Craybacks and Lobsters
Subaerial Stromatolitic Stalagmites in Australian Caves

By Garry K. Smith

Newcastle and Hunter Valley speleological Society Inc.

As published in Caves Australia, No. 208, P. 3-6. (June 2019). Official publication of the Australian Speleological Federation Inc.

Stalagmites which resemble the shape of a "crayback" or "lobsters ", have a distinctive hump ridge shape, with a characteristic layered or stepped profile, described by 'Argus' (1898) as similar to a crustacean's segments.

They are only found in partial daylight and twilight zones of caves where there is air movement, a steady supply of dripping cave water and the presence of photosynthetic cyanobacteria.

Examples can be found in NSW at Nettle Cave (Jenolan), Victoria Arch (Wombeyan) and Arch Cave (Abercrombie) (Cox 1984). Other examples have been reported in Daylight Cave – (Yessabah, NSW) (Vaughn-Taylor, 1991) and on the other side of Australia in 6KNI80 cave (Ning Bings, East Kimberly, WA) (B. Kershaw, pers. comm.).

Sonia Taylor-Smith with crayback in Victoria Arch, Wombeyan NSW. Photo by Garry K. Smith

The nickname or colloquial term used to describe these features often becomes confusing as different terms are used at each of the three main cave areas in NSW where they are found. Terms used in historic and scientific literature include; 'crayback', 'lobster', 'lobsterback' and 'crayfish like'.

Argus' 1898 description of these uniquely shaped stalagmites at Jenolan Caves, appears to be the first instance where they are likened to a crustacean's back.

He writes, 'Other stalagmites take the form of immense lobsters……' The presence of 'craybacks' at Wombeyan were first recorded in the book *Wombeyan Caves* (James *et. al.* 1982 p. 130). The study by Cox *et al.* (1989a) identified 28 similar stalagmites of various sizes in Nettle Cave, Jenolan and notes the presence of examples at Wombeyan and Abercrombie. Osborne (1991) described ‘craybacks’ as being abundant in the Abercrombie Arch, with the best examples located in the Hall of Terpischore. It appeared that the more people looked, the more were being found.

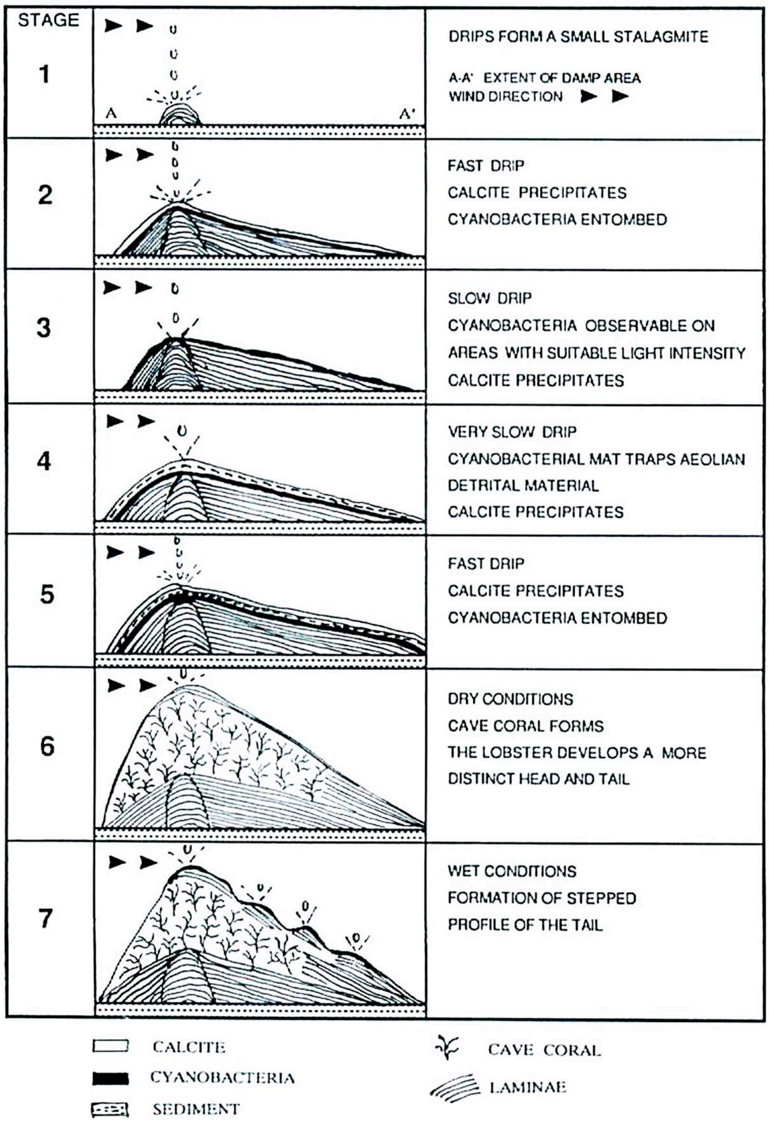

Figure 1: Proposed model for the formation of a crayfish-like stalagmite after Cox et al. *(1989a)*

