ANDYSEZ 59 - Thick stalagmites … and thin ones - is there a conundrum?

Here is another Guest ANDYSEZ - this time from **Professor Andy Baker** from UNSW Sydney. Andy B is very well-known figure in the world of cave and karst science. He and his colleagues are conducting research into karst processes at several sites in New South Wales and Western Australia.

Andy S will make some comments following Andy B's note.

Explaining girth … of your stalagmites. Why are some stalagmites thicker than others?

Aerospace and cave research colleagues in Belgium and France have joined to recently publish a paper explaining all (Parmentier, J. et al, 2019). The title of the paper has the answer: 'A drop does not fall in a straight line: a rationale for the width of stalagmites'. Published in the Proceedings of the Royal Society, this is very technical fluid mechanics, so I will try to summarise.

First, the observation. You can have a stalactite with a drip source that never moves, yet the water lands at different places on the floor or a stalagmite surface. The authors use high-speed photography to show five drops coming from one stalactite but landing on different spots on the same stalagmite, up to 13.15 centimetres apart (Figure 1).

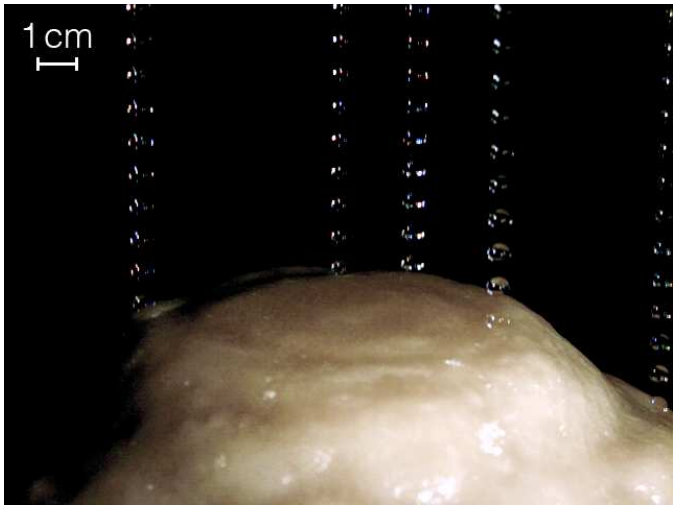

Figure 1. Distribution of drops across a stalagmite from a single source in Aven d'Orgnac, France. Image courtesy of Dr Justine Parmentier.

All water drops falling more than a few centimetres will have these chaotic vortices - pushing them, each time, a little bit more out of a vertical, straight line.

So, the further a drop falls, the longer the time it spends falling and the more opportunity for these random forces to push the drip from the vertical. The authors report impacts onto a stalagmite that are 13.15 centimetres apart. Maybe you will see something larger in your cave?

And the further a drop falls, the faster it will fall. And the faster it is on impact, the greater the amount of splash (Figure 2).

Why does this occur? It turns out that, as a water drop falls, its motion is quite complex. The authors report that vortices appear periodically in the downstream wake. These behave chaotically after just a few centimetres of falling.

If the water is saturated with calcite, then more splash means a wider area for stalagmite formation and a wider stalagmite.

The authors calculate the velocity of a drop for us. For a 10-centimetre distance from stalactite to stalagmite, the drop will have a velocity of about 1.5 metres per second at impact. At a one-metre drop distance, the velocity will have reached four metres per second at impact. And at 10 metres from the drip source, the velocity will be over eight metres per second. At even greater distances, the velocity doesn't get much faster, as the drop can't go any faster than the terminal velocity of around 10 metres per second.

So, there you have it. To explain the girth of your stalagmite, you just need to know the distance the drop has fallen. The further a drop falls, the more variable is its impact point. And the further a drop falls, the faster the velocity on impact, generating more splash.

Which means that, in your cave, if you have even a short way for drips to fall, the impact points would widen, and it would be impossible to form a minimum-diameter, candlestick-shaped stalagmite (this has been calculated to be three centimetres wide, Curl 1993). Which matches my observations. And probably those in your cave … (and, if you do see a minimum-diameter stalagmite and you have a high ceiling overhead, it means the stalagmite formed closer to the ceiling, and one or both have moved since then).

Figure 2. High speed camera set up in the Aven d'Orgnac, France. Note the splash 'umbrella'. Image courtesy of Dr Justine Parmentier.

More from Andy S

Accompanying this ANDYSEZ is an image of 'Cleopatra's Needle' in Jersey Cave, Yarrangobilly. NPWS IT officer for scale - sorry you can't quite see the top of the classic 'candlestick' stalagmite (Figure 3).

