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HYPOGENIC CAVES IN PROVENCE (FRANCE). SPECIFIC FEATURES AND SEDIMENTS

MORFOLOŠKE ZNAČILNOSTI IN SEDIMENTI HIPOGENIH JAM V PROVANSI (FRANCIJA)

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Philippe Audra & Jean-Yves Bigot & Ludovic Mocochain: Morfološke značilnosti in sedimenti hipogenih jam v Provansi (Francija)

Članek obravnava razvoj jam Adaouste in Champignons v francoski Provansi. Nove raziskave kažejo, da jami ni oblikovala meteorna voda, pač pa voda, ki je v arteških pogojih dotekala iz globin. V članku so obravnavane specifične jamske skalne oblike in sedimenti, ki podpirajo trditev o hipogenem razvoju jam.

Ključne besede: Jama Adaouste, Jama Champignons, hipogeni kras, hidrotermalnost, podvodno izločanje kalcita, kondenzna korozija, stožčasti stolpiči, sledovi mehurčkov.

Abstract UDC: 551.44(449.1/.3)

Philippe Audra & Jean-Yves Bigot & Ludovic Mocochain: **Hypogenic caves in Provence (France). Specific features and sediments**

Two dry caves from French Provence (Adaouste and Champignons caves) were until now considered as “normal” caves having evolved under meteoric water flow conditions. A new approach gives evidence of a hypogenic origin from deep water uprising under artesian conditions. Specific morphologies and sediments associated with this hydrology are discussed.

Key words: Adaouste cave, Champignons cave, hypogenic karst, hydrothermalism, subaqueous calcite deposits, condensation corrosion, folia, cone tower, bubble trails.

INTRODUCTION

Most explored cave systems have evolved under seeping meteoric water carrying biogenic CO_2 under gravity flow, torrential type in the vadose zone or under hydraulic charge in the phreatic zone (Ford & Williams 1989). Except for pseudokarsts resulting in processes other than solution, few minorities of cave systems find their origin in artesian and hydrothermal settings. Other solvents can be substituted to biogenic CO_2, like endogenous CO_2 linked to magmatic degassing or H_2SO_4 stemming from sulphide oxidation of evaporites or hydrocarbon at depth. These are known as hypogenic caves. Hypogenic karst results from a source of aggressiveness produced at depth (CO_2 or H_2S) and linked to confined or rising flow, without the direct influence of surface recharge. It corresponds approximately to artesian flow, where hydrothermalism is a variant (Klimchouk 2000; Palmer 2000). The sources of aggressiveness, although well localised, produce an enhanced solution resulting sometimes in enormous voids.

Corrosion and sedimentation gravific cave forms are, on the whole, well known from long term studies throughout the world (White 2000). Hypogenic caves can go unnoticed if by error they are attributed to a classic formation process, particularly in France where these phenomena are rare. The two examples shown here highlight sedimentation and corrosion forms, which do not result from seeping under gravity (Forti 1996; Dublyansky 1997, 2000).

Adaouste and Champignons caves are in Provence, in strongly folded Jurassic limestone (Fig. 1). The first opens at the top of Mirabeau cluse where the Durance River crosses it; the second is in the scarp of the famous Sainte-Victoire Mountain.

In the two caves, most of the morphological and sedimentary features related to classic gravific origin are totally absent:

- Rapid current flow features (scallops, potholes, vadose entrenchments...)
- Superficial or allogenic sediments dragged in depth by diffuse or concentrated recharge (clays from soil erosion, fluvial sands and pebbles, etc.)
- Cave pattern general organisation, convergent to outflow point.

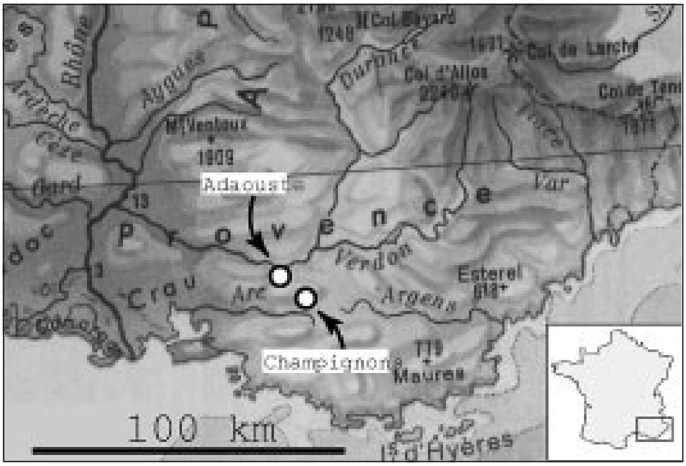

Fig. 1: Adaouste and Champignons cave locations.

CHAMPIGNONS CAVE

Topographic and structural context

Champignons cave opens in the middle of the Sainte-Victoire mountain scarp, close to a gully, above Saint-Ser hermitage. It is located on the topographical map (Fig. 1). The scarp corresponds to a truncated, thrusted anticline inverted limb (Corroy 1957; Chorowicz & Ruiz 1984). In this area the vertical dip at the cave base is found side by side with the sub-horizontal dip above.

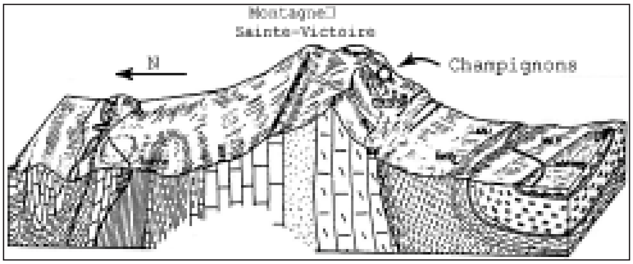

Fig. 2: Champignons cave, in the Sainte-Victoire Mountain overthrusting overturned fold (Corroy 1957).

Cave pattern organisation

A short tube-like pipe emerges in a vast, 60-m wide circular chamber, with a rounded roof. The ground is cluttered with big blocks, flowstone domes and a lateral alluvial cone comprised of gelifracts (Fig. 3). This feature comes from a torrential sinkhole next to a gully sink, which operated in a periglacial context. Except for these relatively recent gelifracts, all of the cavity and its sediments are relatively old. Moreover, there are three boundary rifts on the chamber side, going down about twenty meters between wall and blocks. They have a tendency to get smaller at the bottom.

