounding areas, Indonesia and Borneo.

In 1974 the Speleological Research Council Limited agreed to support the Journal with financial assistance and in 1976 took over full responsibility for its production. From 1974 to 1997 the Journal was edited by Julia James assisted by other members of the Speleological Research Council Ltd. In 1988 the Speleological Research Council Ltd became the Speleological Research Council Inc.

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Journal of Australasian Speleological research

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Cover: Sand speleothems in The Alcove, Loch Ard Gorge. Photo by K. G. Grimes.

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This issue is published in August, 1999.

Editorial

Ken Grimes and Susan White.

New faces in 1999:
Commencing with volume 36, *Helictite* has a new editorial team, based in Victoria, comprising Susan White and Ken Grimes as joint editors and Glenn Baddeley as business manager. Ownership remains with the Speleological Research Council. Helictite was founded by Edward A. Lane and Aola M. Richards in 1962. In 1974 the Speleological Research Council Limited agreed to support the journal with financial assistance and in 1976 took over full responsibility for its production. Production since then has been by a Sydney based team headed by Julia James to whom we extend our thanks for 22 years of quality work.

Editorial Policy:
The new brooms will not sweep overly clean, but you will note some progressive changes in style and content. Our editorial policy is to continue with the current format of mid-length refereed scientific and technical papers, but with the addition of short notes, theses abstracts, book and article reviews and a regular "News and Views" section. We also hope to expand the "Asian" part of "Australasian" by seeking papers from south-east Asia, and the Pacific in general. We hope that *Helictite* will continue to be a vehicle of encouragement for publication of speleological work in the Australasian region.

Staring with the next issue, we will no longer be associating volume numbers with sequential years. Each future issue will carry the actual publication year.

All papers will be sent to at least one outside referee. In the case of a paper authored by one of the editors, as in this issue, we will use two outside referees to avoid any charges of bias.

Wanted:

- Local representatives in each Australian state and other countries, to promote Helictite locally and to assist in soliciting articles. Also people in major institutions who are prepared to send summaries of research in progress and other items for the "News and Views" section.
- Volunteers to join the editorial and production team.
- Authors! Cavers should not be shy. Look through our back issues, there have been many authors who were "informed speleologists" rather than professional scientists. We want to encourage people to write up their speleological work in a form accessible to the scientific community. If you are not associated with a major institution, we can assist with drafting of figures and formatting of photos and are happy to make preliminary comments on proposals for papers. See the Information for Contributors given inside the back cover.

J. Rowling, 1998, Ribbon Helictites: A New Category. *Helictite* **36** (1), 2-10.

Ribbon Helictites: A New Category

Jill Rowling

Abstract

This paper describes the size, shape, abundance and location of ribbon helictites and proposes possible growth mechanisms for them. SEM photographs of the surface of one ribbon helictite have shown an unusual crystal form for a calcite speleothem, together with apparent etching and pitting of surfaces. These surfaces exhibit some features found in organically deposited calcite. Further optical work has revealed that the stem of ribbon helictites is composed of a twinned pair of crystal aggregates, with the stem's central canal lying in this twin plane. The ribbon also appears to exhibit twinning. Oval features on the ribbon's surface appear to be twinned aggregates, originating from the ribbon's central canal.

It is proposed that ribbon helictites form by two growth stages: development of the stem and then a ribbon, with influences from acidic solutions. Overall shape is strongly controlled by crystal habit.

Keywords: helictite, calcite, twinning, Jenolan, lublinite.

Introduction

Helictites are classified by Hill & Forti (1997) into four basic categories: filiform (thread-like), beaded (anemone-like), vermiform (worm-like) or antler (twig or rod-like). This paper describes a fifth form which is ribbon-like. It occurs at Jenolan Caves, Australia.

Jenolan Caves lie to the west of Sydney in the Blue Mountains (see Figure 1) in a band of massive dark Silurian limestone. Over 300 cave entrances have been recorded, the largest and most significant of which are in the tourist complex. The caves are horizontally developed with multiple levels. The lowest levels contain small streams and the upper levels are typically large, well-decorated chambers. Sediments in the caves are mostly partially cemented ancient stream gravels comprising quartz porphyry and shales.

In upper level areas of the tourist caves some of these sediments appear to have reacted with the limestone bedrock, resulting in unusual calcite crystal coatings. Whilst making a list of interesting speleothems at Jenolan Caves in 1994, I noticed unusual helictites in Jubilee Cave and Orient Cave and called them "ribbon helictites" on account of their flattened ribbon-like appearance as shown in Figure 2. Samples were taken from already broken pieces near an area of the Jubilee Cave called "The Pincushion". Tests showed that the material was calcite (not aragonite) with 0.5 % Fe in the tested sample (Rowling, 1997). Further work on these enigmatic speleothems has included SEM photographs of the surface of a ribbon helictite. This highlighted the similarity between the crystallites of ribbon helictites and some of those published for lublinite (a variety of calcite often associated with moonmilk, eg Moore and Sullivan (1997), also called needle-form calcite). Twinned crystal aggregates appear to be a common feature, with both the stem and the ribbon exhibiting crystal twinning.

This paper examines ribbon helictite structure, as a guided tour. It starts with the stem, pointing out features

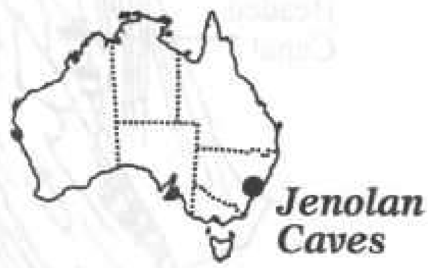

Figure 1

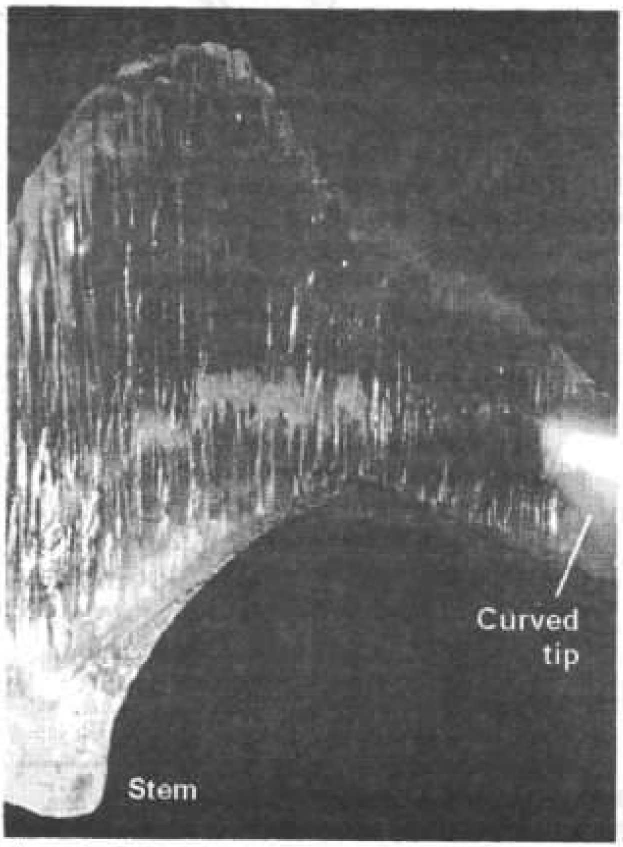

Figure 2. A ribbon helictite from Jubilee Cave, Jenolan Caves. Size is about 7 mm x 7 mm. The broken stem is to the left of the picture and the tip is curled to the front right.

along the way to the tip. Fine details are described, then the paper concludes with a discussion of their formation.

Description & Characteristics of Ribbon Helictites

General Description

Ribbon helictites are typically about 20 mm long, 5 mm wide and about 1 mm thick. They appear to grow from a fairly straight stem (like a miniature flagpole) and are made of calcite bundles which have a pronounced elongation of the calcite c [0001] axis. Like other helictite forms, ribbon helictites have a small central canal and appear to grow by capillary action. Unlike other helictite forms, ribbon helictites' calcite c axes are aligned parallel to each other, rather than evenly radial to the central canal. This results in the flattened appearance. They are usually white or clear, although grey, brown and yellow ones have been seen. Some blackened and inactive ones have been seen in Jubilee Cave, however it is unknown as to whether they are coated with soot or whether they grew that colour.

Although ribbon helictites are not particularly common, even in the Jubilee Cave, they are locally abundant. Jubilee Cave has about 50 well-formed examples, usually on the wall but also on roofs composed of infill. The substrate is usually partially cemented ancient stream gravels. Where ribbon helictites occur, vermiform, filiform and antler helictites were often found nearby.

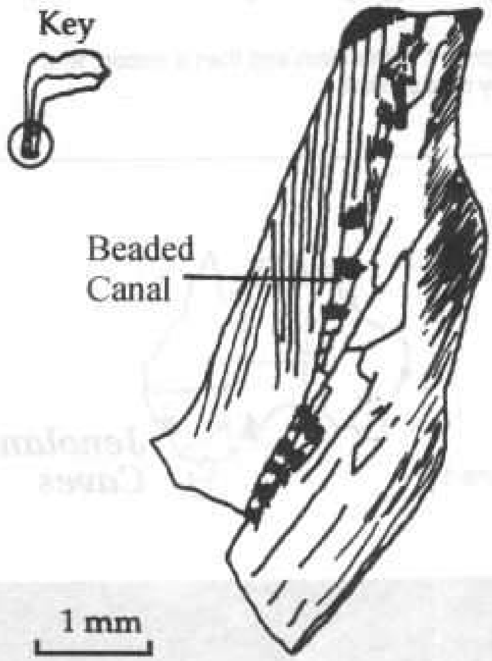

Figure 3. Part of a broken stem. Key shows location (circled) on a typical ribbon helictite. The beaded canal lies inside the stem and striations shown are crystal boundaries on the surface.