However, compared to the majority of other speleothems found in caves, crayfish-like stalagmites are not common as they require specific conditions to exist. This is because the photosynthetic cyanobacteria creating them are only able to grow and flourish where there is a balance between microbial activity, sunlight, wind and rate of cave drip water (Barlow 2017). Mulec *et al.* (2007) states that, ‘At present just a few examples are known where growth of speleothems is linked with biolithogenic activity of certain organisms.’

These odd shaped speleothems are the result of photosynthetic cyanobacteria (sometimes loosely referred to as blue-green algae) growing on the surface and between the layers of calcite crystals. In simplistic terms, they use the carbon from the hydrogen carbonate in the cave drip water and release oxygen to the atmosphere.

By reducing the carbon dioxide content of the cave drip water (particularly within the sticky mucilage layers covering their surface), the bacteria cause preferential deposition of calcium carbonate ($CaCO_3$) around their structure. In addition any aeolian sediment particles landing on the damp surface are trapped and cemented together along with the precipitated $CaCO_3$.

Over time the photosynthetic bacterial colonies grow layer upon layer of calcium carbonate along with trapped aeolian sediment, while constantly reoccupying the uppermost layer to create large calcareous structures. ‘They can be regarded as stromatolites within currently accepted definitions of the term’ (Cox G., *et al.* 1989b).

Orientation and shape

These distinctive shaped ‘crayfish like’ stalagmites are found almost exclusively in the entrance areas of caves, where some direct or filtered daylight can penetrate, and where there is a reasonably constant supply of drip water and relatively high humidity. The airflow past the stalagmite also has a bearing on the relative shape of the stalagmite as constant breezes blow back and forth through large cave arches, causing the drip line to move along a linier axis.

This wet patch of the drip line on the cave floor, is referred to as a ‘footprint’ and is the beginning of a crayback’s creation (Osbourne 1991). Cox *et al.* (1989a) provides an excellent theoretical diagram of a crayback’s growth (Figure 1).

Garry K Smith with a crayback in Arch Cave, Abercrombie NSW.

Thus the orientation of the crayback's elongated shape usually aligns with the airflow direction through an arch. The distance the cave drip water falls and the strength of the prevailing breezes have a great influence over the length and orientation of the resulting crayback. The ratio of a crayback's length to width is a function of the distance which the solution drips fall. The further drops fall, the more they splash to create a broader stalagmite (Gams, 1981). Cox *et al.* (1998a) determined from their study of Jenolan and Wombeyan craybacks that they are all elongated, having their long axis greater than their height. However, recent inspection of some examples at Abercrombie, revealed that there are some exceptions to the physical ratio noted by Cox *et al.* (1989a).

Most have one end larger than the other, the larger end being referred to as the head and a tapering off end called the tail. Cox, *et al.* (1989a) found there was no relationship between direction of the most intense light (presumably the region of maximum calcite deposition) and the head orientation of the crayback.

The three main locations of craybacks in NSW, Jenolan, Wombeyan and Abercrombie are in arch or tunnel caves at the bottom of deeply incised valleys. Pockets of temperate rainforest in the bottom of the surrounding valleys help to maintain a higher humidity in the prevailing breezes which blow back and forth with changes in surface meteorological conditions.

Linking speleothems to stromatolites.

You may recall the article published in *Caves Australia* No. 203 (Smith 2018) which provided an overview of the photosynthetic bacteria being among the earliest life form on earth, which created stromatolites and thrombolites. The majority of which grew while immersed in shallow saline to hypersaline waters and, depending on location, may be subject to brief periods out of water.

There are other examples in fresh alkaline water, such as those in the Blue Lake and at least eight sinkhole (cenote) lakes around Mount Gambier SA (Thurgate 1996). However, the photosynthetic bacteria causing the creation of craybacks in caves are only under a thin film of water and may have extended periods when they are completely dry. Cox *et al.* (1989a) states 'they are the only known stromatolites which have formed without even periodic submersion'.