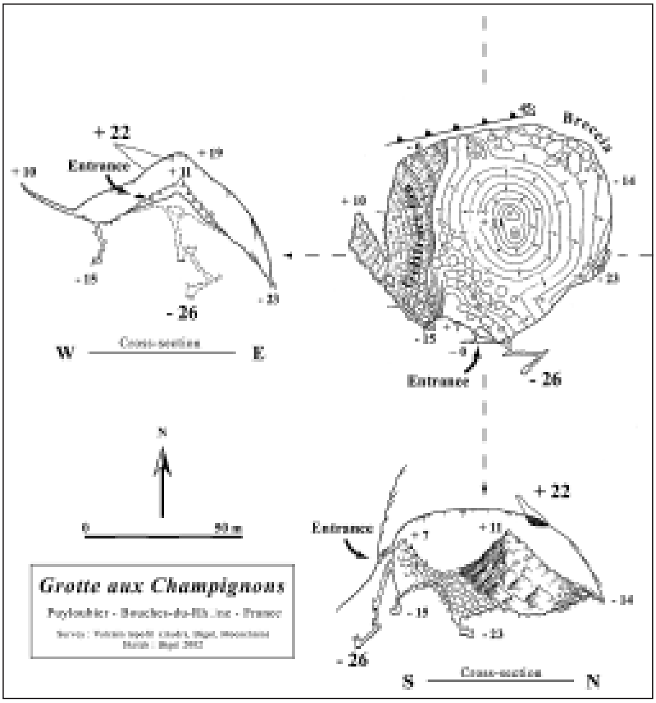

Fig. 3: Champignons cave survey.

Recharge upwelling from rifts

An intense but localised solution

The rifts that open along the chamber perimeter do not correspond under any circumstances to the runoff sink points that scoured the room. Their overhanging wall is notched by a few decimetre width hemispherical channel aligned with the steepest slope (Fig. 14). Softly cemented angular blocks make up the chamber talus (filling like breccia) occupying the entire surface. Along the rifts, white limestone blocks, set in red cement, are rounded and corroded by small vertical tubes that sometime intersect breccia.

A generalised subaqueous calcite coating

Except for the localised corrosion zones, all the rift walls are covered with an extremely pure 10-cm thick calcite crust. The crust is found as a mammalies coating, a white microcrystalline popcorn, a nailhead spar or as dogteeth (Fig. 4). These deposits were formed in low hydrodynamic conditions in water supersaturated with calcite (Dublyansky 1997, 2000; Hill & Forti 1997).

Fig. 4: Mammalies calcite coating on rift walls.

Solution induced by degassing of the uprising recharge

The following forms result unquestionably from the presence of ascending gas in a phreatic flow:

- Ceiling half-tubes have developed in the phreatic zone close to the water table as gas bubbles diffused from the solution (like when opening a Champagne bottle), and run along the overhanging walls to reach the water table. The process of corrosion is induced by condensation which occurs continuously at the interface between the bubbles and the wall; these channels are referred as “bubble trails” (Chiesi & Forti 1987).

- A generalised subaqueous spar coating formed from CO_2 diffusion from supersaturated water; these do not occur on overhangs along bubble trails where solution is predominant.

These rifts are thus produced by the juxtaposition of degassing solution phenomena and supersaturated water deposition. This simultaneity of solution / deposition phenomena in the same basin accounts for the proximity of both corrosion forms (bubble trails) and deposition forms (calcite coating). The transition is made over a distance of few centimetres at the edge of the channel. This combination constitutes an infallible identification criterion for identifying upwelling in a karst environment. An attentive examination makes it possible to easily differentiate these key-forms from secondary corrosion phenomena of flowstones that are frequently observed and which are explained by seeping water chemical changes, involving two successive and not simultaneous hydrochemical states.

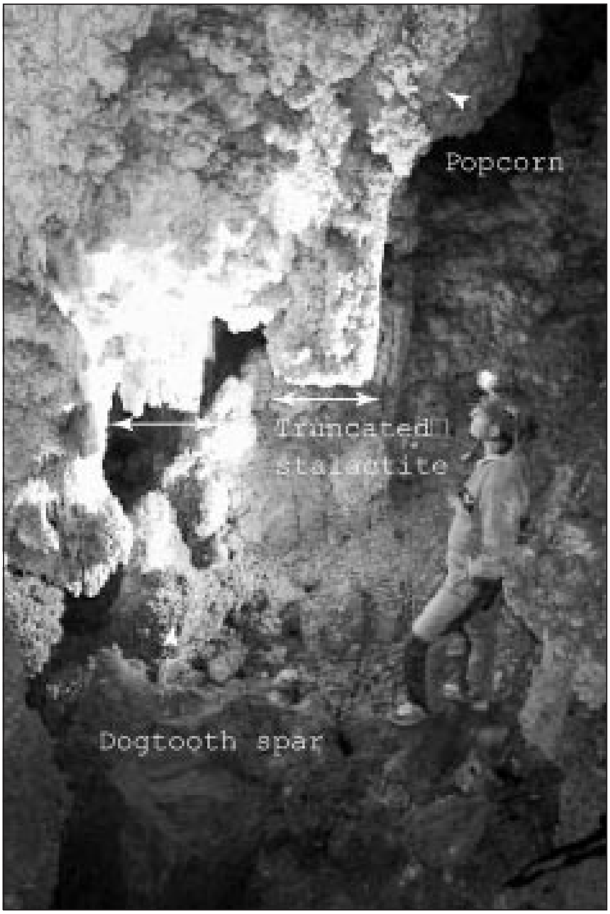

Fig. 5: Mammalies calcite coating and popcorns occurring on the lower part of the chamber, stalactites with basal truncation.