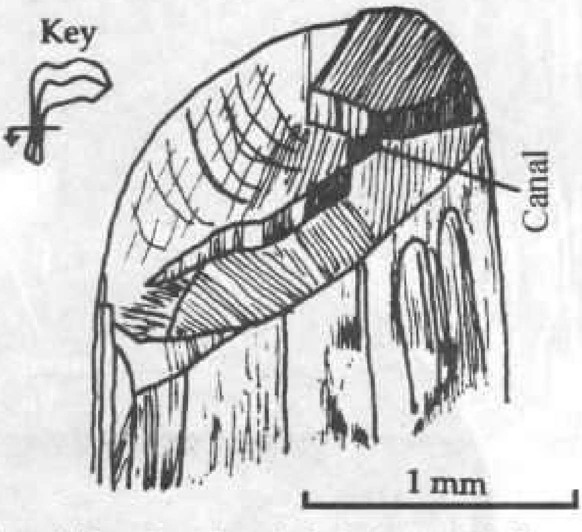

Figure 4. View down the end of a broken stem. In this sample, three crystal aggregates form columns with the central canal (arrowed) in the middle of them. There are apparently two halves to the stem with the change in cleavage defining the boundary.

Stem Details

Some helictites have a smooth transition from surface coating to stem however often the stems are engulfed in surface coatings so as to be obscured. Figures 3 and 4 show two views of a broken section of stem. The habit of the crystals making up the stem's surface seem to be a combination of sheaf-like layers and a "fence paling" type (discussed later). The stem's central canal is irregular in cross section and lies in what appears to be a crystal twin plane. It is beaded (as shown in Figure 3). This beading occurs primarily in the supposed twin plane and is visible when looking perpendicular to the plane. There are also fine hairlike tubes (canalicules) running parallel to the central canal, but in the bulk of the stem (not just the twin plane). These are also a feature of the ribbon, described below.

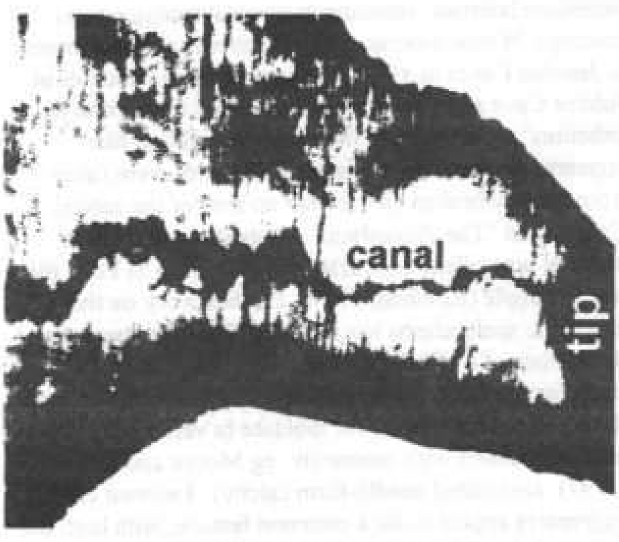

Figure 5. The same helictite as Figure 2 using transmitted light. The central canal is visible as a darker line.

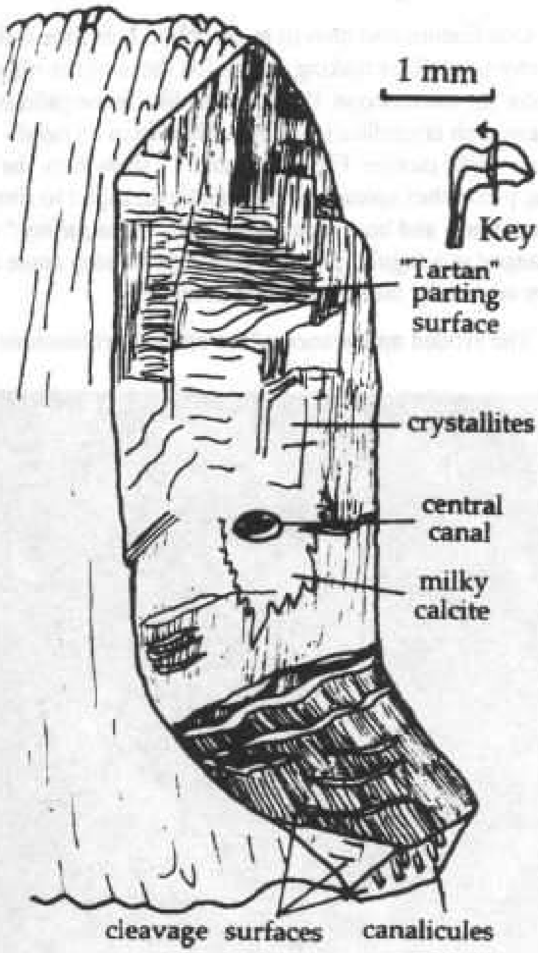

Figure 6. Broken surface of a ribbon. Characteristic of ribbon helictites are the elongated, roughly hexagonal cross section of the ribbon and the "tartan" parting surface texture.

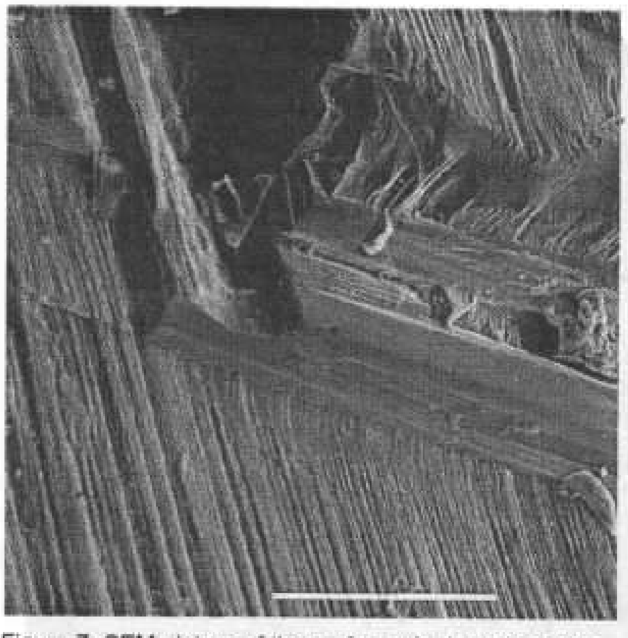

Figure 7. SEM picture of the surface of a broken ribbon showing the "tartan" parting surface texture in more detail. Parting of crystallites alternates with perfect cleavage of thin layers of calcite. Scale bar is 100 µm. Electron illumination is from the right.

The Ribbon

The ribbon forms the main part of the helictite and can vary in length from about 5 mm up to about 120 mm, however its width (about 5 mm) and thickness (about 1 mm) are relatively constant over the entire length. Figure 2 shows the general shape of the ribbon with the central canal appearing as a lighter streak.

In general, the lower edge of the ribbon which curves from the stem exhibits flat crystal terminations giving a smooth surface. Some specimens have laminations along this edge. The upper edge and edges furthest from the stem usually have well-developed crystal terminations.

The Ribbon's Central Canal

Figure 5 shows a transmitted-light view of the same sample as shown in Figure 2, with the central canal appearing as a dark line. The canal is approximately in the centre of the ribbon, with a tendency to be closer to the outside of bends. Unlike the stem's central canal, it has a roughly circular cross section, about 0.3 mm diameter, with a milky coloured calcite surround. This milky calcite has a drusy appearance in some broken samples. The ribbon's central canal also exhibits beading at right angles to its growth as shown in Figure 5 and 13. Beading appears to be associated with crystallite boundaries and often appears spiky as a consequence. Along the main part of the ribbon, the diameter of the central canal is much greater in the middle than at either the tip or the stem.

Cross Section of the Ribbon

Figure 6 shows a sketch of a broken ribbon. Ribbon cross sections are approximately hexagonal but elongated in the calcite c axis direction, though, occasionally they can be trapezoidal. Canalicules can be seen in this view, towards the bottom edge. Of the sample helictites, half had broken ribbons. This broken surface was similar in each case, having a parting surface at right angles to the ribbon and a calcite cleavage surface. Parts of the ribbon are more firmly cemented (cleavage surface) than other parts (parting surface). Figure 7 is a SEM photograph of detail from the parting surface of a broken ribbon, showing a "tartan pattern" which results from a combination of parting along loosely-cemented crystallite boundaries and conventional calcite cleavage of fine layers of calcite (perpendicular to the crystallites). Figure 7 also shows a long crystallite which may have a hole continuing under the material to the right.

Growing Point (Tip)

The general shape of the tip of a ribbon helictite is a tapering structure. Some specimens taper gradually (like conventional vermiform helictites) and others are more chisel-shaped as shown in Figure 8. At the tip, the calcite crystallites are narrower and appear needle-like in shape. Their relatively wide spacing suggests that this structure is porous. The needles are aligned in one direction which

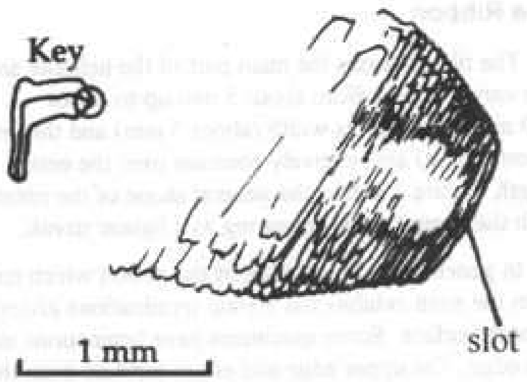

Figure 8. Tip of a ribbon helictite. The central canal is the lighter area just before the tip, although the hole does not appear at the surface. The tip may have a slot as shown (arrow). Crystals near the tip are poorly cemented and very fine, needle form, whereas further away the crystals are larger.

is not the radial orientation one might expect from crystals growing at the tip of a capillary tube. The hole at the tip is not usually visible.

Crystal Forms.

Figure 9 is a SEM picture showing typical pseudo-hexagonal crystals near the edge of a ribbon, looking down the c axis. Only the m {1010} faces (long sides) on these crystals are well developed and the other faces are relatively poorly defined with pits and holes visible. The crystals are irregular hexagonal prisms, flattened in one direction. They appear to be intergrown. This sample was found sitting loosely on a pile of old bat guano, so has probably been etched. Samples which were found fallen onto gravel showed shiny crystal terminations. Other crystal forms include wedge-shaped terminations and chisel-shaped terminations on fairly flat laths.

