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Cuciulata Pit (Bihor Mountains), a lithological-contact cavern

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Abstract. Cuciulata Pit from the Bihor Mountains is a deep cavern of Romania. It is a unique and stunning network developed up to near 200 m in depth. The cavern appeared between the soluble and insoluble rock formations. The contact between limestone and quartzite rocks is the distinct path of the running water.

History of exploration

In the sixties, the geologist Gheorghe Mantea found the big entrance of the Cuciulata Pit. Then, the discovery fell into oblivion. In the summer of the 1977 year, the Speleological Club “Z” organized two expeditions in the upper valley of the Someşul Cald River. Liviu Vălenaş and Horia Mitrofan re-discovered the pit. They started the exploration and reached a sump opened at 141 m depth. Liviu Vălenaş passed solitary through it and stopped at a second sump opened at -182.5 m. The next day, Liviu Vălenaş, along with Dorel Pop, passed through the second sump and stopped in front of an impenetrable sump at 186.6 m depth. During exploration between July 21 and 24, 1977, the exploring team did the map of the cavity. Then, Romanian cavers again ignored the pit.

Description

Cuciulata Pit has the entrance at 1400 m elevation in the upper Cow Creek (Pârâul Vacii), a typical sohodol valley from the Someşul Cald river basin, and in a forested area, with large- and medium-sized sinkholes (Figs. 1, 3, 4, 5). It is one of the highest altitudes for a cave entrance in the Bihor Mountains. The Pit entrance is a classic type of letter-box, 16 m long and 4 m wide. A pillar at 14.5 m depth divides the entrance shaft into two branches: P 37 and P 33. Both shafts overhang in the lower part. The entrance shaft has the appearance of a bell. At the bottom of the shaft, it advances into the largest hall of the cavern, 35 m/ 25 m/ 20 m high. Perennial snow covers the high angled floor. After narrow passages at -41.7 m and -49.0 m it descends a small 4 m vertical step among boulders and enters at -63.5 m in the Great Corridor (Marele Culoar). The Great Corridor is a 30-35 degree angled large gallery by 12 m width and 5 m average height. Small verticals, between 2 m and 5.5 m, created exclusively by the accumulations of stone blocks, fragmented the slope. A very tortuous loop in a side of the gallery can help to avoid a low section of the gallery. At -141.5 m in depth, the ceiling suddenly falls to 15 cm from the water surface, and the width of the gallery is only 2 m. The water passing through a small limestone layer created the First Sump. A small fracture, extremely narrow (18 cm) bypasses the sump but is not accessible to cavers.

Beyond of First Sump, it meets the lithological contact with the Liassic quartz bed again. After three extremely spectacular waterfalls, the highest being of 6 m, it reaches the Hall of Waterfalls (Sala Cascadelor), 31 m/ 9 m/ 8 m. After this hall, the water flows on a relative horizontal course. At -174.0 m depth, the gallery receives through a 2.5 m high waterfall, a major tributary of an unknown origin, and its gallery is soon impenetrable. A new sump (Intermediary Sump) opens at -184.5 m and a relatively large gallery continues forward for more 20 m. Gallery ends in a closed sump (Final Sump) at -186.6 m depth.

The Cuciulata Pit is 925 m long and has a 230 m extension on an aerial distance. The significant length of the cavity is due to the rock pillars. They split the cavern into several descending and parallel branches up to 141.5 m in depth. It mentions the presence of sinuous loops generated from uninterrupted rock fractures (Fig. 2).

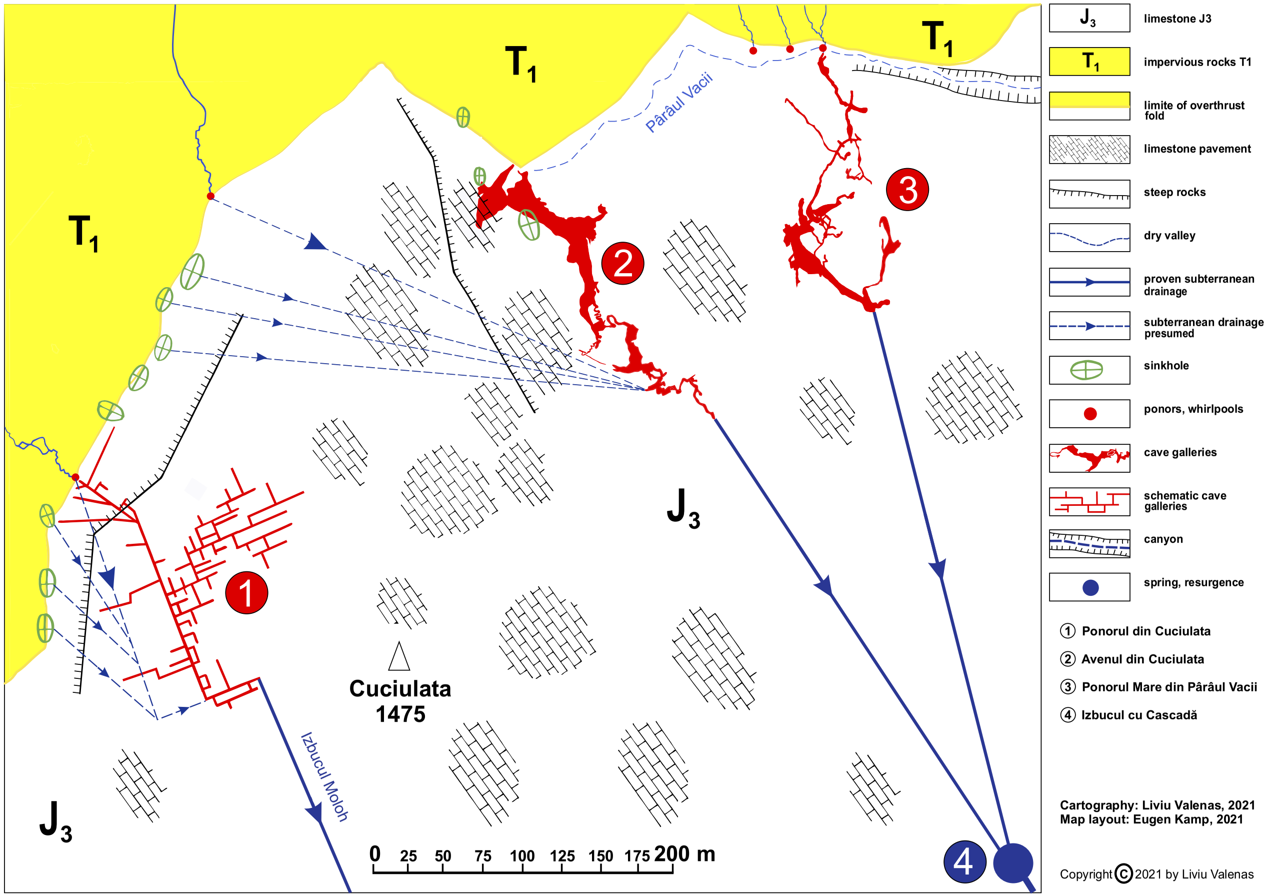

Figure 1. Cuciulata Mountain area, 1: Ponorul din Cuciulata; 2: Cuciulata Pit; 3: Ponorul Mare din Pârâul Vacii. Cartography: Liviu Vălenaș, 2021, map layout: Eugen Kamp, 2021