Oversize room genesis

In comparison with the reduced size of the supply channels, the Champignons cave chamber appears oversized. Its study is not completed, but the following observations allow estimation of its origin:

- In the low part of the chamber a calcite coating occurs; it is of comparable nature to that of the cracks (Fig. 5), with stalagmites made up of dogteeth.
- Some massive stalactites do not have a sharp apex, but a horizontal truncation localised at various levels (Fig. 5). After examination, a break origin due to human activity is excluded.
- The upper part of the walls and the ceiling cupola present a naked and corroded rock with vast round forms and softened contours.
- The large central calcite dome (Fig. 2) presents both a rough surface and softened

forms different from usual flowstones, and it overlies a scree accumulation made of angular blocks. Some stalagmites also have an unusual mushroom shape led to the name of the cave.

The presence of subaqueous concretions (coatings and dogteeth) in the lower part of the chamber shows that a lake once occupied it (Fig. 6). The existence of stalactites with horizontal truncation and the absence of quiet watermark indicate that the level of the water table must have varied. Degassing from deep water in the confined system has charged the atmosphere with carbon dioxide. The atmosphere in contact with the water table had to be relatively hot to cause condensation in contact with the colder walls. Combined with the CO_2 rich atmosphere, condensation was aggressive and corroded the emerged walls and ceiling. In the same way as in an aquatic environment, air convection currents must have occurred, explaining a regular cupola form of the ceiling in which more reduced size cupolas are fitted.

As for the central dome and mushroom stalagmites, later research will probably show that they are subaqueous concretions of the same type as the Adaouste cave “Penitents” (*infra*). In any event, the hypothesis of flowstones corroded by a secondary flooding is incompatible with the presence of very angular underlying blocks, which would also have been corroded.

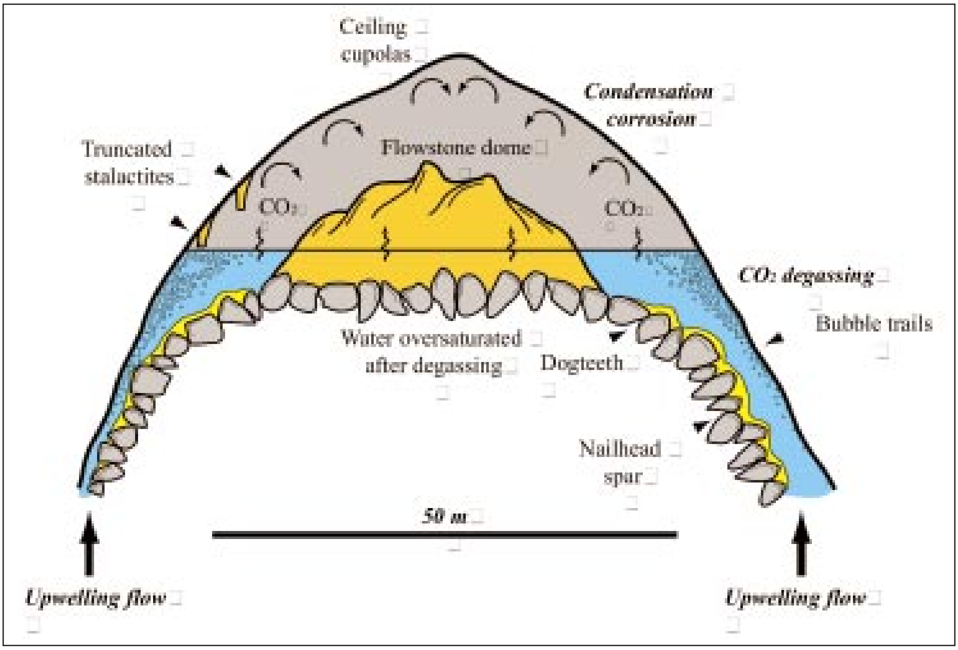

Fig. 6: Champignons cave hydrodynamic.

A probable age of Miocene or earlier

Arguments integrating this original cave in its external environment lack for the moment. The top of Sainte-Victoire (969 m) is truncated by an infra-Oligocene planation surface, now uplifted

(Nicod's "fundamental surface", 1967). Tortonian's sediments correspond to a marine shore at the occidental foot of the chain at 400m altitude. Without excluding tectonic movements, which could have exaggerated this altitudinal difference, it seems that Sainte-Victoire was individualised as an inselberg between these two chronological millstones. Champignons cave, located at middle height of the chain, marks undoubtedly an intermediate stationary period of base level during relief release. Although further study will allow testing of the hypotheses an estimated age of 35 to 11 Ma between the two above-mentioned periods is proposed. It is interesting to note that the draining of the cave has enabled it to remain intact without any collapse since this period. The vault form ensures stability. No recent filling occurs except for the periglacial gelifracts lateral intrusion and slight calcite deposition. The lack of surface recharge linked to seepage water is explained by lack of connection with overlying surface that is closely related to its genesis *per ascensum*.

ADAOUSTE CAVE

Adaouste cave opens at the top of the Mirabeau anticline limb entrenched by the Durance cluse (Fig. 7). It is a 3-D maze, organised in two downward series, strongly tilted (45-50°) with two horizontal levels perpendicular to the anticline axis (Fig. 8). In the absence of impervious strata, these two levels record old base level positions, which correspond to Mirabeau cluse entrenchment.

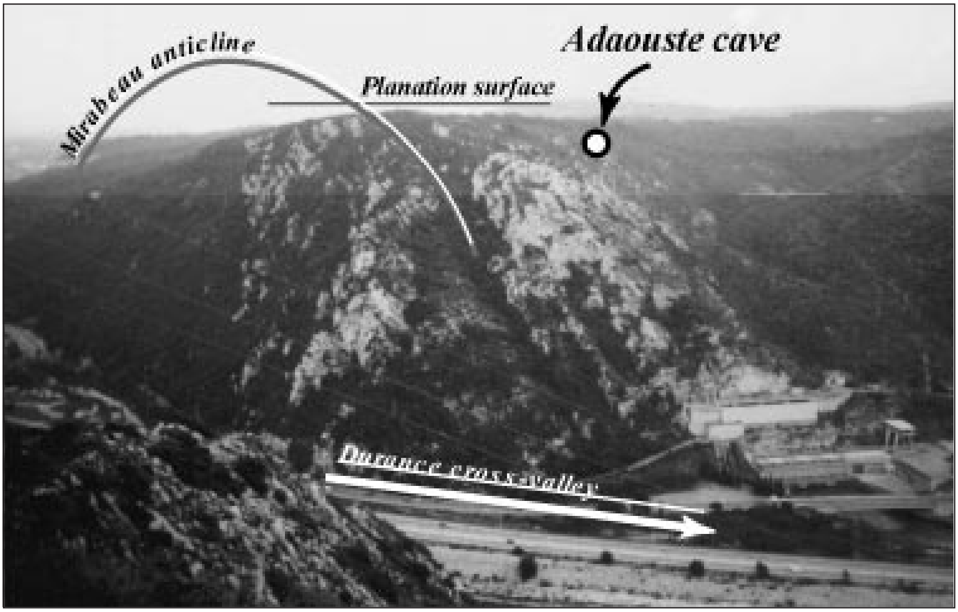

Fig. 7: Adaouste cave location, at the Mirabeau anticline top with truncated saddle, entrenched by the Durance cluse (Photo: J.-L. Guendon).

