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Report of Lechuguilla Cave trip

(15 h inside)
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I - Motivation

I.1 – Jean-Yves Bigot

My name is Jean-Yves Bigot, I live in South-east of France and I'm caving for 35 years.
In 2000, we have made the first recognition of a hypogenic cave in France: the Adaouste Cave, in Durance Valley, Provence (see AUDRA Philippe, BIGOT Jean-Yves & MOCOCHAIN Ludovic (**2002**) – Hypogenic caves in Provence (France). Specific features and sediments. *Acta Carsologica*, 31/3, Slovenska akademija Znanosti in Umetnosti, pp. 33-50).

After that, we have extended our researches in whole Provence. By the way, we have concluded that many hypogenic caves occurred in Southern France, even if nobody noticed them.
In 2002, we have visited a few caves in Central Italy (Frasassi, Acquasanta, and Giusti), because the Italian were more advanced in this thermal speleogenesis knowledge.
We have proposed "new" theories of speleogenesis, but we have noted that they already were known in most of speleologists of English language...
After to be aware that the French speleology was behind the American, we have accepted the great offer to visit Lechuguilla Cave with Peggy and Art Palmer.

It exists many kind of hypogenic caves, but Lechuguilla Cave and the most of Guadalupe Mountains Caves are the sulfidic caves which keep many witnesses of the genesis as gypsum in particular.

The goal of our visit was identified features and characteristics with all minerals and deposits in situ. The huge caves and the arid climate have keep well preserved as amount of gypsum, many vents and replacement pockets, speleosols, etc…

On the footpath of Lechuguilla Cave.

I.2 – Laurent Bruxelles

I do caving for 20 years, and since the beginning, I want to understand a very complicated karst systems in the south of France: the Trabuc Cave. It seems that it is not a hypogenic cave but there are special features as ghost rocks and a lot of gypsum. By this trip in Lechuguilla, I wanted to see some key points and to understand the main processes. As there are some big faults in the south of France, associated with hydrothermal mineralizations, it is possible that this kind of speleogenesis have contributed to the development of some caves. See the most famous example could be a good way in order to learn to recognize them in my futures researches.

II - Observations

We attempt to answer of questions of the guide book made by Paul Burger, Art Palmer and Peggy Palmer.
Although the answers are well-known and we haven't got pretension to learn to authors or guides how their caves formed…
Of course, the answers are own opinions and nothing else, no true, no judgement.

1. Hike to cave entrance

On the footpath, we can see little lapiaz, but the arid climate of this area (few rains) does not allow a big development…

Weathered rock. The soils preserve the limestone, while the uncovered parts are exposed to the rain. When it rains…

2. Cave entrance

Topics for discussion: Was this an old water input? A spring? Neither? Is there any evidence of the speleogenetic process?

It's clear that the entrance is not an old water input. It's difficult to find evidence in the shaft entrance, but we can give an answer by watching the profile.
It's difficult to believe that the actual entrance is the only outlet of the system. Generally, there are many outlets formed during the cave activity.

Cave entrance area. Let's go to Lechuguilla Cave.

On the profile, the entrance zone is the highest known, but did the top of all chimneys completely explored?
Did the explorers go further or stop very soon their trip according advices and recommendations provided by the National Park (for cave preservation for example)?
In this case, it's possible that other outlets exist, but yet unexplored.
As we can suppose that the cave is older that the landscape, we think that the entrance corresponds to an accidental opening. In fact, the digging and the widening of the little valley cut the summit of an old chimney, perhaps because the cave and the valley follow the same discontinuity (fault, breccias, paleokarst…).

3. Boulder Falls

Take the opportunity to look at the morphology of the shaft. Is this a typical vadose shaft, or was it formed by rising water? Is it possible that some (or even all) of the dissolution took place in the vadose zone, by atmospheric H2S being absorbed by moisture on the cave walls?

I didn't notice the features in boulder falls, because we were focusing on our descent.
It's obvious that the volume doesn't result of typical vadose shaft. However, the main evolution of the shaft was made in vadose conditions.

Top of the Boulder falls. The circular form of this conduit doesn't look like a typical vadose shaft…

The evidences are the gypsum blocs in the bottom, fallen from the walls and accumulated in the bottom of the pit. Of course, it exists also limestone blocs but the most of the void results from the dissolution by atmospheric H2S.

The evidence takes place on the top of the shaft where we can see a little rim on the ceiling of the gallery just 5 meters before the shaft.
I think that the voids of this shaft result of the atmospheric dissolution, its evolution was made by expansion and its functioning will be as well as a "smoking shaft".
It is not sure that the entrance series had been used by the water, as an old spring.
It's possible to assimilate these upper parts as the fissure which was only expanded by the smoking shaft while the outlet of spring was located lower.

In general the passage follows the dip of the beds. It is possible that rising water was confined by the beds, as the passage ceiling follows the bedding dip in many places. Can you see any evidence for this?