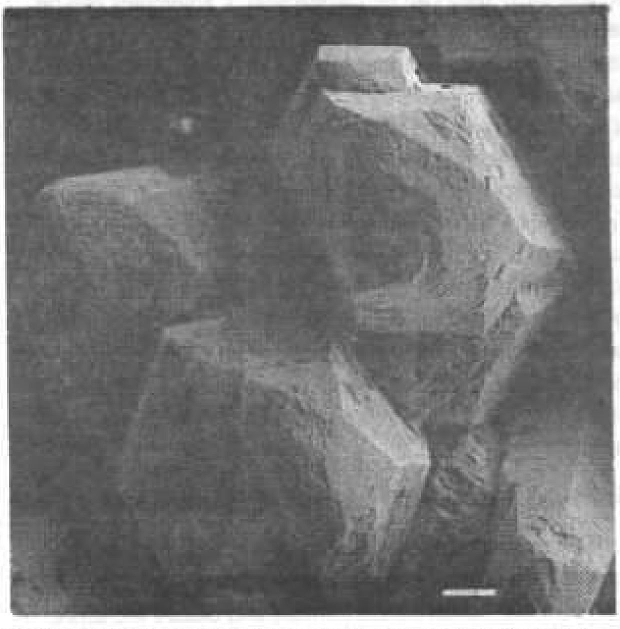

Figure 9. SEM picture of a group of pseudohexagonal columnar crystals near the edge of a ribbon. The ends are pitted and the faces poorly defined whereas the sides are well developed. The columns appear to be split. Scale bar is 100 µm.

"Fence Paling" Sides

One feature common to most ribbon helictites is the blocky crystallites making up the flat faces of the ribbon. Under the microscope, these appear like fence palings, where each crystallite is slightly offset from its neighbour. SEM picture, Figures 10 and 11 show how the long pseudohexagonal crystals can be arranged to form this pattern, and how it can vary. The "fence palings" are arranged in a regular pattern, although the step angle can vary across the face of a ribbon helictite.

The eroded appearance of the crystal terminations

Figure 10. SEM picture of part of a ribbon showing the "fence paling" crystallites and their diagonal surface texture. Scale bar is 100 µm.

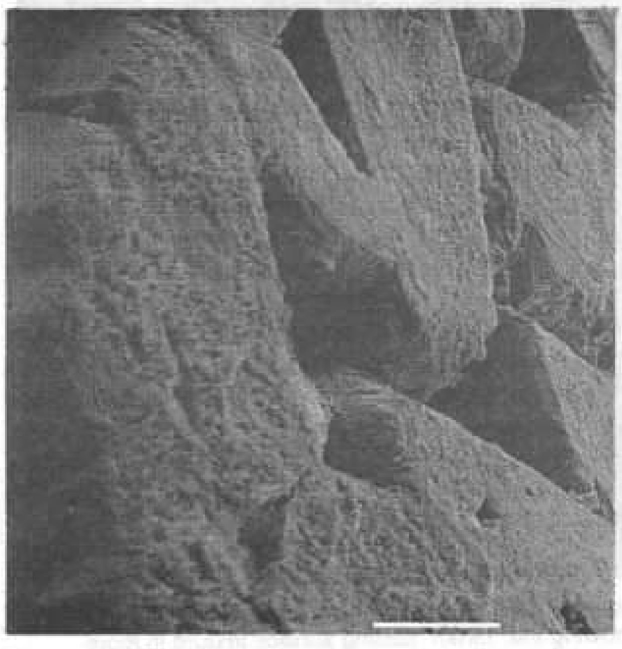

Figure 11. SEM picture of an area near the lower edge of a ribbon, showing the ends of flattened hexagonal crystallites arranged to form canalicules and "fence paling" sides. Scale bar is 100 µm.

could be an artefact of the guano deposit. It is difficult to determine whether the flat terminations are a growth feature or an etch feature; perhaps both mechanisms are at work here. The gaps between the crystallites are most likely the short, light flecks and tubes (canalicules) seen under the optical microscope on cleavage areas of broken ribbons. They would be able to conduct water, however it has not been proven that they connect with the central canal. The overall structure presumably leaks water out of both the tip and these canalicules. This would explain why in Jubilee Cave, the entire surface of ribbon helictites has been observed to be wet due to seepage of water through the helictite.

Figure 12 shows more detail of one crystallite with diagonal lines which can be seen on the crystallite sides. They sometimes occur on only one side of a ribbon and are not visible on the other side. They are at about 90° to the cleavage plane of broken samples. These are similar to a feature of the lublinite variety of calcite (discussed later) and show up well with side lighting. Also shown are the two types of ribbon fracture: the parting surface and the cleavage surface.

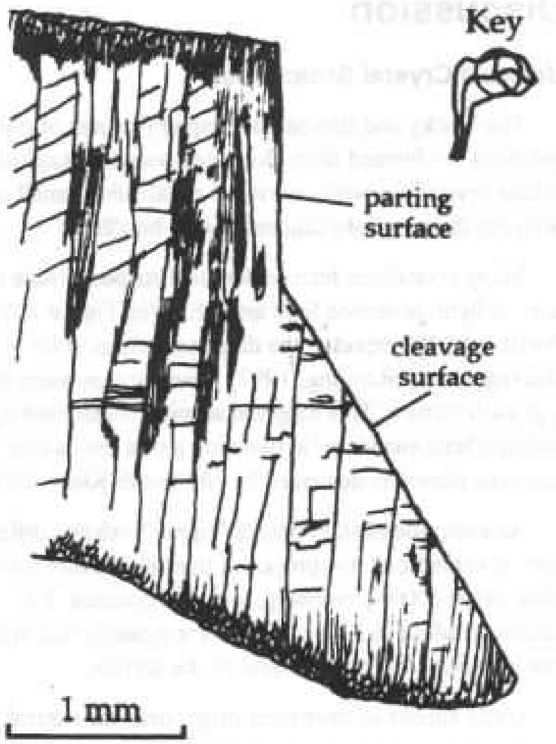

Figure 12. Broken ribbon showing "fence paling" sides and diagonal surface texture (stripes on upper half). Crystallites near the edges are much smaller than the ones near the centre.

Symmetry of a Double Ribbon Helictite

Figure 13 shows a double ribbon helictite. This beautiful helictite has two ribbons, both appearing to be mirror images, and indicating a common environmental influence, possibly the result of multiple twinning in the stem. Central canal beading is apparent, and the canals are not open at the tips.

Apparent Twinning on Ribbon Faces

In a few samples, on that part of the flat ribbon surface closest to the central canal, there is often a "zipper" pattern formed by interlocking crystal terminations either side of the central canal. Each side of the "zipper" exhibits different optical extinctions.

Ovals

Several ribbon helictites have a structure which I have termed an "Oval" on their surface: see Figure 14. Ovals seem to be associated with a bend in the ribbon's growth direction and are often symmetrical. At the centre of an Oval is sometimes a field of spiky terminated calcite blades. This may be the start of a structure similar to some rod-shaped antler helictites.

Figure 13. Double ribbon helictite is about 9 mm x 6 mm, and about 2 mm thick.

Figure 14. An Oval feature on a ribbon helictite. The helictite is coated with platinum for the SEM. Note the apparent twinning of the Oval with the ribbon sides. In the centre of the Oval can be seen a bundle of thin pseudohexagonal calcite crystals. Broken stem is at top right. Photographed with normal light. Helictite is approximately 9 mm x 14 mm.

Discussion

Unusual Crystal Structures

The blocky and fine needle shaped features of ribbon helictites are formed from elongated pseudohexagonal calcite crystallites with interstitial canalicules (small gaps between the pseudohexagonal crystal bundles).

Many crystallites feature diagonal stripes, visible in normal light, polarised light and SEM (eg Figure 10). Previously, I interpreted the diagonal stripes to be cleavage lines, (Rowling, 1997) however they seem to be a growth feature. This diagonal striping is assumed to be polysynthetic twinning (ie twinning along the calcite cleavage plane) as described by Hurlbut & Klein (1977).

As each side of the ribbon's "zipper" exhibits different optical extinctions it is proposed that this feature may be basal plane {0001} twinning, which is common for calcite (Hurlbut & Klein, 1977). It is possible that water can leak from the central canal to the surface.

Ovals appear to have their origin near the central canal and seem to be twinned at approximately 90° with the long crystallites of the ribbon's face. Twinning in calcite is often caused by pressure and thus the Ovals are probably a growth or pressure feature rather than a dissolution feature.

Preferential growth of crystallites, their diagonal striping (like lublinite), twinning features and their overall shape may be influenced by chemical "poisoning" of the normal calcite structure, resulting in dislocations to the crystal lattice. The 0.5 % Fe in the tested sample may be sufficient to cause such dislocations, however it is not known whether this was a surface contaminant.

Similarities found with Calcite Formed in the Presence of Microorganisms

The terminations of some of the long crystals on the thin edges of ribbon helictites are similar to spiky and "Gothic Arch" forms of calcite in biologically active travertines, described by Folk, Chafetz & Tiezzi (1985).

The diagonal lines noted before on the surface of the ribbon (Figures 10 and 12) have certain similarities with the needle form, lublinite variety of calcite often associated with microorganisms and moonmilk. The diagonal stripes on the pseudohexagonal crystallites resemble those of lublinite laths, although the crystallites on ribbon helictites are about two orders of magnitude larger than that published for the lublinite laths in moonmilk (Moore and Sullivan, 1997). Additionally, some ribbon helictites have a laminated edge almost as though it was made of stacked lublinite laths. Moonmilk is fairly common at Jenolan, although not particularly a feature where there are ribbon helictites, so the application to ribbon helictites is not conclusive.

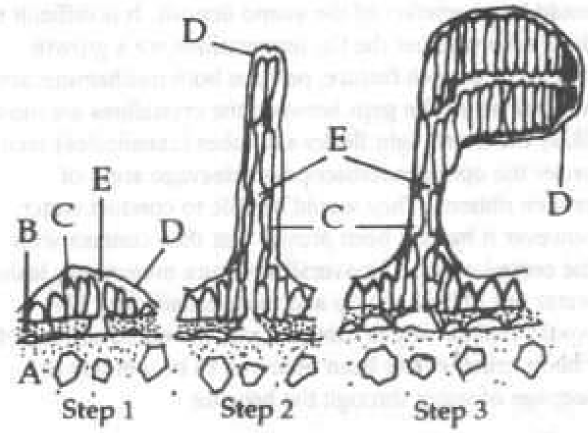

Figure 15. Proposed growth mechanism for ribbon helictites. See text for details. Step 1: Initial deposition of pseudohexagonal calcite around a pore forms the wall attachment. Step 2: Development of basic helictite. Step 3: Development of ribbon. A = porous sediment; B = thin calcite coating; C = columnar calcite; D = surface water film; E = central canal.