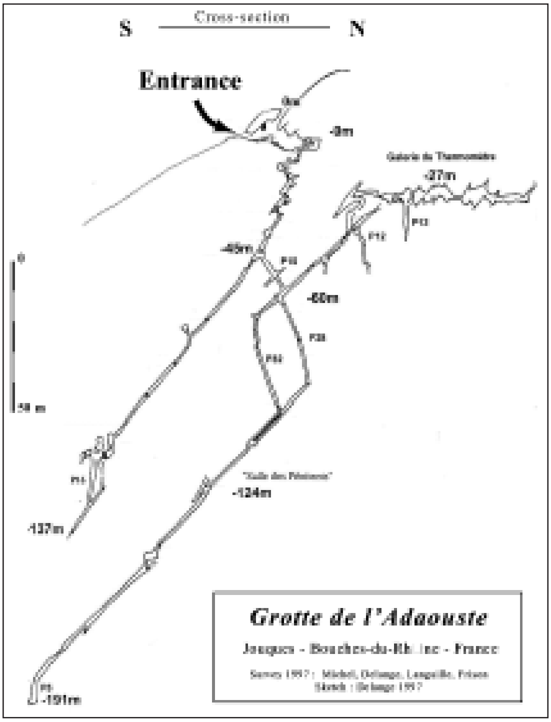

Fig. 8: Adaouste cave survey.

Corrosion-deposition in deep series

In Adaouste, we find the same phenomena as in the Champignons cave, upwelling of aggressive deep water and simultaneous calcite deposition by carbon dioxide degassing. "Penitents" chamber at -124 m harbours the most interesting phenomena. It is unknown if this phenomenon occurred at depth in a ceiling pocket with trapped gas or near the water table when base level was at this altitude.

Deep origin water is decompressed during uprising and releases dissolved carbon dioxide. Bubbles accumulate in a ceiling pocket, probably exclusively filled with this gas. Water condenses in contact with the relatively fresher roof. It is extremely aggressive due to the strong CO_2 partial pressure. Condensation corrodes the ceiling and forms a boxwork (Fig. 9) (Palmer & Palmer 2000).

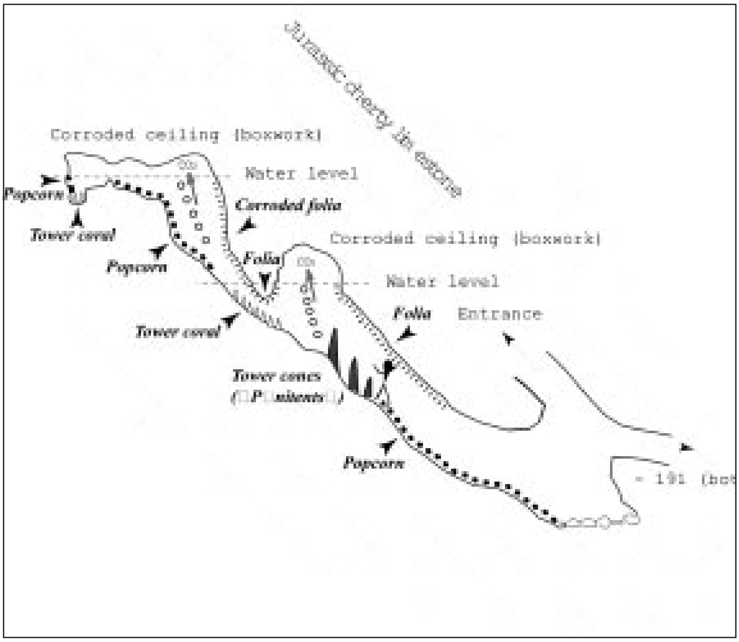

Fig. 9: Condensation corrosion in the ceiling pockets and subaqueous calcite deposition.

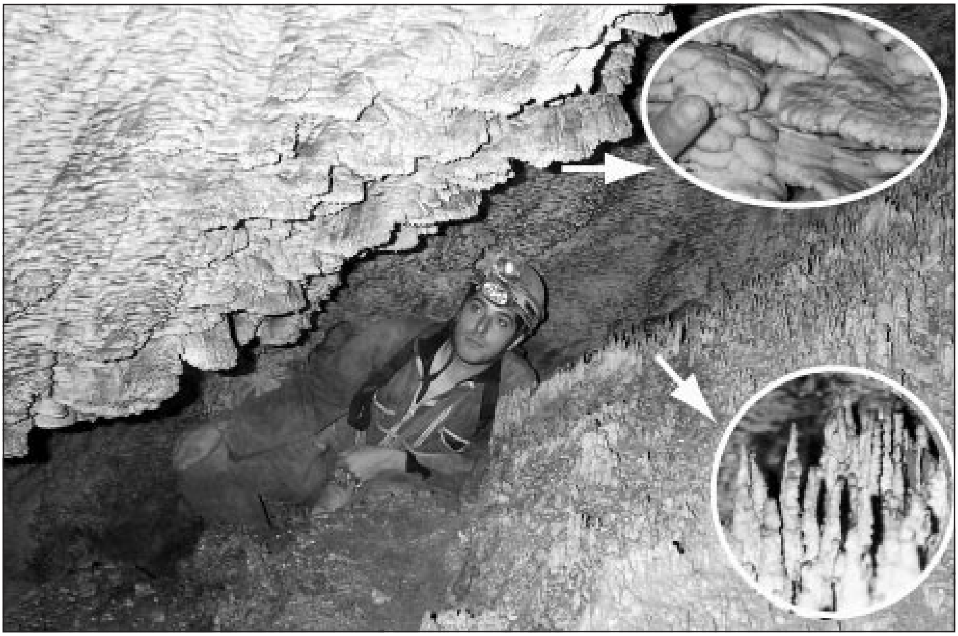

Fig. 10: Subaqueous calcite; folia on the overhanging walls and tower coral on the ground.

