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WHAT IS A CAVE?

- Andy Spate

I have always regarded this a fairly trivial question – but I can now see very good reasons for being careful with definitions of caves. I am sitting in Melbourne Airport waiting for an aircraft to fly to Perth where Rauleigh Webb has shanghaied me to appear in a Mining Warden's Court as a witness on behalf of ASF. The Federation has lodged an objection to a limestone quarry within a "Reserve for Conservation and Limestone Resource Management" (such a reserve is a bizarre-enough concept in itself!) at Cape Range.

When Elery, Kevin Kiernan and I visited Cape Range in 1996 to report on karst conservation and values for the Western Australian Government we were struck by the definition of a cave used by a quarrying proponent at that time. We will come back to this definition later.

Many of you who have heard me and others pontificate on cave development in the past will remember that we have talked about protocaves and microcaverns – spaces in the rock up to about 6 mm diameter – which are the precursors of the caves that you and I can visit. Again we will come back to this.

The usual way of starting to think about definitions is to look in a dictionary (and this must be the Oxford English Dictionary! (OED)). So here goes… The New Shorter OED states:

> "Cave… 1. A large natural underground hollow, usually with a horizontal opening.
> 2. Political. A dissident group (compare with Adullamite) (Mid 19th Century)."

I couldn't resist looking up Adullamite, could I!

> "2. A frequenter of the cave of Adullum [in Canaan].....; figuratively a member of a group of Liberal rebels in the House of Commons in 1866; a member of any dissident political group."

However, this diversion should be abandoned very quickly (unless it has some relevance to the Republic debate?). The OED definition doesn't help much better with caves either. What is "large", for example?

The Australian Speleological Federation Inc defines "cave" as follows:

> "A natural cavity in rock large enough to be entered by man. It may be water-filled. If it becomes full of ice or sediment and is impenetrable, the term applies but will need qualification." [The size of the "man" is also relevant?]

Joe Jennings (who developed the above definition), in his book *Karst Geomorphology,* says:

> "A cave is usually defined anthropocentrically as an underground space into which one can get. Although this size limit governs the way in which we learn about caves, it has no significance as regards natural processes.... Thus, although the common idea about what constitutes a cave is a practical one to adopt, it is important to remember that accessible passages connect with larger volumes of impenetrable fissures and small tubes which function in much the same way" [as the larger spaces; emphasis mine].

Dave Gillieson, in his book *Caves: Processes, Development and Management* asks:

> "**What is a Cave?** Your choice of definition will depend on your dominant interest in these widespread and fascinating landscape features. A strictly scientific definition would be that *a cave is a natural cavity in a rock which acts as a conduit for water flow between input points, such as streamsinks, and output points, such as springs or seeps* (White 1984).... A simpler, non-scientific definition would be that *caves are natural cavities in a rock which are enterable by people*. This implies a minimum size of about 0.3 m diameter.[?]

Whilst agreeing that White's definition is getting there it needs further discussion. Is an old cave high up in the landscape which is no longer a conduit now not a cave? What about a cave produced entirely by dispersed rain infiltration – is this not a cave? Or a cave which is a conduit but discharges to a groundwater basin with no definable or findable outlet? (This is possibly being a little too pedantic.)

In 1996, a limestone quarrying proponent at Cape Range proposed in a letter to me that a cave is:

> "... an open cavity within the limestone formation being mined exceeding 2.0 m diameter horizontally or 1.0 m vertically and giving reasonable indications of extending to the water table."

I suspect that these dimensions relate to the sort of sized hole that non-cavers feel that they are able to move through or where they might not feel totally claustrophobic? I am not sure about the horizontal/vertical differences either – the dimensions of an inclined cave will vary with its slope!

All of the above is long-winded and tedious background to the sorts of arguments that the Mining Warden is going to have to listen to over the next few days. If we are going to think about the health of the physical, chemical, atmospheric and

biological health of karst systems – all of the complexities that I have rabbited on about in the past – we clearly need to think about things much smaller than Gillo's 0.3 m.

If I, and others, are going to be able to convince Mining Wardens on this and future occasions that the health of karst ecosystems might depend on small spaces, formal, adopted definitions such as ASF's might not help our cause. We will see what happens… Stay tuned.