But who was the first to determine that crayfish-like stalagmites in Australian caves were actually stromatolitic structures? James *et al*. (1982) identified that the unusual speleothems in Victoria Arch at Wombeyan were classed as stromatolites. Cox et al (1989a), determined that the stalagmites found in Nettle Cave, Jenolan must be considered as 'stromatolites', because they fit the classification described by Aitken (1967). Aitken's description refers to stromatolites being structures created by an organic film directly trapping or agglutinating sedimentary material or indirectly precipitating calcium carbonate as a result of the life processes of microbiota.

The quandary over a more scientific name for the 'crayback', 'lobster' and 'crayfish-like' stalagmites was finally resolved in the paper by Cox *et al.* (1989b), when they referred to as 'Subaerial stromatolitic stalagmites'. Needless to say the debate over which nickname or colloquial terminology should be used, has continue at various cave sites with the inevitable reference back to historic literature. It is proposed here that the term 'crayback' could be used as a generic nickname, instead of the other terms, which liken the 'Subaerial stromatolitic stalagmites' to a shape similar to a segmented crustacean's back.

Structure and Scientific Value

Physical analysis of sectioned crayback samples from Jenolan and Abercrombie revealed their structure to consist of alternating coralloid and laminated layers and incorporated detrital grains. Their composition was found to be primarily calcite. (Cox *et al.* 1989a and Osborne 1991).

Seasonal conditions cause layering of the crayback structure, 'with solid or coralline layers deposited in wet seasons and allochthonous layers of dust, grains, and animal matter deposited in dry seasons' (Cox *et al.* 1989b).

Uranium-thorium dating by mass spectrometry of a piece of cyanobacterially covered stalagmite from Nettle Cave, Jenolan, indicated the sample was over 20,000 years old. Cox *et al.* (1989b) estimated some of the larger structures to be at least 100,000 years old. Further study of oxygen and carbon isotope data from speleothem layers and trapped organic materials could provide additional past climatic information. Due to their morphology and composition, craybacks represent a well preserved, consistent paleoclimatic record, as they have not been exposed to intense weathering like stromatolites outside the cave environment.

Cyanobacteria

The bacteria creating craybacks, belong to the phylum – the principal taxonomic category - of Cyanobacteria also known as Cyanophyta, which obtain their energy through photosynthesis and are the only photosynthetic prokaryotes able to produce oxygen. The name cyanobacteria, comes from the cyan colour of the bacteria (Greek: κυανός).

'Cyanobacteria (popularly called blue-green algae) are not true algae but prokaryotes (allies of the bacteria). They do, however, carry out photosynthesis in exactly the same way as true (eukaryotic) algae' (Cox *et al*. 1989a).

Cycles of cyanobacteria activity and calcite deposition were observed on crayback stalagmites in Nettle Cave Jenolan, by Cox *et al*. (1989a, b). Below permanent drips in dry periods, the cyanobacterial colonies were active and a deep blue-green colour. Dust and detrital material whipped up by the dry breezes, was observed collecting on the colonies.

The stalagmites then turned white when drip rates increased during periods of heavy and prolonged rainfall. The increased deposition of calcite, partly buries the active cyanobacterial layer which is contributing to the increased calcite precipitation rate. When the drip rate slowed during drier periods, the cyanobacteria continued to divide and break through the calcite crystals to recolonise the surface of the stalagmites in a matter of weeks. Within five months the surface of the crayback stalagmites returned to a bright bluish-green.

Garry K Smith with a crayback in Arch Cave, Abercrombie NSW. Photo by Garry K. Smith

Subaerial stromatolite stalagmite section close-up (sample at Jenolan). Photo Garry K. Smith

However, in extended dry periods the surface of the stalagmites may become dry, causing the photosynthetic bacteria to become dormant, loosing most of their dark green colour and becoming pale green or grey-black.

An in-depth study by Vardeh *et al.* (2018), comparing Jenolan and Wombeyan craybacks, they identified 'significant differences between the microbial communities of speleothem biofilm…' within different caves, '… and between actively accreting and inactive and weathered structures.' There was dominance shifting from Chroococcales to Actinomycetales and highly desiccation-resistant and oligotrophic Rubrobacterales with decreasing water availability.