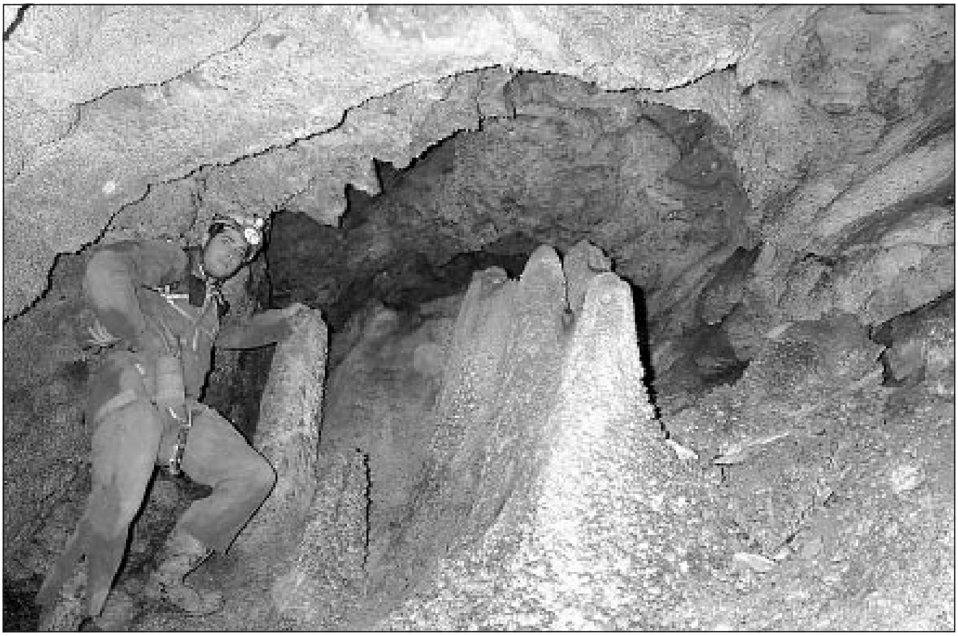

Fig. 11: Penitents chamber cone towers, subaqueous stalagmites made of calcite rafts accumulation.

Degassed water becomes supersaturated and deposits calcite on the walls. Several types of subaqueous calcite deposits were identified:

- Folia, along the overhanging ceilings, (Fig. 10). These deposits look like inverted rimstones. Their origin, the detail of which is still not entirely known, involves simultaneous deposition on the lower edge and corrosion in the pocket where the carbon dioxide is trapped in low hydrodynamic condition (Hill & Forti 1997).
- On the ground grow small tower corals up to 10 cm high. These deposits, which correspond to a calm supersaturated environment (Hill & Forti 1997), should not be confused with encrusted silt pillars, like the “100 000 Soldiers” of Trabuc cave (Gard, France) which result from completely different processes.
- “Penitents” found on the basin surface: their form evokes normal stalagmites but they correspond to tower cones (Fig. 11). On the surface of the supersaturated basin, cave rafts form. Condensation droplets flow along the ceiling and drip at the same place from sharp ends. Dripping water sunk rafts at discrete points. With time, they accumulate and are cemented, building a tower cone (Forti & Utili 1984).
- The preceding types were located in low hydrodynamic conditions, away from the main drain where the current went up. In slightly more agitated zones calcite coatings dominate with vuggy structure, dependent on fast crystal growth in a strong degassing context (Forti, person. comm.). Two principal types are identified:
    - Saccharoid texture white calcite flakes accumulation, with many interstitial vugs (Fig. 12).

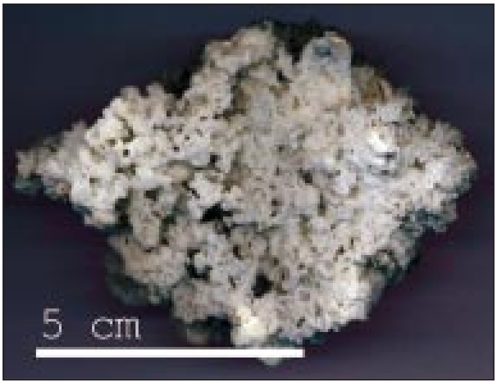

Fig. 12: Subaqueous saccharoid calcite coating.

Fig. 13: Subaqueous large size coralloids.

Fig. 14: Tubular bubble trail, corroded by ascending gases, with ceiling channel and popcorn on the bottom.

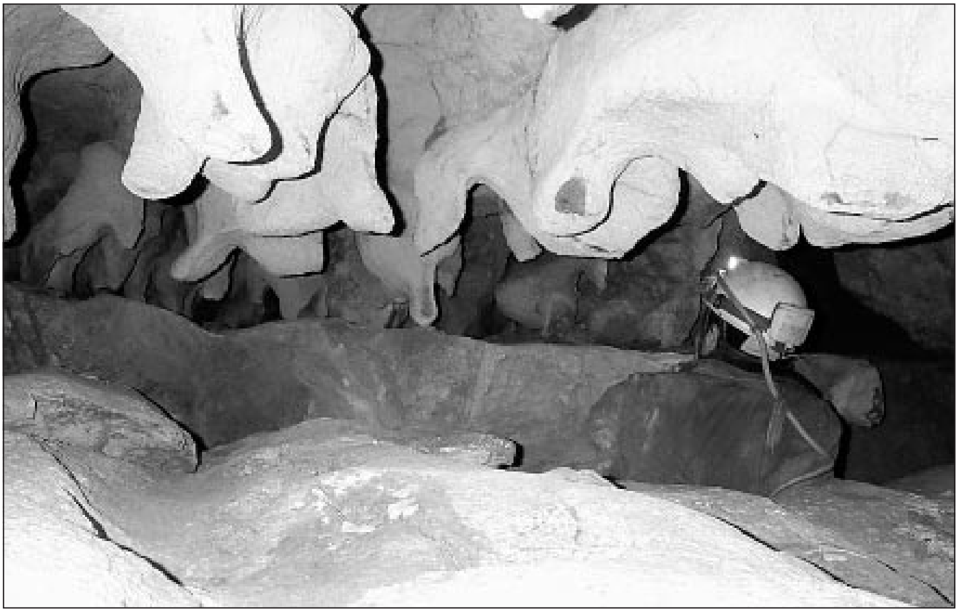

Fig. 15: "Elephant feet" like pendants derived from braided bubble trails originating from aggressive ascending bubbles.