We didn't see evidence in this cave, but I have seen that in many cases in the caves we have surveyed. Generally, in the bedding layers, the conduits formed a maze pattern in 2 D. We've noticed it in many hypogenic caves of Gréoux-les-Bains (Provence, France).
But it isn't sure that the water has followed the beds, the atmospheric H2S can also follow the beds of the same way…

4. Glacier Bay

How can we explain the dual-level aspect of the room? Was there a drop in the water table, or is there some geochemical process that can account for it? Does it appear that the passage formed all at the same time below the water table? Or could it have formed during various stages of a dropping water table, with pauses at certain levels, such as Glacier Bay? If so, does Glacier Bay represent a major pause in the water-table drop? Did the massive gypsum form in ponded water? Did it accumulate from pieces that dropped off ceiling and walls into water? Was there no ponded water at all?

I don't know Land Down Under, but it seems that Land Down Under an Left Hand Corridor may be an ancient level of ponded water.
Glacier Bay is developed in vadose conditions into the beddings of layer. The dissolution atmospheric H2S on the wall and roof has probably enlarged an initial maze pattern developed in beds.
There are not two levels, but only one. The false level of Glacier Bay result of atmospheric dissolution provided by the ponded water located just under the Glacier of gypsum as the Frasassi Caves (Italy).

The glottis in Glacier Bay. The drips have dug many holes in massive gypsum deposit.

The massive gypsum was formed above the ponded water, but if the level rises, the gypsum would surely disappear.
I think that the level of watertable has dropped down; therefore the massive gypsum had been preserved.

5. Windy City

Are there questions or comments about the origin of any of these features?

The vents show that Lechuguilla Cave is naturally ventilated before its closure.
Why the air-look entrance has been installed?
Probably in the goal of cultivate mushrooms as in Lascaux Cave?

The vents are very impressive. There are non common in Europe.
It seems that they are also developed after the cave activity according to the observations made before the closure (?).
It will be interesting to know if the vents appear after or while the limestones were dissolving and gypsum was accumulating.

In France, there are some kinds of vents but without gypsum. There are vents with rims of calcite (Chat Cave, Alp Mountains, France).
These are developed in vadose conditions when the water table was located a few meters underneath.

A vent in Windy City. This form is very common in Lechuguilla Cave.

6. The Rift

It is generally thought that the Rift was once a zone along which H2S-rich water rose, and that the widest part, at the top, is where oxidation of H2S and production of sulfuric acid was most intense. Does this appear to be a valid interpretation?

Yes, I believe it.

The Rift. You have to use a rope (traverse), because the gap is behind you.

The Rift. The clastic dikes facies of the Rift.

F Survey. These forms result of atmospheric weathered extended by expansion, probably after a former stage where the replacement pockets of gypsum attack the limestones.

7. E-F Junction

There is a nice tray at Junction ("dinning room").

E-F Junction. This tray (horizontal limit of crystal growing) results of different densities of air.

8. F Survey

Is there any discussion about what might account for this steepening?

No, it's always possible that the others conduits located underneath are unknown.
It's a detail in the footpath, the route rise and after go down.
I am not chocking about it.

F Survey. The brown weathering residue is called speleosols, it covers the rock and gypsum crusts.

Have you seen examples elsewhere? Any comments on its origin and chemistry?

It seems that there is some speleosols in Trabuc Cave. This kind of black powdery deposit reminds me some places in that cave. In fact, I thought first that it was only due to the weathering of the walls. Now, I must reconsider it and launch some studies in order to see if it is speleosols or not.

9. Descent to Lake Lebarge

Discussion: What is the origin of this solutionally aggressive water?

We've seen deep rills in Vapeur Shaft (Pyrénées, France) and Adaouste Cave (Provence, France) which display a gradient. Of course, there was very aggressive water in the part of cave. We've seen deep rills in Vapeur Shaft (Pyrénées, France) and Adaouste Cave (Provence, France) which display a gradient.

In the upper parts, when the aerosols rise and condense on the cool walls, they weather the ceiling but form many drips loaded of aggressive acid, then those fall on the floor and form a little catchments providing and digging the rills.
The deep rills are due at the difference in levels, because there is the most difference of temperature; it's one of reason of the condensation.
I don't believe that it is the end stage. Of course, the water table is underneath but for the phenomenon condensation exists, it needs the hot water table closed or not far, may be 30 or 50 m below…

The Lake Lebarge. A very nice place.

10. Lake Lebarge area

The Lake Lebarge is a very nice place. In the pools, there are special speleothems called in French "atolls".
These are developed at the surface of the water and display arabesque forms when there are enclosed.

Lake Lebarge. The "Atolls" grow up from the bottom.

At the beginning the calcite grows up on the bottom of the pool, then they are reached the surface, they are developed as well as pool rims. The direction of pool rims is particular ant depends of the stream way and many others conditions, probably biochemical.
In this case, the atolls of Lake Lebarge display convex part is adjusted front of the stream.