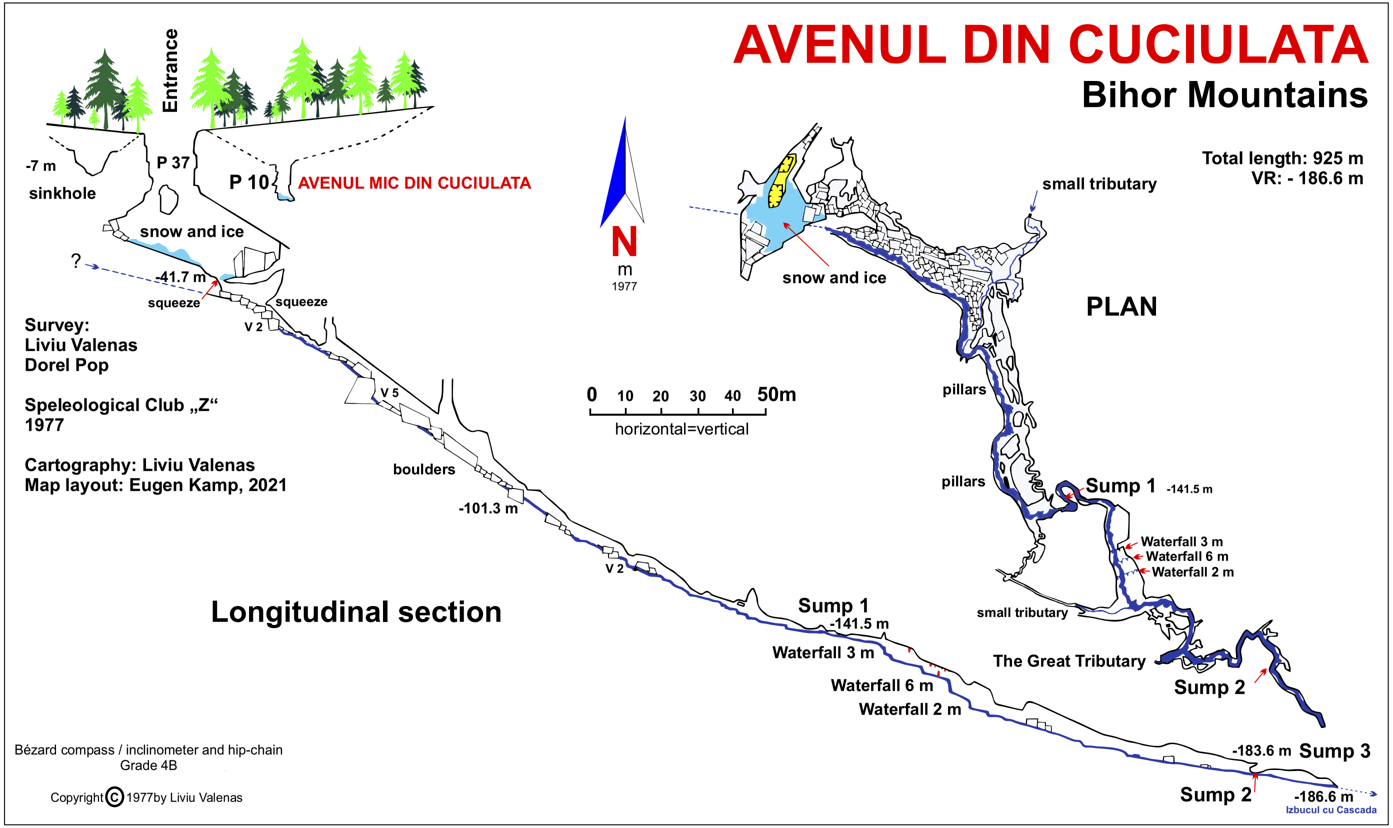

Figure 2. Cuciulata Pit (Avenul din Cuciulata), survey: Liviu Vălenaș and Dorel Pop, cartography: Liviu Vălenaș, map layout: Eugen Kamp, 2021

Geology and Tectonic

Lithologically, Cuciulata Pit begins on the contact between layers of limestone of Malm (J1) age and quartzite of Werfenian (T1) age (Fig. 3). The last one belongs to an older thrust layer glided over limestone. Moreover, the water eroded partially one gallery under the quartzite unit. At -40 m, the cavity intercepts another quartzite layer of Lower Liassic age (Hettangian – J1) in a normal stratigraphic relationship with the limestone of Malm (J 3) age. The watercourse follows the lithological contact up to -174 m and then passes through the limestone of Malm (J3) age up to the last sump at 186.6 m in depth. The quartzite is a sandstone made of quartz granules and other elements as plagioclase crystals, biotite and opaque minerals. It mentions the lack of the Upper and Middle Liassic layers, especially of the Toarcian marlstone. This situation is common to the Bihor Mountains. As for the limestone of Malm (J3) age, the main cavern developed on obvious lithological diastems and joints. The proximity of the Cuciulata Pit to 200 m of the banatites massif of Vlădeasa supports the idea of a certain crystallization of limestone of Malm age (J3).