- Popcorns, reaching sometimes significant dimensions (20 cm and more). Directional coralloids clearly show an ascending current. In section, three kinds of fabric appear: white calcite at the origin, whose structure is covered by red cement and then by a laminated greyish growth in periphery (Fig. 13).

Horizontal galleries at the water table

Below the water table, carbon dioxide degassing produces various types of forms according to the local structural context:

- In oblique bedding planes, bubble trails similar to those described in Champignons cave, corrosion at the ceiling and calcite deposition at the bottom forming popcorn (Fig. 14).
- In the tilted rooms developed under a roof made of layers, ascending bubbles follow the contact with the ceiling, forming braided channels by corrosion and isolating pendants similar to elephant feet (Fig. 15).
- Vertical rifts allow a fast water rise (“P12” and “P13” in Fig. 8). They are present in the form of elongated fissures, which enlarge when approaching the gallery edge.

When approaching the water table, ascending water mixes with meteoric seepage, enhancing mixing corrosion and giving rise to conduit development. Slow water flow towards a close outlet generates a horizontal current. Rectilinear tube-like galleries develop (Fig. 16), cutting structural discontinuities which are vertical rifts or tilted bedding planes that provide only local enlargements.

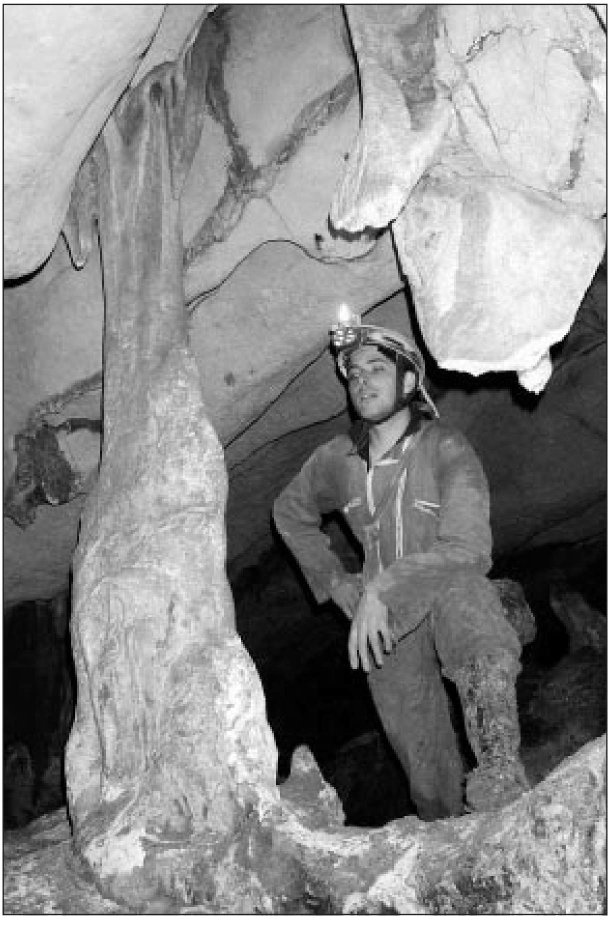

Fig. 16: Horizontal tube-like gallery in the upper series, with intensively corroded massive flowstones.

Except for some recent classical flowstones linked to the presence of the nearby surface, the most important part of the chemical and clastic deposits are related to the original upwelling dynamic of the cave.

- Massive flowstones (stalagmites, stalactites, columns…) have been intensively corroded by flows (Fig. 16). Some ceiling cupolas equally cut the host rock and the flowstones. The presence of such formations implies a genesis in several steps: (i) conduit initiation, (ii) lowering of the water table allowing calcite deposition, (iii) corrosion of the flowstones during flooding.
- Clay sediments of superficial origin were deposited in horizontal sequences by the phreatic flows. They are situated only in some nooks. The study of these deposits remains to be done. On the whole, river sediments are rare and the cave is clean. There are some red clays which came from the surface after the draining of the system in a recent phase.
- In the entrance series pockets filled of light yellow sands and cut by the ceiling cupolas occur, like well calibrated gravel containing tortonian marine fauna (Conrad & Onoratini 1997). These deposits are related to the leaching of the tortonian clastic formations, which cover the plateau’s surface (marine sediments and “Bèdes gravel”).

A tortonian hypogenic cave system

Knowledge of the local paleogeographic evolution allows an accurate identification of the age and evolving conditions of the cave (Clauzon 1979, 1988; Delange 1997; Nicod 1967; Rousset 1963).

- **Middle Miocene:** the anticline is truncated by a wave-cut platform (present altitude: 430 m). Karst could have occurred after this stage but without any relation to the Adaouste system.
- **Tortonian:** a transgression / regression cycle allows marine and then river deposits (“Bèdes gravel”) which spread on the surface.
- **Upper Tortonian (8.5 to 5.8 Ma; Fig. 17-1):** the fluvial network entrenches in the sediments and then cuts by superimposition the anticline vault. An artesian aquifer in limestone outflows across this window. The two horizontal series of the entrance area mark two successive steps of the Durance entrenchment, corresponding to a valley embankment of 40 m under the plateau’s surface. Afterwards tectonics warp the anticline, which is raised up from about 100 m. The Durance adapts by an antecedence phenomenon and the upper part of the cave drains.
- **Messinian (5.8 to 5.3 Ma; Fig. 17-2):** the salinity crisis of the Mediterranean Sea shows up by a powerful embankment of the tributary valleys. The Durance thalweg lowers by more than 200 m into the Mirabeau anticline (present elevation: 87-m asl.). The Adaouste is totally drained, the ascending water having to find an outlet in the bottom of the messinian canyon.
- **Pliocene (5.3 to 2.5 Ma; Fig. 17-3):** the “high stand” marine transgression floods the canyon in a ria and fills it with marine sediments. River aggradation lifts the base level up to 40 m below the entrance (altitude: 370 m).The cave is flooded, but present it is unknown if hypogenic recharge still occurred.
- **Upper Pliocene and Quaternary (from 2.5 Ma):** due to eustatic (lowering of the sea level) and tectonic (plio-quaternary uplifting) causes, the Durance entrenches down by successive