Growth Mechanisms.

A mechanism for the formation of helictites in general is summarised in Hill and Forti (1997). I have modified this theory to show how ribbon helictites might form:

Porous substrate: At Jenolan Caves, the ribbon helictites are associated with cave fill composed of porous, ancient river sediments.

Corrosion source within the substrate: The Jenolan substrate material possibly contains pyrite (as do other sediments at Jenolan: Armstrong Osborne, pers. comm.) and the limestone bedrock in contact with these sediments usually looks corroded. In the damp environment of the Jubilee Cave, a complex series of chemical reactions (eg Rowling, 1995) involves oxidising the pyrite, liberating sulphuric acid, eroding the bedrock, releasing CO_2 (both to air and in solution) and calcium sulphate (aqueous). Additional carbonate-rich water seeping over this sediment can deposit a thin film of calcite (common ion effect), however in places it can be eroded by sulphuric and/or carbonic acid again (at the sediment-calcite interface) which may create pin holes in the calcite film. Where the tourist cave track work has exposed layers of sediments, one can view this corrosion.

Creation of a stem: Instead of depositing calcite with its c axis evenly radial to the pin hole and the substrate as one might expect (and has been shown by Davis, Palmer & Palmer, 1991), ribbon helictites appear to initiate with the c axis perpendicular to the pin hole (Step 1 in Figure 15).

The stem's central canal forms the same as "normal" helictites, presumably from capillary action above the original pin hole in the substrate (Step 2 in Figure 15). This could occur randomly by competitive growth above the canalicules. The crystals of the stem are comprised of bundles which appear to be twinned. In the presumed twin composition surface lies the central canal. Growth proceeds in the direction perpendicular to the substrate, mainly from water seeping through the central canal under capillary action. To a lesser extent, water could pass through the canalicules and deposit calcite at their ends. Water could also travel by capillary action across the surface, depositing on the sides of the stem, with crystal alignment the same as the stem. The stem comprises at least two bundles of long pseudohexagonal calcite crystals with their c axes nearly aligned. These bundles appear to be twinned on an m face (unusual for calcite, but common for aragonite) and do not have the overall cylindrical symmetry of common vermiform helictites.

Deposition at the tip is such that the original twinning is reproduced. This could occur by repetition of the crystal lattice dislocation during crystal growth.

The beading of the stem's central canal is probably due to periodic dissolution, eg if the tip becomes blocked, CO_2 would not escape to atmosphere and conditions may become such that chemical equilibrium tends towards dissolution (through carbonic acid) rather than precipitation of calcite. This would occur mainly in the direction of the c axis at the end blockage (which is the fastest growth/etch direction for calcite). This could etch back a "bead" (hole) at the tip. Unblocking the tip would result in a change of chemical equilibrium as CO_2 is allowed to escape: a calcite deposition phase results. Further growth may deposit calcite over the old tip, leaving a crystal grain boundary, possibly even leaving contaminants at the boundary. During a subsequent etch phase, the tip may re-open and etch back another "bead", also, if contaminants are present at previous grain boundaries, these previous "beads" may be enlarged also.

From stem to ribbon: The stem's central canal changes direction through approximately 90° (once or twice) to begin ribbon development. The initiation of this direction change appears to be at the edge of crystallites. The first 90° bend appears to be between pairs of crystallites and the second 90° bend (if present) is toward the side. In this part of the ribbon helictite, the surface crystallites' c axes remain aligned with those of the stem. During the process of central canal development, the axis of the central canal wanders within the stem's twin composition plane. During a canal enlargement phase, it is possible that the central canal may reach the side of the stem, and this is presumably what initiates ribbon growth. Canal wandering may also be aided by the density (or lack) of canalicules. Since the bulk of the water would be drawn by capillary action through the central canal, this side "leak" in the central canal may become the major growth point. Growth may still continue via canalicules and surface capillarity, however the latter may even block the original tip.

Deposition at the tip is with the calcite's c axis the same as the local substrate (ie the stem) producing the ribbon (Step 3 in Figure 15). It is highly likely that the apparent twinning of the ribbon is a continuation of the stem's twinning. Additionally, the upper and lower halves of the ribbon may be twinned, resulting in a four-way symmetry. Initially tiny needle-like crystals of calcite are deposited at the tip, but competitive crystal growth over time forms the larger crystallites of the ribbon. Similarly, the sides may grow due to spiky calcite being deposited at the edges, following the alignment of underlying crystallite terminations. The water for this edge development is assumed to come from canalicules as well as from the tip.

Central canal features: The central canal in the ribbon section is much larger than the central canal at either the tip or the stem. This could be due to preferential dissolution in the calcite c axis direction (at times), with the milky calcite being deposited (at other times). This would require changes to the chemistry of the solution in the central canal as ribbon growth progressed. Beading of "normal" helictites from Harz, Germany, has been examined by Kempe and Hartmann (1997) and was considered by them to be related to annual growth. In Germany, in winter, precipitation usually occurs as snow which means it is drier and less water is available for helictite growth. Unlike Germany, Jenolan does not have a definite predictable dry season, so the beading in ribbon helictites may simply be an indication of fluctuations in water availability rather than annual growth.

Tips: The tips of ribbon helictites are not usually visible; perhaps the hole gets periodically blocked by calcite and then unblocked as dissolved CO_2 in the central canal water makes it more acidic from carbonic acid, H_2CO_3.

Ovals: At times, the ribbon's central canal may become blocked and subsequent dissolution of the central canal may be responsible for multiple tips, giving rise to multiple ribbon growth and development of Ovals. Ovals, in particular, are interesting as they share some characteristics with the stem (fence paling sides, long crystallites, symmetry about the oval axis, spiky calcite inside the oval). Ovals seem to be twinned with the ribbon sides, so could be influenced by pressure exerted by the growth of the ribbon surface.

Finally, ***old age:*** Ribbon helictites may "die" from their water supply drying up (ie changes to local hydrology), or become engulfed by flowstone, or they may continue to thicken, forming flattened loops, for a very long time.

Acknowledgments

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Sand Speleothems: an Australian example

K. G. Grimes

Abstract

Sand speleothems have formed in sea caves at Loch Ard Gorge, Victoria, Australia, by the localised precipitation of calcium carbonate in loose sand that fills the caves. Calcite-saturated waters have entered the caves from the surrounding porous limestone, either dripping onto the sand, or seeping directly into it from the walls. Removal of the uncemented sand has exposed the cemented formations which have shapes analogous to those of conventional stalagmites, stalactites and shelves.

Keywords: *caves, karst, sand speleothems, concretions, Australia.*

Introduction

Sand speleothems are small to medium-sized features composed of cemented sand which are found within caves that contain, or once contained, sandy sediments. Hill & Forti (1997, p.219-222) report a variety of sand and mud speleothems that have been found in caves. They describe several types of feature, with "stalagmites" being the most common, and list several quite distinct processes which have been suggested for their formation. Sand speleothems do not appear to be common in the caves of the world, but that might be partly because their significance was not realised.

Setting

This paper describes sand formations found in caves at Loch Ard Gorge, Victoria. Loch Ard Gorge is a deep ravine, with associated caves, cut into the cliffed limestone coast of the Port Campbell area, in western Victoria (Figure 1). The gorge is named from the shipwreck of the *Loch Ard* which occurred in 1878, and has two caves that are named after the only survivors of the wreck, Tom Pearce and Eva Carmichael, who sheltered therein. In addition to the two main caves, Pearce Cave (3SW-2) and Carmichael Cave (3SW-3), there is also a smaller cave which I shall refer to as The Alcove (3SW-29).

The host rock is a soft, porous, Miocene marine limestone, the Port Campbell Limestone (Abele et. al. 1988), that forms coastal cliffs about 30m high. The caves are primarily sea caves, but they also show some karst features. It is probable that marine erosion has intersected prior karst cave passages and enlarged them. Both caves contain numerous normal calcite speleothems; the end chamber of Pearce Cave is particularly well decorated with short stalactites, some columns and flowstone floors. Pools here once contained "cave pearls" (described as "pisoliths" by Baker & Frostick, 1951, who also provide a detailed description of the caves), but those have all since been collected by visitors. An underground stream rises at the back of Pearce Cave and flows out onto the beach.

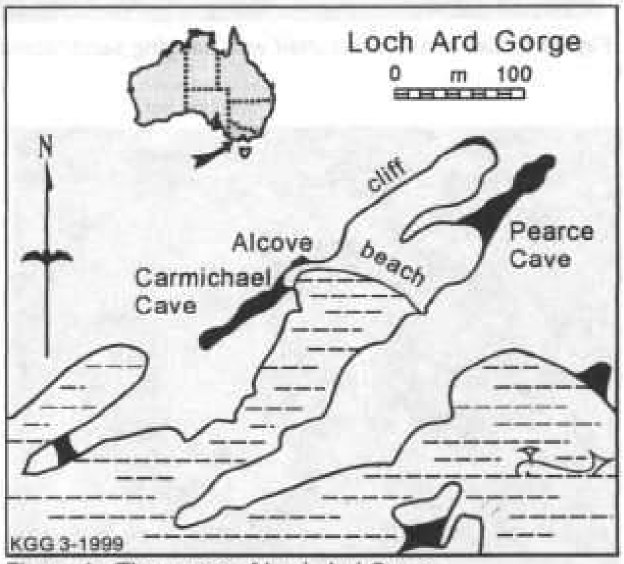

Figure 1: The caves of Loch Ard Gorge.

The gorge is a well-known tourist site, and both it and the caves are heavily visited. Access to Carmichael Cave is not possible at high tide, and The Alcove can also be cut off at times, particularly in rough weather. One needs to be careful of the waves at all times when visiting these caves. Pearce Cave is nearly always accessible.

Carmichael Cave and The Alcove contain features analogous in form to the calcite stalactites, shelves and stalagmites found in normal limestone caves, but which are composed of cemented sand. In addition small cemented sand bodies are found lying loose within the sandy floor of Carmichael Cave. Cemented sand also occurs beneath calcite flowstones in Pearce Cave and as shelves on the walls, but it lacks distinctive structures.