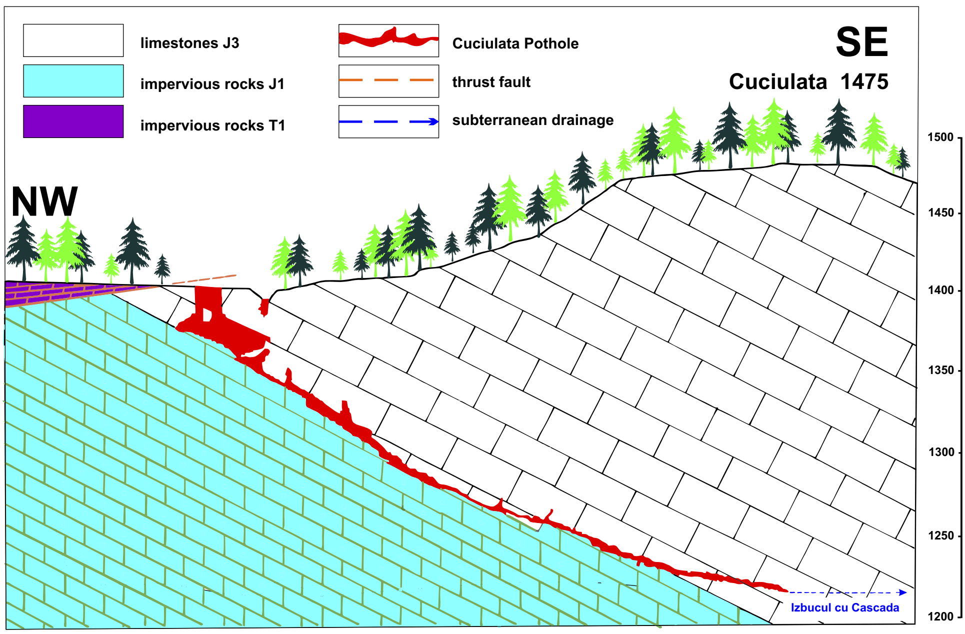

Figure 3. Geological and hdrogeological section of Cuciulata Mountain (graphics: Liviu Vălenaș, 2021)

Figure 4. The entrance of Ponorul din Cuciulata cave (Photo by Liviu Vălenaș, 2014)

Morphology and Genesis

The profile of the underground network looks like closer to an angled cave. The sole particularity of the Cuciulata Pit is its entrance shaft (P 37). The cavity has the origin in a deep phreatic pattern, inclusively the entrance shaft. Later, the water-course passed to vadose flow.

Hydrogeology

The origin of the underground river in Cuciulata Pit is the meteoric water drained in the sinkholes near the entrance in pit. As a result of the water markings in the area made between, the karstic waters drainage is more complicated than the scheme imagined by us in 1978 (Figs. 6, 7). So, the subterranean course in Ponorul din Cuciulata appeared in Izbucul Moloh (Peştera cu Apă din Cheile Someşului Cald) resurgence, situated at 700 m air distance from the final sump of Ponorul din Cuciulata and a vertical range of 125 m (SILVESTRU, 1995). The colour appeared after 35 hours, the average flowing speed: 20 m/hour. The colouring made in 1994 in Cuciulata Pit demonstrated, in exchange, that this great descending cave had another resurgence: Izbucul cu Cascadă in the canyon of the Someşul Cald, situa-

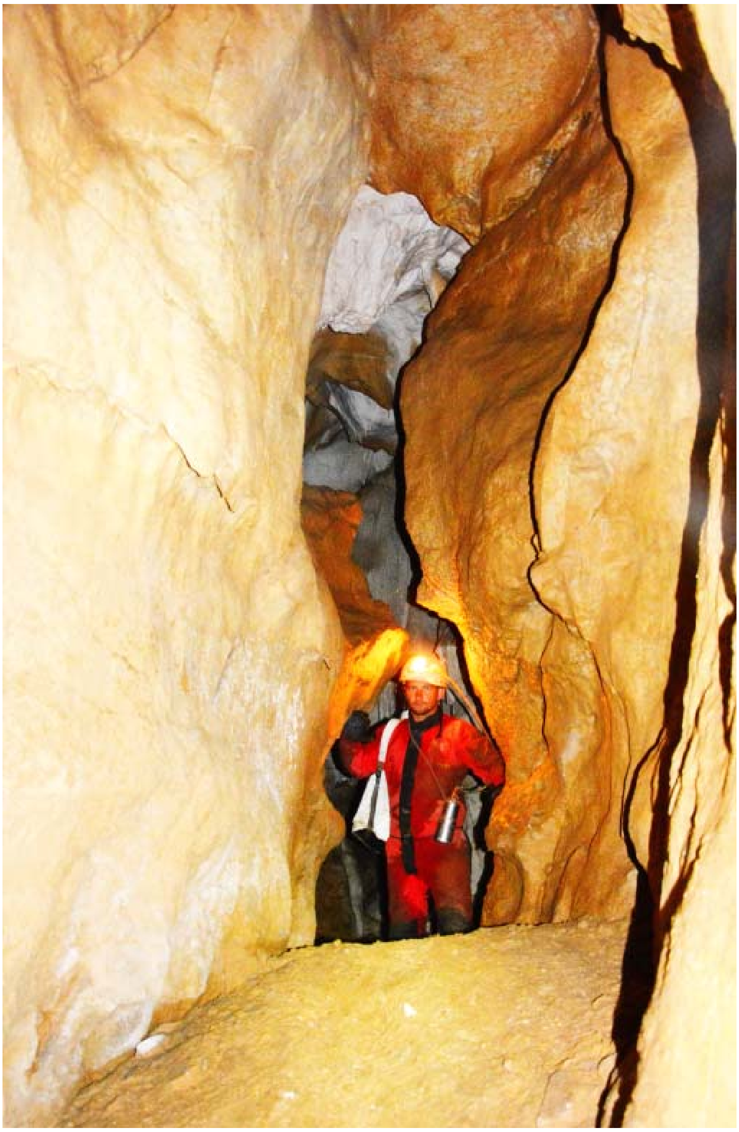

Figure 5. Ponorul din Cuciulata, the Main Gallery (Photo by Liviu Vălenaș, 2014)

ted at 500 m distance and at a vertical range of only 13.4 m (SILVESTRU, 1995). Fluorescein appeared in the resurgence in only two hours and 15 minutes, a flowing speed extremely high: 256.6 m/h. Izbucul cu Cascadă is also joined by the important ponor-cave from Pârâul Vacii, the final sump in the cave being at 450 m air distance from the spring and only at 10 m vertical range. Here the colour has