Taxonomy analysis of the surface bacteria on craybacks showed that cyanobacteria are indicators of active speleothems only, while actinobacteria are mainly indicators of inactive structures and bare rock and soil (Vardeh *et al.* 2018).

Cox (1984), when comparing scrapings of common wall algae - cyanobacterium from the entrance chambers of Spanish and Papua New Guinea caves (Cox *et al.* 1981) - and scrapings from a Jenolan 'Lobster', stated: 'If … this is the alga responsible for the formation of the Lobsters, we have the interesting situation of a fairly common cave-wall alga forming rather uncommon structures - presumably when stringent environmental conditions are met.'

For further reading about other types of subaerial stromatolites, it is worth looking at, *Subaerial freshwater phosphatic stromatolites in Deer Cave, Sarawak - A unique geobiological cave formation* (Lundberg and McFarlane 2011).

Acknowledgement

Thankyou to Dr Julia James for helpful comments regarding terminology used in historic literature.

References

Aitken, J. D., 1967. Classification and environmental significance of cryptalgal limestones and dolomites with illustrations from the Cambrian and Ordovician of South Western Alberta. *Journal of Sedimentary Research,* 37:1163-1178.

Argus. 1898. *The Jenolan Caves and the Blue Mountains*, Cumberland-Argus Newspapers. Parramatta 60 pp.

Barlow E.V., 2017. Conveying the importance of stromatolites to self-guided tourists in Nettle Cave, Jenolan, NSW. *Proceedings, 17th International Congress of Speleology*, Penrith NSW pp. 129-133.

Cox G., Benson, D. and Dwarte, D.M., 1981. Ultrastructure of a cave-wall cyanophyte - Gloeocapsa NS4. Arch. Microbiol., 130: 165-174.

Cox G., 1984. Phototropic stalagmites at Jenolan Caves, NSW. *Helictite, Journal of Australasian Cave Research,* 22(2), 54–56.

Cox G, James JM, Osborne RAL, Leggett KEA, 1989a. Stromatolitic crayfish-like stalagmites. *Proceedings of the University of Bristol Spelaeological Society*. 18(4): 339–358.

Cox G., James J.M., Leggett K.E.A., Osborne R.A.L. 1989b. Cyanobacterially deposited speleothems: Subaerial stromatolites. *Geomicrobiol Journal*, 7(4): 245–252.

Dyson, J., Ellis R., James, J.M. (eds) 1982, *Wombeyan Caves*, Sydney Speleological Society Occasional Paper No. 8, ISBN 0959960848

Gams I., (1981). Contribution to morphometrics of stalagmites. *Proceedings, VIII International Congress of Speleology, Bowling Green,* pp. 276-277.

James J. M., Jennings J. N. and Dyson H. J. 1982. Mineral decoration and weathering of the caves, [in] Dyson, J., Ellis, R. & James, J. M. (eds), *Wombeyan Caves*. Sydney, Sydney Speleological Society. Occasional Paper No. 8. pp. 121-136. IBSN 0959960848

Lundberg J. and McFarlane D., 2011, Subaerial freshwater phosphatic stromatolites in Deer Cave, Sarawak — A unique geobiological cave formation. *Geomorphology,* No. 128, pp. 57–72

Mulec, J., Kosi, G. & Vrhovšek, D. 2007. Algae promote growth of stalagmites and stalactites in karst caves (Škocjanske Jame, Slovenia). *Carbonates Evaporites*, Volume 22, Issue 1, Article 6, Published by Springer Netherlands, ISSN 0891-2556

Osbourne R.A.L. 1991, A Geological Review of Abercrombie Caves, *Helictite*, Journal of Australiasian Cave Research, 29(1): 8-18. lSSN : 0017-9973.

Smith G.K., (2018), Karsting light on Stromatolites and Thrombolites**,** *Caves Australia,* 203: 11-13.

Thurgate, M.E. 1996, The stromatolites of the cenote lakes of the Lower South East of South Australia. *Helictite,* 34 (1): 17-25.

Vaughn-Taylor K. 1991, What Happened At Yessabah, *Proceedings of 18th Biennial Conference of the Australian Speleological Federation,* Margaret River W.A. pp. 108-113

Vardeh D.P., Woodhouse J.N. and Neilan B.A., 2018. Microbial diversity of speleothems in two southeast Australian limestone cave arches. *Journal of Cave and Karst Science*, 8(3): 121-132. Publish by the National Speleological Society, ISSN 1090-6924

Melissa Hadley next to crayback in Nettle Cave Jenolan, NSW.
Photo by Garry K. Smith