History

Baker (1942) first described "sand stalagmites" from Carmichael Cave. However, his descriptions are restricted to the small formations that were sitting loosely in the sand floor (see Figures 4, 5 & 6). He made no mention of the larger sand formations that are now visible. A later paper (Baker & Frostick, 1951)

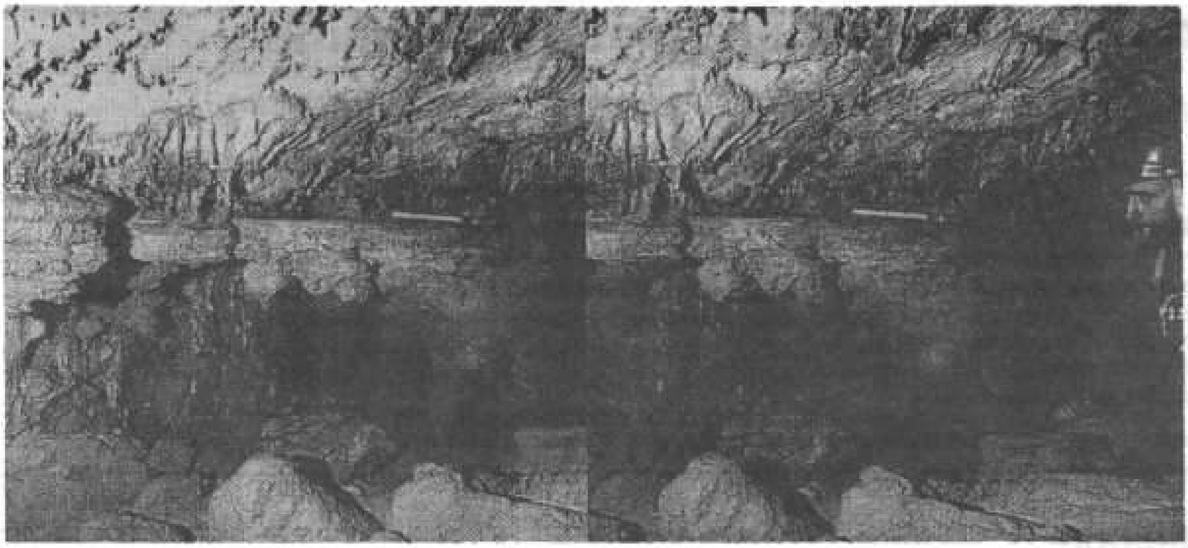

Figure 2: Cemented sand shelf with hanging sand "stalactites". Carmichael Cave. (Stereo-pair)

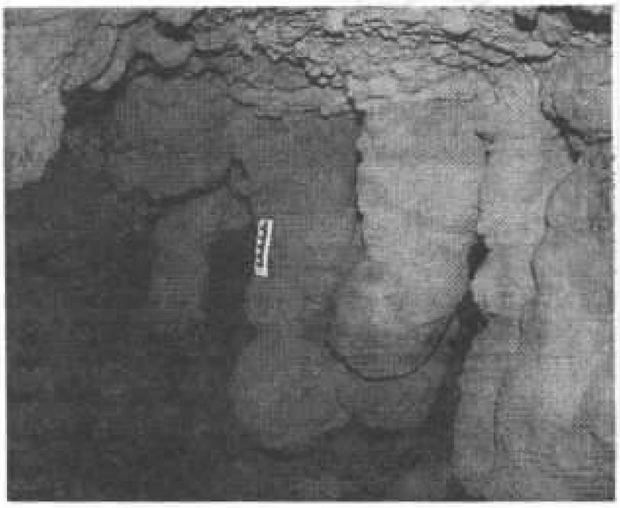

Figure 3: Bulbous sand "stalactites" in The Alcove, Loch Ard Gorge. 10cm scale bar.

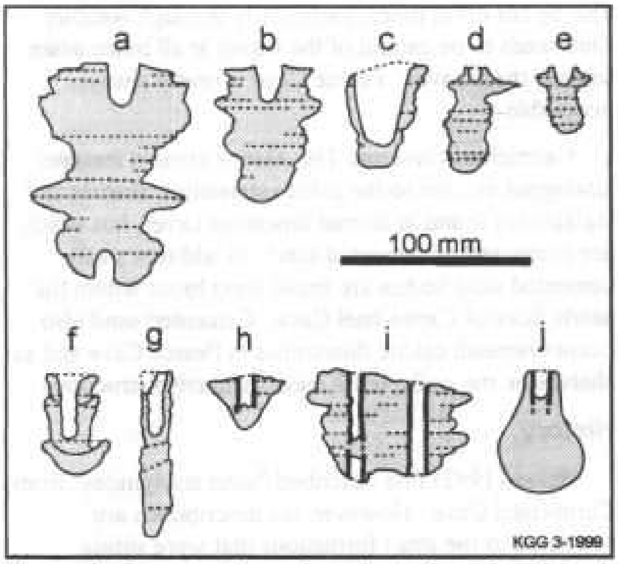

Figure 4: Cross-sections of sand pots from Carmichael cave. Top row is Baker's specimens. Bottom row sketched by author. Heavy lines are calcite linings in drip-pits.

mentions that in April 1947, high seas apparently just reached the rear of Carmichael Cave and the previously described sand "stalagmites" had been undermined and tilted. This later paper mentioned the cemented sand "shelves", calling them "sand plasters", but still made no reference to the hanging bulbous sand "stalactites" that are seen at present. One suspects that there has been further erosion since 1951. The present floor of Carmichael Cave is about 0.5m below the top of the sand "shelves" on the wall - which presumably represent the floor level when Baker described the cave in 1942. Baker could well have missed the formations in The Alcove, even if those were not buried at the time, as that small cavity is hidden behind a large fallen block and not obvious. Baker (1943, p380) also described "sand plasters" attached to sea cliffs at the back of partly eroded sandy beaches elsewhere in the region which appear to be similar to the "shelves" seen in the caves.

The Sand Speleothems

Description

The sand speleothems are formed in calcareous beach sand that has been washed into the caves by the sea. The medium-grained sand is 70 percent carbonate and 30 percent quartz and other insoluble material (Baker, 1942). The thin, gently-inclined bedding of the original sand bodies is still visible on the sides of the sand speleothems and indicates its origin. The sand has buried prior calcite speleothems in places and a broken fragment of a calcite stalactite was found embedded within one of the sand speleothems.

The sand speleothems exposed at Loch Ard Gorge comprise four forms.

1: Horizontally banded *sand "shelves"* occur plastered to the cave walls up to 0.5m above the floors of both Pearce and Carmichael Caves, and are up to

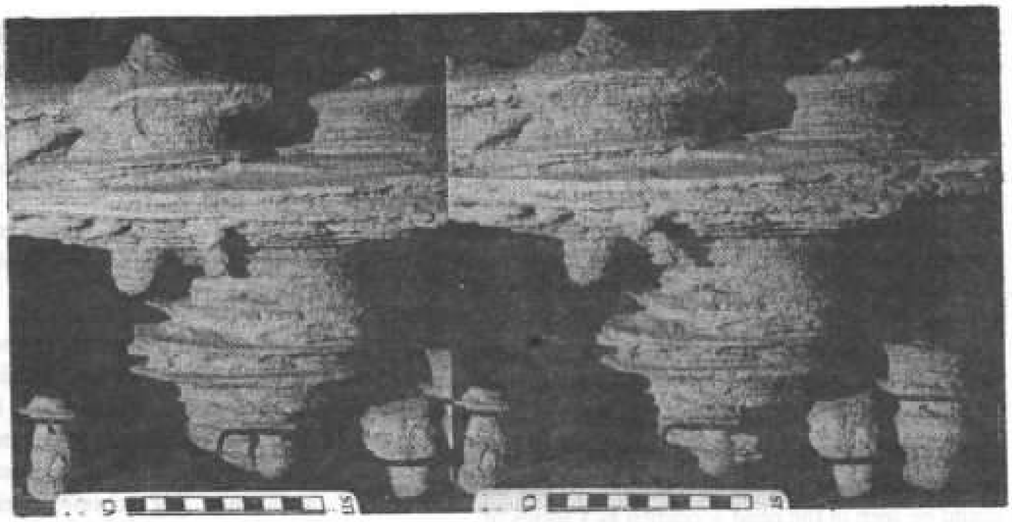

Figure 5: Stereo-photo of Baker's specimens, held as a mounted display at Melbourne University. Scale bar is calibrated in centimetres.

0.5m wide and 0.3m thick (Figure 2). Some shelves now have a hard, smooth, impermeable upper coating of calcite flowstone. These are the "sand plasters" of Baker (1943).

2: Bulbous *sand "stalactites"* up to 30cm wide and 80cm long descend from either the roof, or from beneath the shelves, and occasionally reach the floor to make a column (Figure 3).

3: Less common are bulbous to platy, round or flat-topped *sand "stalagmites"* seen rising from rock-slabs at the entrance to The Alcove. These are up to 40cm wide and 80cm high. The plates appear to be cemented bedding planes of the original sand deposit and the flat top may have been the original surface of the sand. No pits were seen on the tops of these "stalagmites"; the largest had a calcite coated top with a small calcite stalagmite forming beneath an active drip.

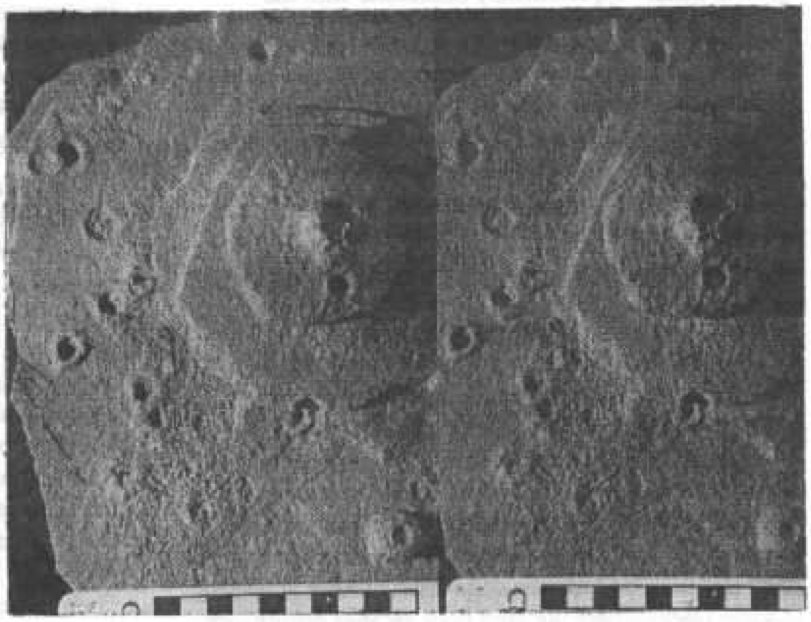

Figure 6: Stereo-photo of upper surface of Baker's large specimen, showing drip pits with marginal rims.