Well we have now had the first two days of the hearing and Elery, Stefan, Bill Humphreys (troglobitic scientist at the Western Australian Museum) and I all argued the case for smaller things to be considered caves. His Worship, the Mining Warden, seemed to understand what we were going on about – as did the Counsel for the applicants. But how palatable the concept is legally remains to be seen…

As you have endured the torment of all the above, assuming you have had the stamina to read this far we might examine what various people have had to say about things smaller than "man"-sized.

Jennings says "a significant natural limit is the diameter of around 1 cm…". Gillieson suggests that "…once this type of conduit has a diameter larger than 5-15 mm, the basic form and hydraulics do not change much, though the diameter can be as much as 30 m".

Conventional groundwater hydrology is based on the assumption that the aquifers are considered to be simple porous media in which Darcy's Law operates with laminar flow. (We won't go into Darcy's Law at this time – we might come back to groundwater mechanics in a future ANDSEZ. Laminar flow is the sort of smooth, bubble-free flow you get when you turn on a tap gently and you get a nice conical stream of water running into the sink. Turn it on harder and you get bubbles and turbulence.) But even in well-sorted sands and gravels water behavior will often depart from the theoretical. The presence of large, open conduits (greater than 5 mm or so) in which laminar flow is replaced by turbulent (= critical) flow regimes as in karstified rocks produces great changes in the dynamics of flow systems.

Ford and Ewers (1978) consider that the lover limit for critical flow is about 6 mm diameter. Below this size solution and mass transport of dissolved materials is slow. Once critical flow is developed both solution and mass transport can become very rapid dependent on the rate at which water moves through the system. So from a karst geomorphologic process perspective about a quarter of an inch is a good starting size for defining caves. Caves of this size are called *protocaves*.

What about from other perspectives? Let's try the creepy-crawly brigade. The spaces through which subterranean fauna move have their own nomenclature as defined by Howarth (1983):

> "In both soluble and volcanic rocks, therefore, a great complex of inter-connected voids of varying sizes anastomoses throughout the rock in a great labyrinthine system. Within this system there is a continuum of various sized voids from the microscopic to the largest caverns. The existence of these voids, their size, depth, and extent, depends on the geological history of the area. From a biological perspective, this continuum can be divided into three size classes: microcavernous (<0.1 cm), mesocavernous (0.1-20 cm) and macrocavernous (>20 cm)."

The total volume of micro- and mesocaverns voids may exceed the volume of man-sized caves. Much cave fauna is essentially mesocavernous; these cavities maintain high humidities and sometimes high carbon dioxide levels both of which may be essential for the maintenance of these communities. The occurrence of animals in large (man-sized) caves must often be as an accident of their mobility; they sometimes tumble into, or enter in their search for food, spaces big enough for humans to find them in.

While we are talking about man-sized caves we might talk briefly about the chance of finding caves by "traditional" drilling techniques as used in the mining industry. Commonly we see statements along the lines of:

> ….x holes (commonly less than 10 per hectare) were drilled and no caves were encountered."

The implication is that there are no caves on the site – the existence of the smaller, geomorphologically and biologically significant caves are simply not considered. They do not exist in the minds of geologists and drillers – although the latter are often highly inconvenienced by karst features within the rock mass.

An unpublished 1967 BHP drilling report that I have seen recently suggests that, at Cape Range, one drill hole is adequate to sample 1000 square feet (say 10 x 10 m). Thus, by this measure about 100 holes are required in each hectare to sample the rock mass.

Benson and La Fontaine (1984) provide estimates for the number of drill holes required to detect a cave of the following sizes nine times out of ten (a 90% probability; metrification mine):

- Cavity size of 23 m diameter: Requires ~ 25 holes per hectare (one every ~ 400 square metres).
- Cavity size of 7 m diameter: Requires ~ 250 holes per hectare (one every ~ 40 square metres).
- Cavity size of 2.3 m diameter: Requires ~ 2500 holes per hectare (one every ~ 4 square metres).

These calculations assume uniform grid spacing. If the drilling locations are randomly selected the number of borings increases!

Might do less damage to let them quarry! In the interests of space I have not included the references. Please ask if you want the full citations.