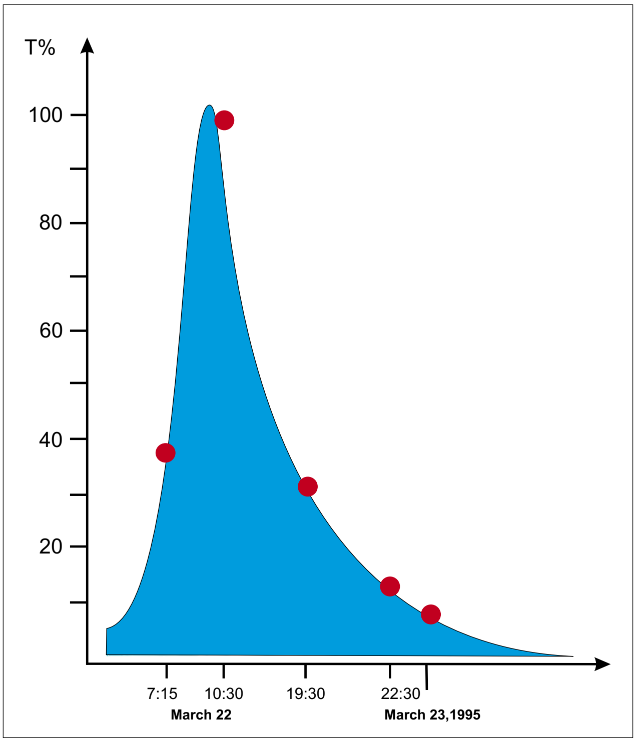

Figure 6. Graph of the tracer outpout at Izbucul cu Cascadă spring for the input in Cuciulata Pit, credit by Emil Silvestru, 1995

travelled in 12 hours, the average flowing speed being: 37.5 m/h (SILVESTRU, 1995). Concerning the origin of the important tributary from -174.0 m in Cuciulata Pit, we suppose that it comes from swallow hole located at 200 m North-West of the pit. In conclusion we are dealing in the searched zone with two different systems of drainage, there is no hydrological connection between Ponorul din Cuciulata and Cuciulata Pit. The nearing to these ponor-caves of the Someşul Cald canyon did not allow the organization of a unique drainage system.

Climatology

The temperature inside the Cuciulata Pit is between zero and 4.8 degrees Celsius and the humidity is over 90%.

Mineralogy

A study of minerals does not exist. It would be tempting to search an amazing cave developed at the contact of limestone of Malm (J3) age with the quartzite of

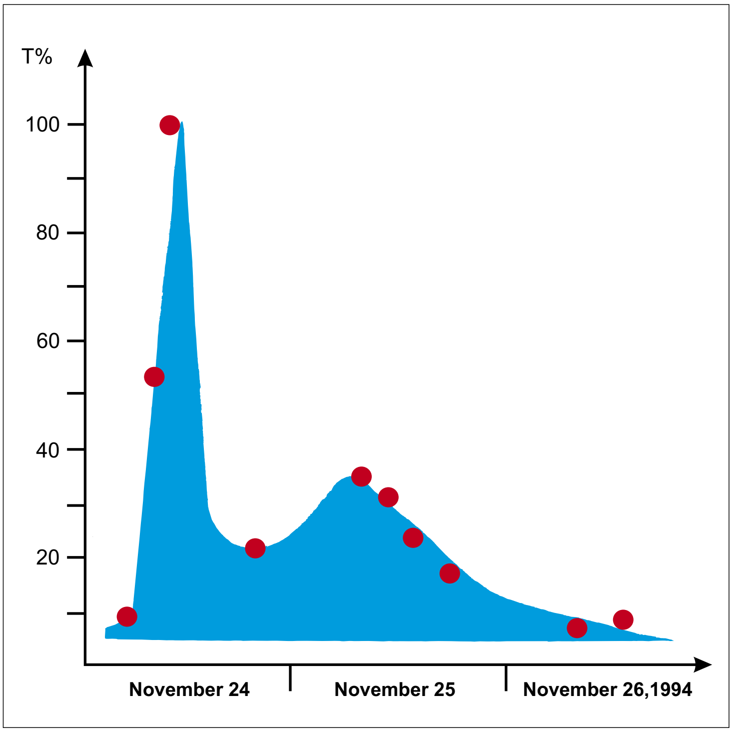

Figure 7. Graph of the tracer outpout at Izbucul Moloh (Peştera cu Apă din Cheile Someşului Cald) spring for the imput in Ponorul din Cuciulata, credit by Emil Silvestru, 1995

Lower Liassic (J1) age. For sure, it exists the chance to find a new kind of minerals because of the neighboring of the banatites massif of Vlădeasa.

Ponorul din Cuciulata

In the immediate vicinity of Cuciulata Pit (Avenul din Cuciulata) there are two more strongly descended slope-caves: Ponorul din Cuciulata and Ponorul Mare from Pârâul Vacii. But they do not make a unique morphological and hydrogeological system, belonging to two different resurgences: Izbucul Moloh (Peştera cu Apă din Cheile Someşului Cald) and Izbucul cu Cascadă.

Ponorul din Cuciulata is situated at 350 m South-West of the entrance to Avenul din Cuciulata on the mountain Cuciulata, too, and at the same altitude, 1400 m as Cuciulata Pit. It was discovered in July 1977, too, by the Speleological Club „Z". The exploration and survey were entirely made that year by Liviu Vălenaş, Horia Mitrofan, Dorel Pop, Nicolae Sasu, Nicolae Paul and Éva Györfi. In September 1977, the explorations were joined by a team of the Speleological Club of Dabrowa Górnicza, Poland.

Figure 8. Ponorul din Cuciulata, the Intersection Hall (Photo by Liviu Vălenaș, 2014)

Ponorul din Cuciulata is a continuously descending cave, developed generally on two levels (Figs. 8-10). Here and there, a small intermediate floor appears complicating the system of galleries even more, is one of the most maze caves in Romania. The 3,140 m of galleries fit in a rectangle of only 200 × 150 m! The cave is continuously descending, having a final river with quite a big flow. It is not known where this course of water comes from; there are only two possibilities: it comes either from the river which gets lost at the entrance or from a nearby slope. In the middle sector, the cave presents a network of galleries, relatively horizontal, narrow, low and maze. In this sector, there is also the only large hall in the cave, 57 m long, 16 m wide and 12 m high.

The galleries are excavated only on fractured lines, the layering faces playing an absolutely minor role. The unique entrance is at the end of a small pocket valley, 10 m wide and 5 m high. Right under the entrance portal, a short gallery climbs up to +10 m. From the end of the entrance hall, the cave branches out in a T shape. The North-East branch ends after 40 m.

The southern branch is narrow and meandering; after a 3 m vertical it presents a bigger one of 6.6 m. At its basis, there is a hall 14 m long and 14 m wide, too, Intersection Hall. From here a complex of extremely branching maze galleries go North-East, the CSER Galleries. Only this sector has a 1,500 m development.