4: Smaller unattached *sand pots* occur in Carmichael Cave (Figures 4, 5 & 6). These are the sand "stalagmites" described by Baker (1942) and also resemble the "drip pots" described by Bull (1974). The descriptive name "sand pot" is suggested here for these distinctive types that have complex bulbous forms with a central pit. Baker described these as apparently floating free in the sand, unattached to either the wall or floor of the cave, with only the tip exposed above the sand surface. None of these are currently seen in situ, but in 1998 several loose specimens were found lying in pockets of wave-washed gravel within the cave.

The smallest of the sand pots was only 25mm wide and 40mm high. The largest of Baker's specimens was a composite form, nearly a metre wide and 0.75m high, that was formed of several of the simpler pots joined by a stacked series of horizontal ledges (Figure 5). The bottoms of the pots were rounded, the tops generally had a small mound around a central pit, typically 6-20mm wide and of variable depth; some pits penetrated right through the pot (Figure 4). The deepest pit, found on the composite specimen, was 70mm deep, but only 7mm in diameter. The composite specimen had a number of drip pits on its upper surface (Figure 6). Rounded bulges protruding from the underside of the composite specimen correspond to drip pits on the top. Most drip pits are unlined, but several had calcite linings about one mm thick. These lined pits have a uniform width of 6 to 7mm and are up to 60 mm deep.

One broken sand pot showed several cemented bands, which in thin section appeared to be a denser micritic cement (see below). One small sand pot was found rotated and embedded within a larger sand "stalactite", indicating reworking of the sand sediment followed by further cementation.

Thin sections were made from two specimens, a fragment of sand "shelf", and a small broken sand pot. The sand "shelf" had a porosity of about 30% and the grains were cemented by a thin isopachous rim of clear calcite spar only a single crystal wide. The sand pot had a similar isopachous rim cement, in places two crystals thick with the initial crystals finer than those outside. But there were also bands and patches with (additional?) fine cloudy micritic cement that almost completely filled the pore space. Within these areas isopachous spar occurred again at the edges of some of the remaining pore space. No specifically vadose features, such as meniscus or pendant cements were seen. The inner edges of the micritic cemented bands were gradational to less well-cemented areas but the outer edges were sharply defined and marked by a continuous layer of isopachous cement, a single spar crystal wide, that could be traced right across the thin section. These bands could be seen in the hand specimen as a series of "growth bands" approximately concentric with the outside of the pot.

Thus the sequence of development appears to have been one of discontinuous thin sparry rim cement, followed by (or contemporaneous with) several stages of localised cementation in bands by micrite cement, each of which ended in continuous thin layer of sparry isopachous cement.

Age of the Loch Ard Gorge sand speleothems

The age of the sand speleothems is uncertain. The loose sand fill appears to be a beach-derived sand with dips similar to the present beach sediments. It buries older speleothems and has been partly removed in all three caves since it formed. So it may have been deposited during a sediment build-up at the maximum sea level of the post-glacial transgression (about 6000 years ago). If so, the sand speleothems have formed since that time, and may be continuing to form at present in some places where the sand floor escapes disturbance by waves, cave streams, or people.

Related features from elsewhere

Hill & Forti (1997, p219-222) describe a variety of sand and mud formations that have been found in caves, and list a comprehensive bibliography. Many of the published descriptions differ in form or apparent genesis from the features described here, but there are some that appear similar. Bull (1974) described sand "drip pots" from caves in Wales; they are very similar to the sand pots described here and by Baker (1942), including the presence of a drip-pit. Bull attributed the banding (i.e. Baker's "ledges") to the primary sedimentary bedding. Wojcik (1958) described from a cave in Poland cemented concretions within loose quartz sand; these were stuck to the walls and had been exposed by subsequent erosion of the sand. They were mostly spherical to onion-shaped balls 20 to 50mm in diameter, but there were also larger loaf-shaped concretions. His photographs show that these are rather different in appearance to most of the formations at Loch Ard Gorge, but a few rounded forms were seen attached to the wall beneath a sand shelf in Carmichael cave (back of photo in Figure 2). Reto Zollinger (pers comm) has described spherical concretions, 1 - 3cm in diameter, that were found embedded in a quartz sand fill in the Barenhöhle in Switzerland. In Marakoopa Cave (7MC-120) in Tasmania, Jill Rowling pointed out some knobs and finger-like formations of cemented sand within a subsiding sandbank. These had a lustre-mottled cement. Unfortunately none were in-situ and no further work has been done on them.

A related feature is the ***conulite***. This term is now mainly applied to thin crystalline linings of drip pits in soft sediments (Hill & Forti, 1997, p57-59), but originally it seems to have also been applied to features that involved the local cementation of the surrounding sediments. For example, Peck (1976) applied it to "any drip-drilled pit in sediments which has been secondarily impregnated and, **perhaps**, lined with a mineral coating" [my emphasis]. His examples were only a few centimetres thick. Some of the smaller sand pots at Loch Ard Gorge could fall within this description, but not the larger features.

In a completely different context, Stoddart & Scoffin (1983, p380) describe phosphate deposits on a coral island in which phosphate-cemented sand and gravel overlies loose carbonate sand with an abrupt contact that shows "an irregular stalactitic relief, indicating variable downward percolation of phosphatic fluids". An accompanying photograph shows bulbous structures that appear similar to the sand "stalactites" seen at Loch Ard Gorge. I have personally seen slightly similar effects at the basal surface of calcrete and other duricrust bands, but the depth of penetration of the bulges was much less than that at Loch Ard Gorge and they are usually embedded in a more cohesive soil which makes them less likely to be eroded out.

Concretions in sedimentary rocks are a related form, but these generally form within the body of sediment and grow outward from a nucleus such as a shell fragment. By contrast the sand speleothems all start their growth at the point of entry of the water into the sand, and expand outward from that point.

Genesis

Hill & Forti (1997, p.219 - 222) suggest two modes of formation of sand and mud "stalagmites". The first involves water dripping onto soft sediment and displacing it to pile up mounds around a central pit. The second involves sediment-laden water that builds up a mound from the sediment that is left behind as the water soaks into the substrate. In both cases cementation of the sand or mud is also invoked. I have seen examples of the second case in a cave on Christmas Island (Indian Ocean), where the cave is flooded with muddy water every wet season which leaves the roof and stalactites coated with mud. After the flood this mud is slowly

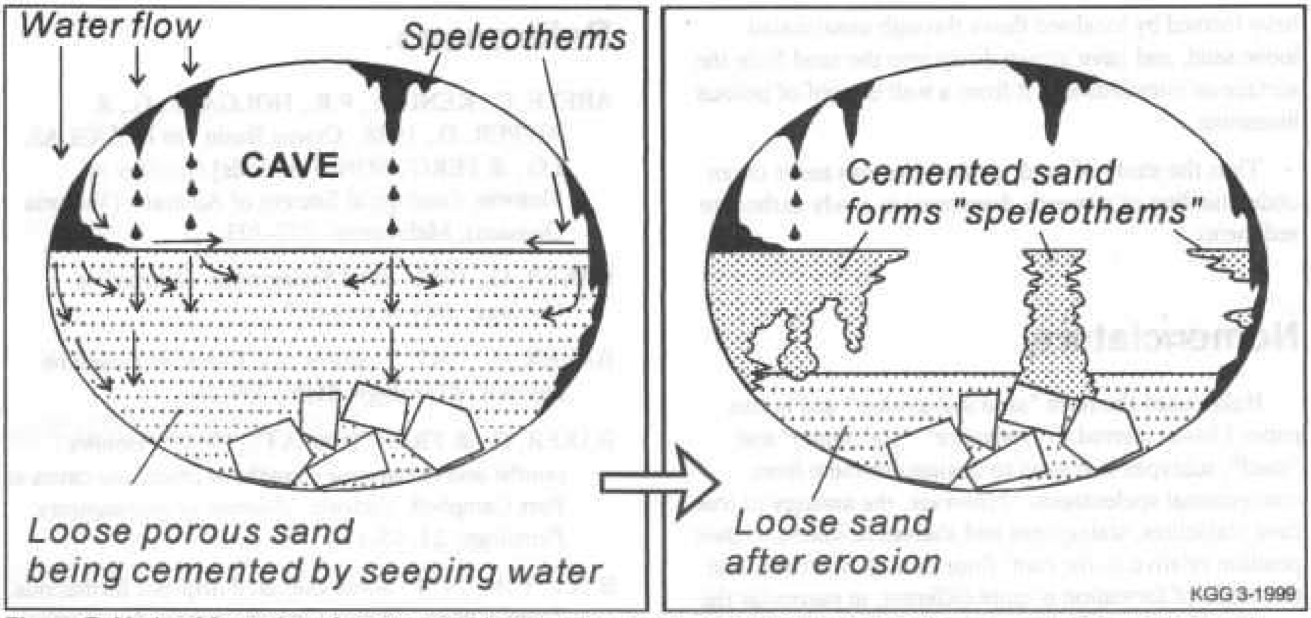

Figure 7: Mode of formation of sand speleothems. The sand is cemented in localised areas, and then uncemented sand is removed.

washed off the roof by seepage water and drips to the floor where it builds up soft rounded mounds. This is quite a different process to that which appears to have occurred at Loch Ard Gorge.

The first process seems more relevant, though actual dripping of water, and the formation of drip pits and mounds, does not seem to be an essential part of the process.

The Loch Ard Gorge Formations

At Loch Ard Gorge, it seems that calcite-saturated waters have entered the sand, either by dripping from the cave roof, flowing down the walls, or across normal flowstone sheets that built over the sand surface. In some cases the sand fill seems to have reached the roof, and the waters would have entered it directly from pores or cracks in the limestone. These waters moved through the sand and cemented it in localised areas close to the source. Once the excess dissolved calcium carbonate was used up precipitation ceased, and the rest of the sand body was left uncemented (Figure 7a). Later erosion (storm wave or cave stream) removed a metre or so of the loose sand to expose the cemented parts (Figure 7b). The smaller sand pots with drip pits would have formed similarly, but in addition the dripping water kept a small pit open in the top of the cemented formation, with a small rim of displaced material, and splash and overflow water cemented the surrounding sand surface.