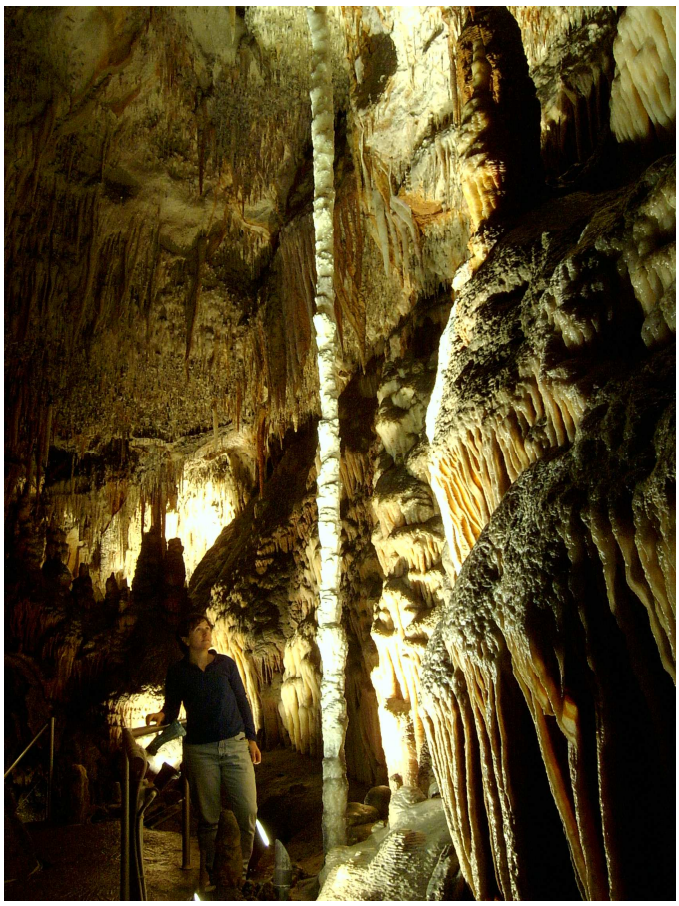

Figure 3. Cleopatra's Needle, Jersey Cave, Yarrangobilly, New South Wales. A tall constant diameter stalagmite. Andy Spate

Looking at Andy B's last comments, we have a six-metre-plus candlestick of virtually constant thickness. There is not enough time for a drop to reach terminal velocity, even when the stalagmite was small, but still enough height that drip deviation and splashing occurs, forming a wide candlestick stalagmite. This begs the question - can minimum-diameter stalagmites form?

The splashing distribution on thick, and often tall, stalagmites helps us to understand the often complex, small-scale structures that we often see around the base of such stalagmites.

Figure 4 shows some of these blades and similar structures around the base of a 10 to 15-metre-tall stalagmite - the roof was approximately 10-15 metres above. My only image of the whole of this stalagmite is too fuzzy to show - as is a closely related image of a dog lifting his leg on a small stalagmite - common in France and to a lesser extent in Italy.

But immediately adjacent to the big stalagmite - maybe no more than 10 m away - were these small, constant-diameter stalagmites - same roof height (Figure 5).

Figure 4. Blades around the base of a very tall stalagmite, Aven d'Orgnac, France. Andy Spate.

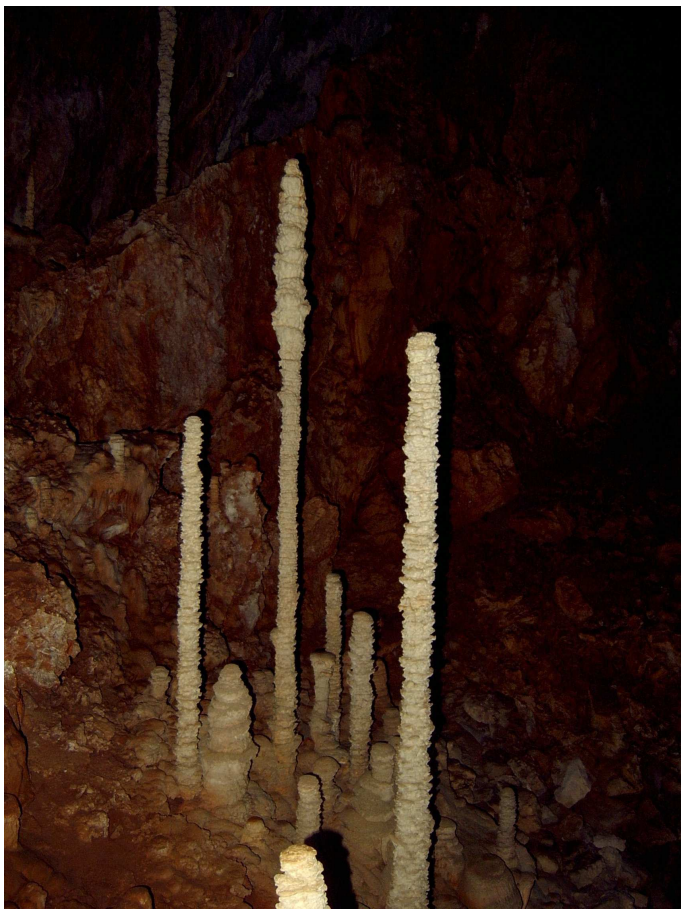

Figure 5. Constant diameter stalagmites adjacent to the very tall stalagmite in Figure 4. Andy Spate.