Figure 9. Ponorul din Cuciulata, the Secondary River in the CSER Galleries (Photo by Liviu Vălenaș, 2014)

From the Intersection Hall, the Main Gallery continues towards South-East, meandering, relatively narrow, with several verticals up to 8 m. It is run by an active which comes from the infiltration water from CSER Galleries. Some sumps are avoided through fosil loops. In the terminal portion you get to the main active which makes

Figure 10. Ponorul din Cuciulata, rimstones in the CSER Galleries (Photo by Liviu Vălenaș, 2014)

a surprisingly sudden elbow towards North-East. At 350 m from the entrance, a gravel clogged final sump, at -75 m, stops any advancement. In this portion, several very narrow fosil galleries have the tendency to pass over the sump but they also end up hopelessly. The sudden elbow of the main active towards North-East set forth in 1977 the hypothesis that Ponorul Cuciulata could be a side network of Cuciulata Pit. But the colouring made in 1995 showed that the final drainage of the cave is done in Izbucul Moloh Peştera cu Apă din Cheile Someșului Cald. In other words, the idea that Ponorul din Cuciulata and Avenul din Cuciulata would form a single morphologic and hydrologic system proved to be wrong. The provenance of the final course from Ponorul din Cuciulata (average flow 15 l/s) is unknown. It probably gathers the waters from the slope at the entrance and from the dolines at its South. We do not see another provenance. In the CSER Galleries there is one more subterranean course, 50 m long, which gets lost separately, through a whirlpool. It probably confluences with the main course after the -75 m sump.

Ponorul Mare from Pârâul Vacii
Ponorul Mare from Pârâul Vacii (1,371 m length, VR: -117 m), discovered by the same Speleological Club „Z“ in July 1977. It is situated at only 230 m West - North-West of the entrance of Cuciulata Pit (Avenul din Cuciulata) at 1305 m altitude. It is also relatively maze cave and contains some large halls and several siphons, the final drainage of the subterranean river is in Izbucul cu Cascadă. At the end of a small pocket valley, three entrances, an 8 m pit included, there opens into a narrow gallery in bare rock, fragmented by several verticals of 3 m, 5.5 m and 4.5 m. At the marking -33 m (in report with the 8 m deep pit) the gallery was found in 1977 totally clogged with river deposits. After 1980, the Speleological Club „Politehnica” of Cluj-Napoca, disobstracted this terminus and explored a complex of galleries, relatively labyrinthine, descending, displayed in an air length of 179 m. It turns out that this cave forms only one hydrogeologic and morphologic unit together with Cuciulata Pit. Of note is that the Speleological Club „Politehnica“ of Cluj-Napoca continued in the 1980s the explorations of this cave and renamed it abusively and contrary to the recognized world rules as *„Peştera Fisura Neagră”*.

Acknowledgments

We are indepted to Emil Silvestru, †Gheorghe Popescu, Dorel Pop and Eva Matei who contributed in various ways to our work.

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Morphology and hydrogeology of the karst area of Lumea Pierdută and Vârtopașul-Iezere (Bihor Mountains, Romania)

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Abstract. Here we describe the karst area situated in the hydrographic basin Izvorul Ursului - Pârâul Sec, which includes the Căput Cave, the Lumea Pierdută System (= The Lost World System), the Peștera Mare de la Izvorul Rece (= The Great Cave at the Cold Spring), and the Iezere Cave that lies in the karst plateau Iezere - Vârtopașul, above Pârâul Sec. The latter is situated at the limit of three great hydrographic basins: Galbena, Valea Ponoraș and Gârda Seacă. Besides the endokarst the area is extremely rich in attractive exokarst elements.

Introduction

The hydrographic basin Izvorul Ursului - Pârâul Sec is a nearly unique karst zone, not only in Romania but also in Europe. On a reduced surface of only 6.4 km² there are 34 caves, out of which the two great systems detach clearly, Lumea Pierdută System (3,322 m total length) and Căput Cave (1,950 m total length) (Fig. 1). But, not only the endokarst is interesting but also the exokarst: stremsinks, ponors, resurgences, dolines, limestone pavements, pocket valleys, canyons, etc.