Dry sand would provide air space for carbon dioxide to diffuse out of the water and trigger cementation, and also would seem more conducive than wet sand to vertical infiltration which would produce the vertical "stalactitic" forms. However, the isopachous cement seen in thin section is generally interpreted as indicating water-saturated (i.e. phreatic) conditions (James & Choquette, 1984). At Loch Ard Gorge the precipitation may have been within a localised area of water-saturated sand, possibly just behind the wetting front. In a completely water-saturated sand one would expect the saturated waters to diffuse in all directions and produce spherical forms except where constrained by variations in permeability - i.e. typical concretions. This might have been the situation with the spherical features described by Wojcik (1958), and Zollinger (pers comm.). The bands of micritic cement may indicate faster precipitation at a series of drying fronts, with the super-saturated waters being replenished from behind the front. John Webb (pers comm.) has suggested that as microbial cements are also micritic these might also be an additional influence. However, no organic structures were seen.

Baker (1942) attributed the "ledges" in his specimens to splashing and overflow from the pits onto the surrounding sand surface, which was cemented; the repetition of the ledges he attributed to progressive build up of the sand surface. Bull (1974) believed that similar "banding" in his specimens reflected the bedding in the sand, which seems a more likely situation. However, one of the loose sand pots seen in the cave had a repetition of rims that suggested progressive upward development of three pots nested within each other (Figure 4.f), and this would agree with Baker's concept of deposition building up the sand floor simultaneously with cementation. The presence of a rotated pot embedded within a sand "stalactite" also implies several stages of cementation, erosion and redeposition of sand.

The process appears to be a special case of that which forms concretions in porous sediments. The distinctive feature is that most concretions form in fully saturated sediments, and grow outwards from a central point, whereas the sand speleothems at Loch Ard Gorge have formed by localised flows through unsaturated loose sand, and have grown down into the sand from the surface or outwards into it from a wall or roof of porous limestone.

Thus the study of sand speleothems can assist in our understanding of meteoric diagenesis in sandy carbonate sediments.

Nomenclature

Baker used the term "sand stalagmites" and in this paper I have referred to "stalactite", "stalagmite" and "shelf", subtypes in quotes to distinguish them from conventional speleothems. However, the analogy to true cave stalactites, stalagmites and shelves is limited to their position relative to the roof, floor or wall of a cave, and the mode of formation is quite different; in particular the sand "stalagmites" are so-called only because they are now seen sitting on the cave floor. In fact, they have grown downward through the sand until they reached the solid rock and remained bonded to it when the loose sand was removed (Figure 7). Bull (1974) used the term "drip pots" in his title, but referred to the pots as "calcreted drip-pits" in his text. Baker (1943, p380) used the term "sand plaster" for the sand "shelves" where they were exposed against the coastal cliffs.

Thus it would be better to avoid "stalactite" and "stalagmite" and use only the general term ***sand speleothem*** for features formed by the cementation of loose sediments. In fact, it might be more appropriate to reserve the term sand/mud stalagmite for features that have actually built up from a floor by physical deposition of clastic material from a drip, as in a true stalagmite (e.g. the Christmas Island "mud stalagmites" mentioned above). The smaller formations found sitting loosely within the sand at Loch Ard Gorge are, however, quite distinctive and I suggest the term ***sand pot*** for those.

Acknowledgements

John Webb and Jill Rowling provided useful reviews of this paper and John also commented on a revised version. Bernie Joyce located Baker's 1942 specimens in the geological collection at the University of Melbourne! John Webb arranged for the thin sections to be made at La Trobe University. Jill Rowling pointed out the sand formations in Marakoopa Cave and Reto Zollinger described formations from a Swiss cave. Sue White and John Dunkley assisted in providing copies of some references. Part of the study was done while the author was a Research Associate at La Trobe University.

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SHORT NOTES

Under the heading of "Short Notes" we will be soliciting brief descriptions of recent work, including preliminary results or summaries of work that you intend to eventually publish elsewhere.. These notes will generally be edited internally, and only sent out to reviewers if we feel out of our depth, or if the results appear contentious. We will, of course, ask contributors to consider submitting a full-length paper at a later date! But do not feel that you are committing yourself to *Helictite* for the final publication just because you have submitted a short note here. We will also consider theses abstracts.

Christmas Island Cave Studies

K. G. Grimes & W. F. Humphreys.

In March - April of 1998 a group of six karst scientists spent two and a half weeks on Christmas Island, in the Indian Ocean, doing a study of the Biology, Geological Hazards and General Management of the island's caves and karst. The team involved Bill Humphreys and Stefan Eberhard, who studied the cave biology, Ken Grimes and Dan O'Toole, who looked at the geological hazards, and Andy Spate and Rauleigh Webb who looked at other hazards and cave and karst management in general. This was done for Parks Australia North, so as to assist them in preparing a management plan for the National Park which now covers a large part of the island. Our job was made easier by a set of unpublished cave maps and reports prepared in the 1960s by local cavers, such as David Powell and Roy Bishop; and also by maps and reports from a later cave expedition from West Australia in 1987. Reports of these studies have been submitted to Parks Australia North.

The island is an old basaltic volcano with a limestone capping that is rising out of the Indian Ocean at a rate of 0.14mm per year and drifting north towards Indonesia at 8 cm per year. The interaction of uplift and a sequence of old sea-levels is a series of old shore-terraces cut into the steep and cliffy limestone sides of the island. The central plateau (about 200-250m ASL, with hills up to 360m ASL) has a partial phosphate cover over a pinnacle epi-karst limestone surface, with the crest of the volcanic surface about 30-40m down. The limestone is mostly a hard massive marine micritic calcarenite with scattered corals and partly recrystallised. It has little primary porosity.

Most of the big caves are at sea level and entered from the base of the coastal cliffs. Higher up one finds uplifted systems that formed at past sea levels, and on the plateau there are some horizontal stream passages. The coastal cliffs which circle most of the island have strong notches cut at sea-level, and well-developed hackly phytokarst sculpturing of the rocks. In one place spring-fed streams running across the Shore Terrace have cut narrow canyons, known locally as The Dales.

Coastal Caves

The coastal caves are horizontal and lie at present sea level. The longest has 2.5 km of mapped passage, and many unexplored leads. Most of these caves have strong outflows of fresh water and submarine springs have been reported from depths as great as 200m.

These caves are horizontal joint-controlled passages with irregular, sharp, spongework walls. At intervals they are punctuated by massive rockpile chambers; some caves are dominantly collapse with little of the original passage visible. Within the coastal caves a fresh water lens is floating on water, so salt/fresh-water mixing-corrosion will be active and responsible for the extensive spongework sculpturing. Tidal mixing and flushing may also assist in the solution of the limestone. The impermeable nature of the rock restricted the original passages to the joints, but spongework cavities are actively expanding from these.

The presence of drowned speleothems down to at least -6 m in the main flooded passages suggests that the original cave development predates the present Holocene high-stand of the sea, and might date back to an earlier sea-level; most likely the 101-104 ka high-stand if measured uplift rates are superimposed on sea-level curves.

Plateau Caves

The few known plateau caves are different. Smaller, muddy, horizontal stream passages run at or not far above the limestone-volcanic contact, and are entered via vertical shafts or collapse dolines. They show some joint-control, but this is partly obscured by a tendency to meander. These caves presumably feed water to the coastal caves (several kilometres away, and 200m down), some of which have impressive water-spouts coming out of small holes in their ceilings. However, no connections have been found so-far. We found foul air (3% carbon dioxide with 17% oxygen) in all the plateau caves. This had not been reported before so perhaps it is just a seasonal thing - we were there at the end of the "wet" season, although it had been an unusually dry one.

Other Caves

There are also a couple of fissure caves, behind and parallel to cliff faces, that seem to be at least partly the result of mass-movement. Most intriguing was a report by David Powell, held in the phosphate company records, that describes a sizable cave near the edge of the plateau that had a stream and was formed mainly in basalt beneath the limestone. Unfortunately, the entrance was filled in some years ago, and is currently lost.

Biology

The subterranean fauna was sampled via caves, boreholes and springs. The sampling was at the end of a relatively dry "wet" season - in which only half the usual rainfall was recorded. The effects of this was observed in the caves and it is likely that a much more extensive troglobitic fauna occurs than was recorded.

None-the-less, the results show that the island has a significant cave fauna in an international context. The fauna comprises swiftlets and a diverse assemblage of invertebrates, both terrestrial and aquatic. The latter include species from the relatively rare anchialine habitat - where freshwater floats over and mixes with sea water.

Identification of both the taxonomy and the troglomorphies of the specimens collected is far from complete, but at this stage there seems to be at least six troglomorphic and six stygomorphic species present along with others who's dependence on the caves is currently unknown. A least twelve of the species found underground are endemic to Christmas Island.

The coastal caves contain a number of terrestrial troglobitic species including the first blind scorpion known from Australia and only the second outside the Americas. These caves contain numerous amblypygids but these are not troglobitic. The plateau caves contain a new troglobitic gnaphosid spider related to one on the Togian Islands, off Sulawesi; possibly the first Australian cave adapted dipluran and a new genus of blind and troglobitic nocticolid cockroach.

The freshwater streams in plateau caves are sparsely populated by cyclopoid copepods and ostracods.

The anchialine waters contain the procaridid shrimp *Procaris sp. nov.* This genus is known elsewhere only from Hawaii in the Pacific and from Ascension Island in the South Atlantic. This primitive and highly aberrant family appears to be restricted to anchialine caves and has only one other known representative, a second genus from Bermuda. All species of Procarididae are sympatric with one or more species of atyid shrimps (Ascension I., Hawaiian archipelago, Bermuda and Christmas I.). These co-occurrences of these two primitive and presumably ancient caridean families support the contention that crevicular habitats have served as faunal refuges for long periods of time. This system is also notable for the presence of several taxa of alpheid shrimps and for ameirid copepods.

Overall, this anchialine system, as elsewhere, deserves intense study - in recent years numerous new species, new genera, at least 10 new families and even a new class of crustaceans (Remipedia) have been described from anchialine caves.

Mud Speleothems in a west Victorian cave.