Similar narrow, relatively constant-diameter stalagmites, such as Cleopatra's Needle, but with different surface morphologies, occur frequently. This is the conundrum. Things, as usual, in caves are not simple. How do these constant-diameter stalagmites escape from findings of Parmentier et al? As they say, not all the answers lie in the field of fluid dynamics. Andy B and I postulate that drip rates may well play a role in producing constant-diameter stalagmites - intermittent dripping such that we might expect in many Australian caves (relative to the wet and massive Aven d'Orgnac) may help prevent stalagmite thickening.

There are many other factors which may play a role in producing both complex and constant-diameter stalagmites. The degree of saturation of the drip waters may well have an influence.

For a fine discussion of speleothem architecture, see Chapter 7 of Fairchild and Baker (2012). The book's diagrams and images are available online.

References

Curl R, 1993, Minimum diameter stalagmites, Bulletin of the National Speleological Society, 35:1-9

Fairchild, Ian J. and Baker Andy, 2012, Speleothem Science: From Process to Past Environments, Wiley-Blackwell.

{Wonderful reference!!}

Parmentier J, Lejeune S, Maréchal M, Bourges F, Genty D, Terrapon V, Maréchal J-C, Gilet T, 2019, A drop does not fall in a straight line: a rationale for the width of stalagmites. Proc. R. Soc. A 475: 20190556. http://dx.doi.org/10.1098/rspa.2019.0556

{Andy B can send a pdf to anyone interested on request (please e-mail a.baker@unsw.edu.au).}

Column, Aven D'Orgnac: Tim Moore

Visits to ancient cave art sites in France

Tim Moore

For several decades, I have been fascinated by the story of the discovery of the Palaeolithic cave art at Lascaux and had promised myself that, should the opportunity arise, I would like to visit. This interest was compounded by the broadcasting on SBS of Herzog's documentary entitled the *Cave of Forgotten Dreams* about the Neolithic cave art discovered in the Chauvet Cave near Vallon-Pont d'Arc in the Ardêche Gorge. Indeed, several years later, my family and I went whitewater kayaking down the Ardêche River past the location of the Chauvet Cave.

As time went on, I read with interest of the intention to make an appreciation of the beauties of the Chauvet Cave available to the world in a fashion that preserved integrity of the cave itself – with this to be achieved by creation of an replica with associated interpretation and educational facilities. The complex for this, known as Chauvet 2, was opened in 2012. I mentally put Chauvet 2 and Lascaux on my "bucket list".

A visit to France for December 2019/January 2020 to have Christmas with my eldest daughter and her family provided an opportunity for me to fulfil these desires. Study reasons for my youngest daughter's HSC in 2020 meant that she and her mother would leave me and my 15 year old son (who shares my interest in caves and caving) with 10 days in France to indulge my desire to visit Lascaux and Chauvet, amongst other locations.

With careful planning, although these two sites are some 600 kilometres apart (going "the long way" via Carcassonne and Rennes-le-Chateau), I crafted an itinerary that permitted us to visit them both as well as tick off several other locations on my "bucket list" unrelated to caves (not to be dealt with in detail, but, for those interested in the "*Jesus' bloodline still exists in France*" conspiracy theory underlying Dan Brown's *The da Vinci Code* and its thematic basing on the conspiracy theories in the book *The Holy Blood and The Holy Grail*, a visit to the small hilltop village of Rennes-le-Chateau is fascinating).

As part of our cave related itinerary elements, I included a visit to L'Aven d'Orgnac (enabling me to contribute a photograph to the Andysez above and to interview my 15 year-old son for the purposes of the piece following this one about his adventure caving at this site).

To round off our cave related itinerary elements, I included visits to Grotte de Font-de-Gaume, a Neolithic cave art site near Lascaux, and to La Roque Saint-Christophe, in the Vezere River valley, used as a human habitation site from the Neolithic period to 1588. Grotte de Font-de-Gaume is described in this article and a short piece about La Roque Saint-Christophe will be published in the June journal.

Before commencing my description of the three sites we visited, there are some preliminary observations to be made. First, as a matter of practicality, photography is not permitted in any of them. While, for Chauvet and Lascaux, the reasons for this are practical (as flash photography would not damage the reproduction of the artwork, but would it significantly inhibit the visitor experience), at Grotte de Font-de-Gaume, it could damage the pigmentation of the art itself.