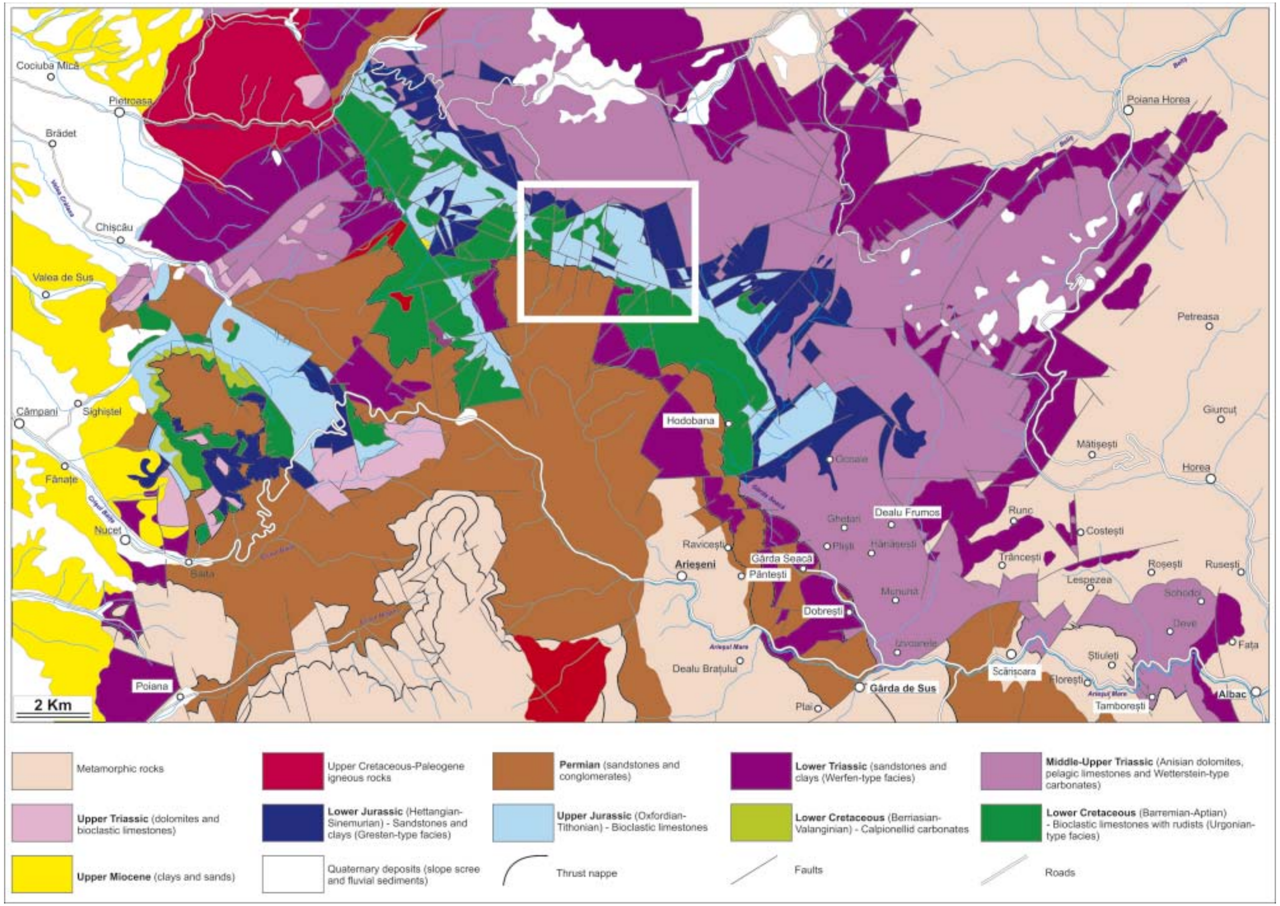


Figure 1. Lumea Pierdută-Vârtopașul-Iezere karst area (in white framework) within the geological map of the central part of the Bihor Mountains. Modified by George Pleș after geological maps 1: 50000, sheets 56a (Pietroasa; Bleahu et al., 1985), 56b (Poiana Horea; Bleahu et al., 1980), 56c (Biharea; Bordea et al., 1988) and 56d (Avram Iancu; Dimitrescu et al., 1977)

Peștera de la Căput (=Căput Cave)

Peștera de la Căput, situated at 1050 m altitude (the main entrance) represents the final drainage point of the closed basins: Izvorul Ursului-Pârâul Sec and also a subterranean drain for the small closed basin Cetățeaua (Fig. 2, 4, 5). The cavity is in fact, a maze-like network formed epiphreatically with a total length of 1,950 m and an vertical range (VR) of -91 m. At present, the cave is subjected to a slow clogging evolution, especially due to large accumulations of logs. This last aspect demonstrates once again the total negative impact on nature as a result of the massive and uncontrolled deforestations after 1989.

Explorations history

In 1861, the great Austrian geographer Adolf Schmidl discovered the entrance to Căput Cave. After about a century, in 1952 Mihai Șerban, Iosif Viehmann and Marcian Bleahu had their first exploration of the cave and they reach the -65 m depth. In 1955 Dan Coman, Marcian Bleahu, Iosif Viehmann and Liviu Mînzăraru they got to the terminal sump (it seems they got to the terminal sump- we do not have precise data) at -91 m (-71 m reported to the main entrance). A schematic map was made for 550 m of galleries, that is, the main gallery exclusively. The map was published for the first time in 1976 when it was already totally outdated. Between 1976 and 1983 the Speleological Club „Z" (Liviu Vălenaș, Gizella Kajtor, Tibor Varrö and Iuliana Kövári) sustained explorations of the Căput Cave, that time the side network being explored, the total length of the cave reaching 1,950 m. The explorations în 1976 were made în common with the Speleological Club „Speodava" (Petru Brijan and Viorel Conete) from Ștei. After 1989, massive clogging did no longer allow any speleologist to get to terminal sump. Since 1994, the upper sector of the cave was used as „school land" by the național speleological schools that were developing în the adjacent area.

Lithology, morphology and genesis

The cave has developed in Jurassic limestone (J3), strongly diaclazed and faulted and developed in a wide homocline. The main faults lines are SE-NW and SW -NE. Practically all galleries in Căput Cave develop on these tectonic lines which can be recognized at the surface, too. The transition from one faulting system to another has created underground false meanders of the main gallery. Morphologically and hidrogeologicaly, Căput Cave belongs to a vast system with a final unloading point în Izbucul Galbenei (815 m altitude). This important resurgence is also joined by Cetățile Ponorului Cave, Groapa de la Barsa (with the adjacent