K. G. Grimes.

An interesting follow-up to the paper on Sand Speleothems in this issue is the recent discovery of possible mud stalactites in a cave at Drik Drik in western Victoria. During exploration and mapping by Victorian cavers last Easter; small, brown, triangular stalactites were seen on the cave walls in several parts of the cave. They looked soft, but no-one liked to touch them to check as they seemed very fragile. The formations were up to 10cm long and a muddy-brown colour. Their form was a triangular ribbon, hanging vertically from a muddy wall, and ending below in a thin string only 1mm thick. The ribbon parts frequently had small holes and gaps which gave the impression that the mud might be coating filaments or cobwebs.

These need to be studied more closely.

The linear stream cave contains numerous soft mud banks and it appears that in the past breakdown has dammed up the stream so that there has been extensive mud deposition. Presumably when the lake drained the soft mud coatings on the walls ran off and in some places dripped to form the mud stalactites.

NEWS and VIEWS

We hope that this "News and Views" section will become a regular feature of *Helictite*. We will welcome contributions covering past and forthcoming events in the karst sciences, together with short notes on work in progress and preliminary results for the "Short Notes" section. We will also publish theses abstracts and book reviews. We would like to receive regular contributions from people in major institutions concerning new staff and activities that are in progress. This issue has a strong editorial input - we hope that this will be replaced by a flow of information from the entire karst community.

The ACKMA Conference, Mt. Gambier, April 1999.

In April, over 80 karst managers and cavers gathered at Mount Gambier for a week of talks, field trips and other activities (some best not described in detail). This was the Thirteenth Australasian Conference on Cave and Karst Management, and the second one at Mount Gambier – the previous one was 20 years ago in 1979 and organised by the Australian Speleological Federation. The recent conference was organised by the Australian Cave and Karst Management Association.

The overall theme for the conference was *The Water Below*: the management of karst aquifers, with a motto of *What goes down must come up!* This was appropriate given that the Gambier Karst is one of the best sources of groundwater in Australia. However, the themes of the 35 papers covered a far wider scope than groundwater, and formal presentations alternated with half and full-day field trips to the surface karst and caves of the region.

The opening session comprised three reviews of the local area: *The Gambier Karst* by Ken Grimes, the *Regional Hydrology* by Fred Stadter and *Human Interactions with the Karst Landscape* by Judy Murdoch. Tom Alley, from the Ozark Underground Laboratory, USA, gave the keynote address *Karst Hydrology: The Dye is Cast* which was peppered with dry humour and several delightful case histories from his consulting experience. The initial *Water Below Symposium* included papers on the management of the local aquifers by Lud Schmidt and Hugo Hopton, a karst hydrological study from Texas by Todd Halihan and one on the aquatic biota by Mia Thurgate. Other sessions covered a diverse range of topics and locations, but all with a management theme to greater or lesser extent. One session was held in Blanche Cave at Naracoorte, followed by a candle-lit tour of the Cave! A full set of proceedings should be available towards the end of the year.

Field trips included surface features such as the cenotes, springs, the Glenelg River Gorge (by boat), the pump station on Blue Lake and a stone quarry as well as all the tour caves and selected wild caves in both the Mt. Gambier and Naracoorte areas. A three-day post-conference study tour covered limestone and volcanic caves and related features in western Victoria.

Coming Meetings and Conferences.

The Fifth Australian Karst Studies Seminar.

Friday 4 February - Monday 7 February, 2000

The fifth Karst Studies Seminar will be held at Wellington Caves, in New South Wales, next February. Wellington Caves are located 8km south of the town of Wellington and 370km from Sydney. The Caves are best known for their impressive fossil and phosphate deposits.

Previous seminars were held at Buchan, Victoria in 1992; Wombeyan, NSW, in 1994; Naracoorte, SA, in 1996 and Mole Creek, Tasmania, in 1998.

The theme of the seminar will be ***Concepts in Karst Studies***. Expressions of interest are invited from anyone wishing to present a paper or poster on any aspect of Karst studies. Abstracts will be required by 24th December, 1999, and should not exceed 3 pages. The seminar is aimed at anyone with an interest in cave and karst studies.

A number of field trips are being planned for the seminar which will include:

- Wellington Caves
- Borenore Caves
- Visit to the Wellington palaeontology museum

For further information contact the organising committee via

Wellington Caves
PO Box 62
Wellington NSW 2795
Ph: (02) 6845 1418
Fax: (02) 6845 3086
Email: wello@well-com.net.au

Dampier 300: Biodiversity in Australia, 1699-1999 and beyond

Place: Perth, W.A.

Date: 6 - 10 December 1999

Organised by the Australian Systematic Botany Society, Society of Australian Systematic Biologists and Invertebrate Biodiversity and Conservation. There will be a subterranean biota session focussed on Australasia.

Contact: Mark Harvey, Western Australian Museum, Francis St, Perth, W.A. 6000, Australia.

Tel: + 61(8) 94272737; Fax: + 61(8) 94272882

Email: mark.harvey@museumwa.gov.au

Website: http://www.museumwa.gov.au/Dampier 300/Dampier 300.htm

Other Meetings

Many meetings of interest to speleologists are listed on the International Union of Speleology webpage at *http://rubens.its.unimelb.edu.au/~pgm/uis/events.html* Most of those listed are in Europe or North America but of particular interest this year are **XIV International Symposium of Biospeleology** in Croatia in September; **VIII International Symposium for Pseudokarst** in the Western Carpathian Mountains, Romania in October; **14th National Cave and Karst Management Symposium** in Tennessee, U.S.A. in October; 3rd **International Symposium on the Conservation of Geological Heritage** in Spain in November and a **Sediments in Karst Systems** mini-symposium in Colorado, U.S.A. at the GSA Annual Meeting in October.

This last event is an oral and poster topical session as well as a pre-meeting 1 day field trip which is designed to bring together researchers working on all aspects of sediments in karst - both speleothems and clastic sediments. Participants are expected from all disciplines incuding: sedimentary processes, paleoclimatology, hydrogeology, surficial processes, mineralogy, palaeomagnetism, chemistry, geochemistry, physics, hydrology, geomorphology, palaeontology and biology. Contact Dr. Ira D. Sasowsky, Assistant Professor, Department of Geology, University of Akron, OH 44325-4101 U.S.A. (Tel: + 1 (330) 9725389; Fax: + 1 (330) 9727611; Email: *ids@uakron.edu* ; Website: *http://www.uakron.edu/geology/facpages/ids/ids.html*).

New Book:

Speleogenesis: Evolution of Karst Aquifers

Editors: Alexander B. Klimchouk; Derek C. Ford; Arthur N. Palmer; & Wolfgang Dreybrodt; with 44 authors from 15 countries - members of the Commission on Karst Hydrogeology and Speleogenesis, International Union of Speleology.

This is a new publication on speleogenesis which is a pioneer attempt by an international group of cave scientists to :

- Summarise modern knowledge about the origin of caves in various settings, including Australia.
- Examine the variety of approaches that have been adopted
- Outline the role of speleogenesis in the evolution of kast aquifers

Along with some well established theories and approaches, the book contains new concepts and ideas emerging in recent years. It is hoped the approach will stimulate further developments and exchange of ideas in cave studies and karst hydrogeology.

Available in hardback. ISBN Number 1-879961-09-1

Published by National Speleological Society, Inc.

2813 Cave Ave., Huntsville, AL 35810 Phone + 1 256 852-1300 Fax + 1 256 851-9241

Email *nss@caves.org* Website *www.caves.org*

Ordering information

Available towards the end of 1999. Credit cards and email preferred for international orders. Email NSS for the shipping cost. **List Price $60 USD.**

Special combined price (until October) for Speleogenesis ($60) plus Cave Minerals of the World by Hill and Forti ($70) ... $115 USD (a saving of $ 15 USD)

Information for Contributors to Helictite

Scope

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

Manuscripts

Submitted manuscripts should be in final form ready for publication. As proofs are not normally sent to authors particular care should be taken to check for typing errors. Manuscripts should be typed, double spaced, on one side of the paper. Do not use multiple columns - this manuscript is for the editors and referees use and does not have to look like the final production.

The title should be upper case bold and the author's names should follow. A brief and explicit summary of the notable aspects of the paper, headed abstract, should precede the main text. Acknowledgements should be placed at the end of the text before the references, and the author's addresses for correspondence should follow the references.

Authors are requested to submit a copy of their manuscript by email or on floppy disk as well as hard copy in the first instance. Disks may be 3 ½" or 5 ¼" in either IBM or Macintosh format. If sending text as a word processing document (Microsoft Word etc.), please also send a copy as plain text on the same disk. Ask for the separate instructions concerning electronic layout.

References

References should be listed alphabetically at the end of the manuscript and cited in the text by the author's name and the year of publication (e.g. "(Grey, 1988)"). Where there is more than one reference to the same author in one year the letters a, b, c, etc. should be added. If there are more than two authors, they should all be named at the first citation and in the reference list, but the first name followed by et al. should be used in subsequent citations. References should be checked particularly carefully for accuracy. Journal titles should be abbreviated following the "World List of Scientific Periodicals", which is available in most large libraries.

The following examples illustrate the style:

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

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

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

Illustrations

Figures and photographs should not duplicate information in tables or other material. Photographs should be clear black and white prints with sharp focus. The number of pages with photographs will be kept to a minimum. Where several photographs are to form one plate they should be mounted together on white card. Any lettering required on photographs should be applied with "Letraset". Figures should be drawn in Indian ink on white card, heavy paper or tracing material and lettered using stencils or "Letraset" or supplied as Laser prints. Ink-jet prints should be enclosed in plastic to reduce the risk of water damage in transit. Most computer drawn documents and photographic images can also be handled. Please ask for additional instructions on file formats, pixel widths and photo "enhancements".

All illustrations should be drawn to fit within a full page print area of 170 x 258 mm and ideally should be a column width (80mm) or double-column width (170 mm). They may be supplied larger provided that these proportions are maintained, but allowance for reduction must be made when choosing letter sizes and line thickness.

Figures and plates should be numbered in a single sequence and specifically referred to in the text. The numbers should be marked lightly in pencil on the margin or back of each illustration. An arrow and the word "top" should be used if orientation is not obvious. Captions should be typed on a separate sheet (or supplied at the end of the text file).

Units

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

Offprints

Twenty free offprints of papers will be supplied after publication. Additional offprints can be arranged at the author's expense. The number required should be stated when submitting the manuscript.

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