stages and removes 150 m of Pliocene deposits down to the present altitude of the valley (220 m). The clay deposit in the Adaouste's bottom is at the same altitude. The intrusion of men and bats leaves archaeological traces and phosphatic minerals, respectively, in the recent entrance sediments (Conrad & Onoratine, 1997).

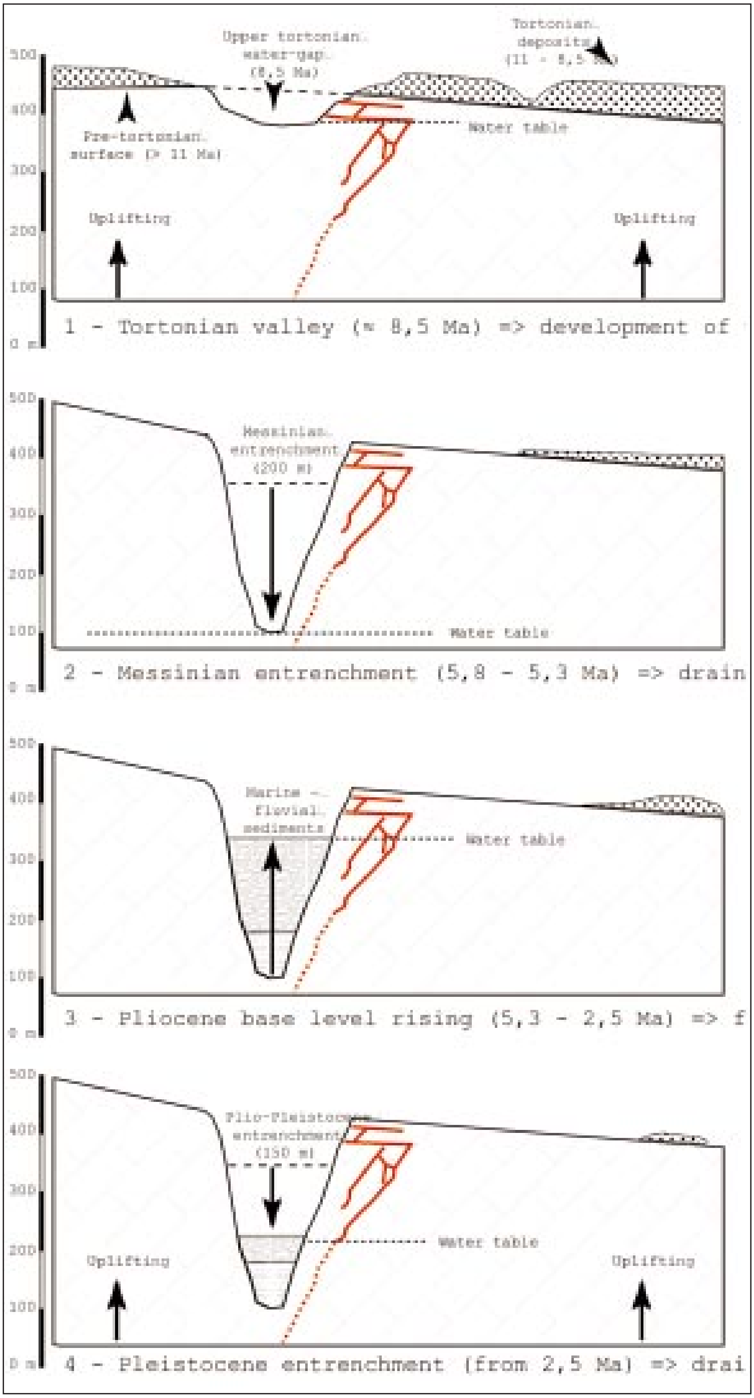

Fig. 17: Adaouste cave evolution since Miocene (after Delange 1997, modified).

In brief, the hypogenic activity of the cave is related to the Upper Tortonian. Then it was drained, flooded and finally definitively dried. The last events did not leave tangible marks. It seems that the cavity has not evolved significantly since Messinian drainage.

CONCLUSION

This preliminary study permitted the identification of a hypogenic origin for the two cave systems for which the activity age was approximately the Miocene. The discoveries suggest new research routes:

- In the paleogeographic field, a better knowledge of the regional geomorphologic evolution would better define the chronology and evolution framework of the systems.
- A structural study would establish the origin and cause of the artesian flow.
- The object of this preliminary study was the definition of morphological and sedimentary indicators for hypogenic karst. Many specific corrosion forms and calcite deposits had been clearly identified.
- The study indicates that water went up from great depths, sufficiently rapidly to have thermal characteristics. Recent fluid inclusion microthermometric measurements confirm this, showing calcite deposition conditions reaching 85°C to 230°C. Geochemical isotopic analysis has to be done to determine the water composition which should enriched in carbon dioxide.

The hypogenic origin of these caves requires that the development of certain cave systems and karst stages in Provence be partly reconsidered.

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REFERENCES

Chiesi, M. & Forti, P. 1987: Studio morfologico di due nuove cavitá carsiche dell’Iglesiente (Sardegna Sud occidentale).- Ipoantropo, 4, 40-45

Chorowicz, J. & Ruiz, R. 1984: La Sainte-Victoire (Provence) : observations et interprétations nouvelles.- Géologie de la France, 4, 41-57

Clauzon, G. 1979: Le canyon messinien de la Durance (Provence, Fr.) : une preuve paléogéographique du bassin profond de dessication.- Palaeogeography, Paleoclimatology, Palaeoecology, 29, 15-40.