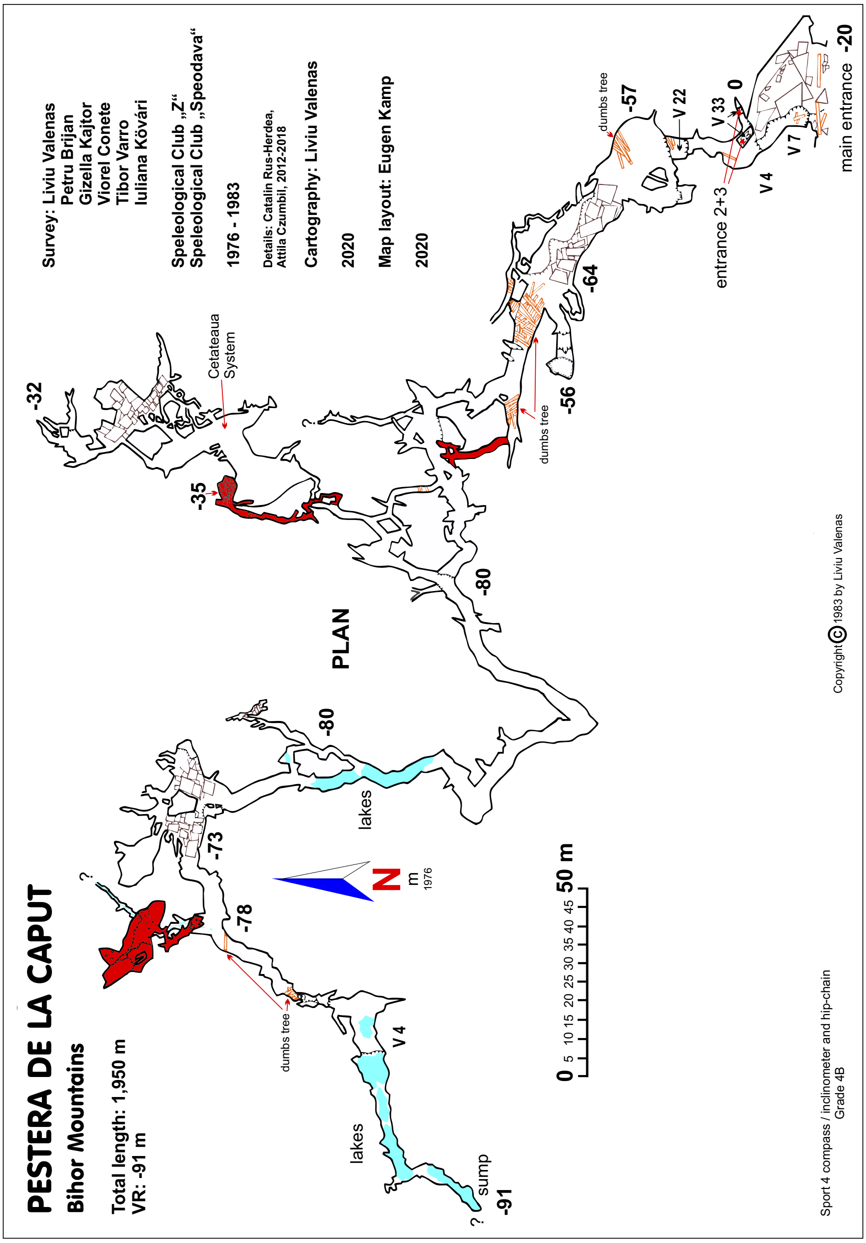


Figure 2. Căput Cave, plan view, cartography by Liviu Vălenaș, 2020.

basins Poiana Zăpodie and Ștevia Lupii) , Poiana Ponor and the two small basins Molhașul Ponorului and Cetățeaua. A total number of galleries of 50-70 km (for this great system) is but a minimum at the moment. The main gallery of Căput

Cave with a length of 575 m can be morphologically considered a first order drain. Towards this main drain, two second order secondary drains, Cetățeaua network and the small tributary from-78 m get along. The ratio between the total surveyed length (1,950 m) and the aerial extension (331 m) characterises a relatively maze-like cave, the branching coefficient being of 5.9. The maze-like character stands out significantly especially at the side network Cetățeaua.

Hydrogeology

During the dry season, the cave has no flow except the small tributary at the -78 m depth. Normally, the waters of the valleys Izbucul Ursului and Pârâul Sec get lost in the bedding of the valley at 40-100 m from the main entry. It is obvious that a groundwater flow is organized under Căput Cave with a final unloading point in the still unexplored sector between the terminal sump in Căput Cave and the last sump in the active tributary gallery in Cetățile Ponorului Cave heading towards Căput Cave. During the flooding season, the last 180 m în the main gallery make practically one sump. Cetățeaua Network and the tributary at the -78 m drains the small closed basin Cetățeaua, more precisely the two permanent small pock-et walleyes leaks developed at the lithologic J1-J3 contact. Mentioning that the first leak organizes at present underground, too, following under the galleries of Cetățeaua Network, a vadose flowing existing probably only at great floods. Iancu Orășeanu (Orășeanu, 2020) supposed the drainage at least, partly of the plateau (more of a closed basin) Paragina, too, through Căput Cave. The hypothesis is wrong: in Căput Cave, there is no tributary coming from Paragina. But we do not exclude, at a lower level, phreatic evidently, to exist such a confluence.

Description

At point of -20 m (in relation to the secondary entrances) is the main entrance, an imposing sloping portal, 21 m wide and 5 m high. Above the portal on a major fault line several pits open, out of which two grouped appear at the marking +20 m from the main entrance. The two pits unite after a few meters and they have a pit of 33 m. The main portal continues with a gallery resembling a canyon fragmented by three pit of 7, 4 and 22 m respectively. The last pit opens into a large hall of 23/15 m immediately followed by another hall full of blocks, 36 m long and 11 m high, point of -64 m. From this depth the cave presents a phreatic gallery with a beauti-ful profile of equilibrium with elliptical sections on average 6/3 m. At a distance of 232 m from the entrance, an important bifurcation appears. Towards North-East a maze-like complex develops, partially storeyed consisting of clay galleries - Cetățeaua Network. The sector (with a cumulated length of 611 m) presents two more large halls of 24.3 ×18.6 m and 31.4m × 7.4m respectively. At the end, a hall (22.8 ×17.1 m), chaotic, full of blocks and pillars and on the left, an ascending gallery. From here, up to the first ponor from the closed basin Cetățeaua there are only 30 m în straight line. The main gallery continues meandering presenting (în the dry season) at 339 m from the entrance a first lake, 23 m long, then a second 9 m long. From the last lake (-81m) the gallery still continues meandering having several slides în living rock, either descending or ascending. At 575 m from the entrance, the explorations have been stopped by a deep overflowing sump (-91 m). From here up to the main gallery in Cetățile Ponorului Cave there is an aerial extension of 300 m. We still have to mention a small tributary at the -78 m running on 50 m up to 60 m în a squeeze line from the second pocket valley in Cetățeaua. Căput Cave also contains large accumulations of logs which endanger any exploration or just a visit.

Mineralogy

Căput Cave is very poor în speleothems. There are some in a hall superior to the tributary starting from -78 m marking.

Possibilities of advance

The main serious possibility of advance is the junction with Cetățile Ponorului Cave forcing the terminal sumps in Căput Cave and in the tributary gallery from Cetățile Ponorului Cave. Maybe in the future, it would be more productive that the diving attempts be done from Căput Cave to Cetățile Ponorului Cave. But to be able to dive into the terminal sump in Căput Cave, the clogging of logs and river deposits must be deblocked from -78 m which was formed after 1990. This operation needs great logistics, which is not impossible. Only a few tens of meters part this sump in Căput Cave from the last sump in the tributary gallery in Cetățile Ponorului Cave. Only theoretically it is possible to advance 100 m more on the last tributary towards the closed basin Cetățeaua but only if the continuous squeezes in this sector are forced.

