Under the Jungle - Geo Karst challenge - Sunday June 14

TAJMA HA GEOLOGY game.

Nat says - Bubbles on the ceiling -- what do they tell us about the cave. Sometimes bubbles collect on the ceiling and make a nice pretty reflective effect on the exit, like in this shot with Hana Cho, sometimes there are bubbles collected on the ceiling even before we enter a place, and sometimes . . . no bubbles. I am sure this has to do with the geology of the cave, but I bet there's quite a bit I don't know about it. What does this tell us?

What are the bubbles and where do they come from?

Yeah - most simply - they are exhaust bubbles from open circuit.

It is possible that in some odd cases there is some gas production inside the caves, but overall the organic matter content in the water, and especially in the cave sediment, is really really low. In the Yucatan - in water production of gases in "clean" cave water is very low potential. Globally, there are some caves where gas does come out of the water, but those are geothermal rising waters in caves, which is not the case in Yucatan.

Where does the air go?

Where possible, the bubbles flow literally through the rock. We have all seen the rocks with obvious holes and tunnels the size of pencils or even your arm going through them. Indeed, wherever the water can flow down through the rock to create stalactites - then that rock bed can typically also have the air flow upwards through it (tip to Lexi!).

It will rise until it hits the surface, or .... Another bed of very hard and "closed" rock. If that "closed" low porosity/low permeability bed happens to be the cave ceiling - then you have nice flat ceilings that hold bubbles well for days - weeks (maybe months?). In QR/Yucatan - we have many beds that are very closed - called caliche (more on that below...)

Also - since the ceiling is flat, a given volume of air will have to spread out so creates a larger surface area bubble. 10 L of air but only 1 cm thick is a very big puddle. If the ceiling is uneven, then you can have 10 L of air easily fit in only a few small ceiling pockets.

Air does diffuse into water (tip to Luca!) - and so not only does the air bubble get depleted by rising up through the rock, cracks, fissures, but it also over time dissolves into the water of the cave.

A story of porosity and permeability

Since we have some bubble entries from Australia - and people diving in Florida, etc - I am going global with this.

Some rocks (the matrix) are dense and don't have much air space in them. They are low **porosity**. The rock in the Yucatan peninsula is mostly between 5 - 45% porosity. High, but also typical of young rocks that have not been geologically tortured much yet. Burial. Compaction. Infill sediments. Cementation. All reduce porosity over time. Compare the average ~17% for Nohoch Nah Chich area (and Yucatan Peninsula in general) to Kentucky, Mammoth Cave, which comes in at ~2%.

For all karst systems - even where the porosity is only 2% - most of the water 96-99% in the system is actually inside the rock matrix. That is because the rock between the caves is just so much volume.

FLUJOS HIDROLOGICOS ESTAN CONCENTRADAS EN LOS SISTEMAS INTERCONECTADAS, TIPICO DE CARST

		Matrix	Fracture	Conduit
Porosity	Mammoth Cave, KY	2.4 %	0.03 %	0.06 %
	Nohoch Nah Chich, QR	17 %	0.1 %	0.5 %
Proportion of Storage	Mammoth Cave, KY	96.4 %	1.2 %	2.4 %
	Nohoch Nah Chich, QR	96.6 %	0.6 %	2.8 %
Proportion of Flow	Mammoth Cave, KY	0.00 %	0.3 %	99.7 %
	Nohoch Nah Chich, QR	0.02 %	0.2 %	99.7 %

(Worthington, Ford & Beddows 2000)

We have all heard the analogy of the Yucatan being a big sponge - and that is an okay way to think about the rock. The sponge holds water - but water also flows through and out of it. We call that flow in hydrogeo the hydraulic conductivity, or **permeability**.

[FYI - It is not suitable to call the aquifer swiss cheese - since the bubbles in swiss cheese are closed - and there is zero permeability.]

Of course - water moves most easily through the big conduit caves.... But some can and does move through the rock itself. There is some permeability between the pore spaces giving some permeability to the rock matrix - AND we also then have the **fractures, fissures, bedding planes - lets throw in some tree roots** - whatever you got.