Clauzon G. 1988: Evolution géodynamique pliocčne du bassin de Cucuron / Basse Durance (Provence, France) : une mégaséquence régressive de comblement d’une ria méditerranéenne consécutive à la crise de salinité messinienne.- Géologie alpine, Mémoire hors-série 14, 215-226

Conrad, G. & Onoratini, G. 1997: Le remplissage karstique de la grotte de l'Adaouste et sa genèse (Jouques, Bouches-du-Rhône).- *Colloque "Karst et archéologie", Tautavel 1996*, 159-174. Association française pour l'étude du Quaternaire, Paris

Corroy, G. 1957: La Montagne Sainte-Victoire.- Bulletin du Service de la carte géologique de France, 251, LV, 1-46

Delange, P. 1997: *L'étude des traces sismotectoniques dans les cavités karstiques de la Moyenne Durance et de la Trévaresse*.- Rapport de contrat CEA-IPSN. URA 903, 88 pp., Université de Provence

Dublyansky, Y. V. 1997: Hydrothermal cave minerals. *In* Hill, C. & Forti, P. 1997: *Cave mineral of the world*, 252-255- National Speleological Society, Huntsville

Dublyansky, Y. V. 2000: Hydrothermal speleogenesis. Its settings and peculiar features. Speleogenesis.- *Evolution of karst aquifers*, 292-297. Klimchouk A., Ford D. C., Palmer A. N. & Dreybrodt W. (Ed.), National Speleological Society, Huntsville

Ford, D. & Williams, P. 1989: *Karst geomorphology and hydrology*.- Unwin Hyman, 601 pp. London

Forti, P. & Utili, F. 1984: Le concrezioni della Grotta Giusti.- Speleo, 7, 7, 17-25.

Forti, P. 1996: Thermal karst systems.- Acta Carsologica, XXV, 99-117. Slovene Art and Science Academy, Ljubljana & Karst Research Institut, Postojna.

Hill, C. & Forti, P. 1997: *Cave minerals of the world*.- National Speleological Society, 464 pp, Huntsville

Klimchouk, A. 2000: Speleogenesis under deap-seated and confined settings.- *Speleogenesis. Evolution of karst aquifers*, 244-260. Klimchouk A., Ford D. C., Palmer A. N. & Dreybrodt W. (Ed.), National Speleological Society, Huntsville

Nicod, J. 1967: *Recherches morphologiques en Basse-Provence calcaire*.- Thèse d'Etat à l'Université d'Aix-en-Provence, Louis-Jean, 580 pp. Gap

Palmer, A. N. 2000: Hydrologic control of cave pattern.- *Speleogenesis. Evolution of karst aquifers*, 77-90. Klimchouk A., Ford D. C., Palmer A. N. & Dreybrodt W. (Ed.), National Speleological Society, Huntsville

Palmer, A. N. & Palmer M. V. 2000: Speleogenesis of the Black Hills maze caves, South Dakota, USA.- *Speleogenesis. Evolution of karst aquifers*, 274-281. Klimchouk A., Ford D. C., Palmer A. N. & Dreybrodt W. (Ed.), National Speleological Society, Huntsville

Rousset, Cl. 1963: Les formations continentales du bassin de Jouques (Bouches-du-Rhône).- Annales de la Faculté des Sciences de Marseille, XXXIV, 147-157

White, W. B. 2000: Development of speleogenetic ideas in the 20th century: the modern period, 1957 to the Present.- *Speleogenesis. Evolution of karst aquifers*, 39-43. Klimchouk A., Ford D. C., Palmer A. N. & Dreybrodt W. (Ed.), National Speleological Society, Huntsville

MORFOLOŠKE ZNAČILNOSTI IN SEDIMENTI HIPOGENIH JAM V PROVANSI (FRANCIJA)

Povzetek

Večino znanih jam je oblikovala meteorna voda obogatena z organskim CO_2, ki se gravitacijsko pretaka skozi kraški vodonosnik. Manjši del jam je nastal s korozijo vode, ki priteka iz globin hidrotermalno oziroma pod arteškimi pogoji in je lahko bogata z endogenim CO_2 in H_2SO_4. Jame nastale z delovanjem takih voda imenujemo hipogene. V Franciji so hipogene jame redke, v jamah Adaouste in Champignons pa zasledimo veliko značilnosti, ki jih ne moremo pripisati delovanju meteornih voda in kažejo na hipogeni izvor jam.

Jama Chamignons je velika dvorana, v tlorisu krožne oblike, z ozkimi špranjastimi rovi (rifti) ob katerih je dotekala hipogena voda (Slika 3). V riftih najdemo korozijske žlebove, ki ustrezajo sledem mehurčkov (buble trails) (Slike 6 in 14). Spodnji del dvorane pokriva kalcit, izločen pod vodno gladino. Pisekani stalagmiti (Slike 5 in 6) so verjetno nastali ob razplinjanju vode v jezero. V močno korodiranem stropu dvorane opazimo številne stropne kotlice in kupole, ki so nastale s kondenzno korozijo (Slika 6).

Jamski sistem Adaouste je kombinacija 3D blodnjaka, ki sledi vpadu plasti in dveh nivojev galerij razvitih ob nekdanjih nivojih podzemne vode (Slika 7). Horizontalni del jame je razvit v nivoju mešanja, v katerem opazimo oblike kot so sledi mehurčkov (Slike 14 in 15), močno korodirani stalagmiti (Slika 16) in razpoke (rifti), vzolž katerih je potekalo globoko napajanje (Slika 7). V naglobjih delih jame najdemo oblike, ki so nastale kot posledica močne korozije v zaliti coni in različne oblike kalcitnih tvorb značilnih za hidrotermalne jame (Slike 8, 10, 11, 13).

Jama Champignons je verjetno Miocenske starosti (11-35 MA), Jamski sistem Adaouste pa po starosti verjetno sodi v Zgornji Tortonij (8.5-5.8 Ma). Dosedanje raziskave jam dokazujejo njihov hipogeni izvor. Meritve vključkov tekočin kažejo na temperature med 85°C in 230°C. V prihodnosti bodo opravljene izotopske meritve s katerimi bo določena sestava vode.