But observe how rapidly the passage diminishes in size in our direction of travel. Does this passage seem to represent a former stable water table?

I think that this passage represent a former watertable. The diminution of size is due at the origin of flux located below the blocs of Lebarge Borehole gallery; it's the reason why the section is reduced. The continuation is underneath of course. In another scale, the Chat cave (Alps, France) displays the same features, the continuation is located below the former watertable, but it's too narrow, because the scale is human. Here too, this continuation represents also a former origin of flux.

11. Yellow Brick Road

Are you familiar with other cave deposits of dolomite? If so, do they share this origin?

No I'm not familiar with the mineralogy. It seems to be very rare in caves.

12. Tinseltown Maze

Note the brecciation of exposed bedrock, especially in projections, caused by the crystallization of gypsum along fractures and in pores (Figure 19). Any comments about the brecciation process? Is the gypsum growth driven mainly by evaporation? Is the bedrock being partly replaced by gypsum?

I remember that the rock was burst out by the growing of gypsum. This is very interesting because we have seen the same thing in Trabuc Cave. In fact, we have called that "gypsoclasty". This phenomenon is located along the Fourche gallery, just at the contact between the hettangian dolomite and the sinemurian limestone. All along the gallery, we can see some piles of little stones at the foot of each wall. If we have a closer look, we can see some gypsum crystallizations in each cracks of the rock. The walls and the roof are not stable and the gypsum is responsible, like the freeze of the water on the slopes outside, of the breaking of the limestone. The gallery is fossil and we can say that these crystallisations grow by evaporation. It is still working today…

Is this kind of transition common in other caves you have seen, especially those of sulfuric acid origin?

It's not amazing because the conduits of Tinseltown Maze are located outside may be underneath. Therefore the small sections of the conduits can be explained.

13. Chandelier Ballroom

Do you have comments about this kind of gypsum and selenite growth?

I remember to have seen small chandeliers in Cottonwood cave.
No comment about these great Chandeliers, astonishing.

Chandelier Ballroom. The famous speleothems of gypsum.

Chandelier Ballroom. The astonishing speleothems.

13. Prickly Ice Cube Room

This place is more interesting than Chandelier Ballroom, because the bedrock appears sometimes in the upper parts and display a Permian paleokarst very brecciated and coloured. Gypsum deposits cover all the bottom of the large rooms.

Prickly Ice Cube room. The pinnacles or pricklies.

Prickly Ice Cube room. The bedrock is highly brecciated.

14. Chandelier Maze

This is a good topic for discussion, although petrographic analysis is needed for a proper interpretation (this is underway).
At the beginning, we have interpreted the white layer in the bedrock as a paleo-flowstone. In South Africa, we work in many caves near Johannesburg, such as Sterkfontein (Gauteng). In this caves, there is a lot of examples of breccias, including flowstones but also other kind of speleothems. At least, during all the Pliocene, several generations of breccias have been deposited. The older are often weathered and karstified, and a new breccia was formed inside the previous one. They are less consolidated than the breccias we have seen in Lechuguilla but it looks like the same.

Chandelier Maze. Is this an old flowstone of paleokarst?

But the geological story of this permian breccia seems more complicated. This paleokarst doesn't look like "classical" filling of caves. And, as we have seen just after, there is also some calcite "flowstone" which has grown on the roof. This means that it was formed under the base level, perhaps very deep, and is more likely a kind of geode. So, these breccias can be considered as paleokarst, formed in some very different conditions than now. For example, to be sure that this breccia is a vadose cave filling, it would be better to see a broken stalactite where we could recognize the growing circles.

Chandelier Maze and Prickly Ice Cube room. In this maze, we walk everywhere on the gypsum.

Prickly Ice Cube room and Chandelier Maze. The brecciated bedrock is so weathered that the pillar doesn't under gird the roof… Stop the disaster!

Chandelier Maze. Tray and pinnacles.

Overall pattern of cave visited on tour

Escape of H2S would have been especially great during periods of low atmospheric pressure at the surface. Droplets

The difference of pressure between the surface of the karst and watertable is not the only reason of air currents. The high gradient (50, 100 m or more?) involve a difference of temperature. It's another reason which explains the features located higher above the watertable.

The extent to which this kind of dissolution could take place, high above the water table, is uncertain. It operates to a smaller extent in some active H2S caves (e.g., Cueva de Villa Luz, Mexico; Hose et al., 2000).

Yes, it's true, the extent is smaller in Villa Luz Cave, but it's difficult to compare Lechuguilla with famous but little hot Mexican Spring.
In low landscape, when the watertable drops, the spring point changes of location and shifts outside.
In Lechuguilla case and Vapor Shaft (Pyrénées, France) and also probably Monte Cucco in Italy, the landscapes are very different. The spring point doesn't shift really far-removed. The dry conduits located above the watertable could be corroded by the aggressive aerosols (air currents by-product watertable).
It depends of landscape; I think that the corrosion can be take place many meters above the watertable (100 m or more).

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