With bubbles though - they are stuck up against the ceiling because of buoyancy. They are not just going with the flow. With water, normally we have 0.02% of the ALL flow in the system is through the rock permeability, but with the bubbles, they have the vertical force driving them up through the matrix permeability and there is most often enough for them to go away slowly - over hours, days, etc.

Could the air bubbles be ancient trapped air?

While that is exceptionally unlikely since the air dissolves into the water..... What is more likely is to have trapped old water. Wherever there is a rock layer that is very closed, with very low permeability, then yes water gets trapped under these "aquicludes". Indeed having layers of no permeability rock - that is required for having oil reservoirs! If there is no pressure to drive the flow, then ancient water can persist. In atoll islands, including the ones off the north coast of the Yucatan, the sea level rose fast enough to flood the top of the island and the paleo fresh water is still there inside the inland thousands of years later, since there is nothing to drive the flow. It is brackish now from diffusion, but still not pushed out by the marine water around it and on top and below it. The trapped water is called "connate water".

FYI - sump divers in "continental" older karst rocks - like many sites in Europe - have some very long persistent air bubbles. Months old.

FYI 2 - The best rock for hydrocarbon traps is actually salt! Since it literally pressure-melts and welds absolutely closed.

What are these really low permeability layers -

including caliche?

In the yucatan, one way we have really low permeability rock is where it is super fine grained (shallow marine) so there was no air and no permeability when it formed (see picture). You can take this super fine grained marine micrite and flake it into blades if you like.

Bonus! **CALICHE!!!!** Wherever the rock used to be exposed on the surface, we also have **caliche**, which is also called calcrete, and kankar.

There is a nice piece propped up artistically at the entrance to Cuzel with a tree root hole in it. The picture (yellow border) is the caliche they cut through outside of Zero Gravity when they put in the overpass. There are alot of weeds now and it is dirty with exposure, but this was the week it was cut. You can see that it is 0.5-1 m thick and not much water is going to get through it.

Caliche is also often the flat extensive ceilings of many passages - since the rock below was easier to dissolve. Many caliche ceilings provide strength to the chambers and conduits underneath. They are only so thick though. The rotary "trenchador" machines they use cut into them, and other types of heavy equipment break them up. If the structural ceiling over a chamber is only 0.5 m thick.... collapse may follow.

Caliche forms when the rock on the surface has all the pore spaces filled in with cement. When it was exposed on the surface and there is just a bit of rain (not a downpour), there was a bit of dissolution, but then it dried out and the mineral then cemented closed all the pore spaces - thus removing all the permeability..... Well except through the tree root holes and fractures and such.

Overall - caliche and the fine grained marine beds are pretty solid, low permeability. You will see water running along the surface until it hits a fracture, or tree root hole, and then goes down. You also have some good sections of cave where the water is forced to flow underneath the caliche, until there is a break, and then water flow level can jump down, or UP!!!! [Does that make you think of anyplace??? :-)]

One implication of caliche, is that contaminants can accumulate on top of them (ie like gasoline leaks)- until they get flushed out in quantity by a big rain....

Also - it is the fine grained marine sediment, OR the caliche why you have sections of ceiling with no stalactites..... Since very low permeability [Tip to Christine! Although sometimes the stall gets too heavy and whole sections of ceiling fall off - you can see that in places in Rio Secreto].

What are the bubbles rising from open water cenotes?

In open water cenotes - there is just so much more organic matter. Bubbles will be produced by the rotting vegetation. If you have green photosynthesizing plants - you will also have bubbles of oxygen rising off of them on sunny days! You will see them next time you are doing a shallow exit in Eden, or Car Wash.

Why the Nohoch bubble puddle around the column in NNC?

Hard to say, but looks like the ceiling is caliche around the column - with the caliche texture to the front left of the column. The column itself looks a bit atypical for a stalactite-meets-salalagmite column. It is too even sided in the upper portion. It may be a calcified tree root hole that has turned into a column.

Bubbles being a few days to week+ old is very possible.

Global! Go karst!