The Lumea Pierdută System (= The Lost World System)

The Lumea Pierdută System represents the undergrounding of the plateau with the same name, a plateau situated between 1200 and 1220 m (Fig. 3). Concretely, it is about a drain of about 2.5 km (considering also the theoretical meanderings in the segments not known yet) and the diffuse sinking stream of Pârâul Sec (the Dry Creek) and the resurgence from Izvorul Rece (The Cold Spring), 1085 m alt. If

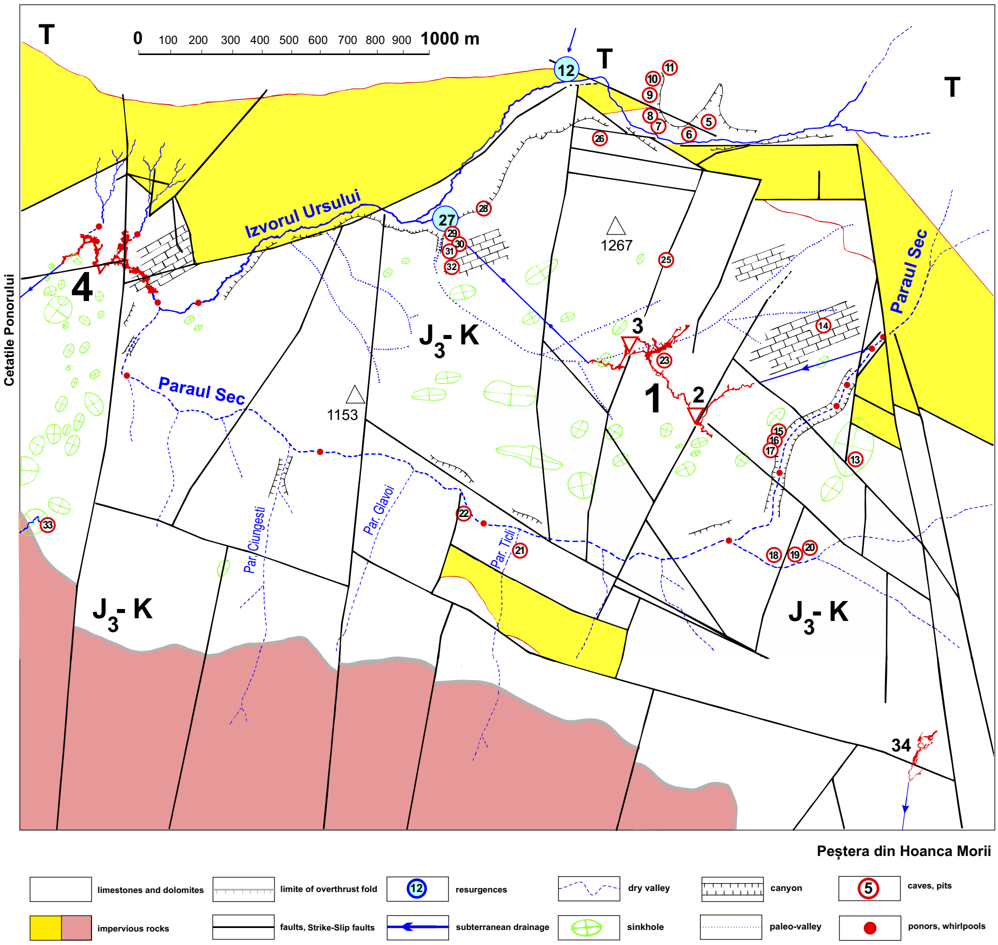
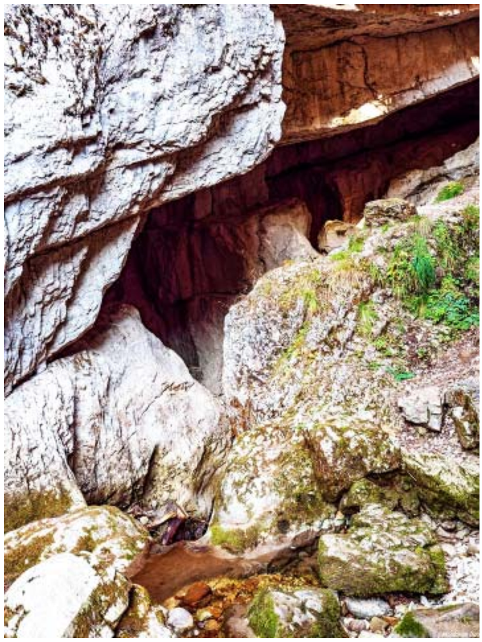


Figure 3. The karst zone Izvorul Ursului and Pârâul Sec. The endocarst: 1 – Rețeaua Lumea Pierdută, 2 – Avenul Negru, 3 – Avenul Gemănata, 4 - Peștera de la Căput, 5 - Peștera I din Chicerile Ursului, 6 - Peștera II din Chicerile Ursului, 7 - Peștera Suspendată din Chicerile Ursului, 8 - Peștera III din Chicerile Ursului, 9 - Peștera cu Hornuleţ din Chicerile Ursului, 10 - Peștera cu Pod Natural din Chicerile Ursului, 11 - Peștera Mică din Chicerile Ursului, 12 – Izbucul Ursului, 13 – Ponorul-Sală de la Izvoarele Pârâului Sec, 14 - Avenul Înfundat, 15 – Peștera cu Viezuri din Pârâul Sec, 16 - Peștera cu Două Intrări din Pârâul Sec, 17 - Peștera Mică din Pârâul Sec, 18 - Peștera Scundă cu Perle din Pârâul Sec, 19 - Peștera II din Pârâul Sec, 20 - Peștera cu Două Intrări din Pârâul Sec, 21 - Peștera cu Două Intrări din Valea Seacă (Pârâul Sec), 22 - Ponorul cu Sifon din Valea Seacă (Pârâul Sec), 23 - Peștera Mică de la Avenul Gemănata, 24 - Avenul Pionierilor, 25 - Avenul Acoperit, 26 - Peștera Mică de la Nord de Avenul Acoperit, 27 - Izvorul Rece, 28 - Peștera I de la Izvorul Rece, 29 - Peștera Mare de la Izvorul Rece, 30 - Peștera III de la Izvorul Rece, 31 - Peștera IV de la Izvorul Rece, 32 - Avenul cu Două Intrări de la Izvorul Rece, 33 - Ponorul din Barsa Cohanului, 34 - Peștera de la Iezere. (Cartography by Liviu Vălenaș, 2020).

Figs. 4 and 5. The main entrance to Căput Cave, photo by Dan Moldovan, 2019.


Figure 6. The 22 m pit in Căput Cave, photo by Attila Czumbil, 2018. **Figure 7.** The first exploration in Căput Cave, 1952, down-right: Marcian Bleahu (who ensures) on the rope ladder: Mihai Șerban, photo by Iosif Viehmann (reproduced from volume „Höhle von Rumänien", Meridiane Publishing House, Bucharest,1961).

Figure 8. The hall at the base of the 22 m pit in Căput Cave, photo - Attila Czumbil, 2018.

the resurgence and the diffuse sinking stream of Pârâul Sec are impenetrable, the underground access was possible due to two important pits: the Avenul Gemănata (The Twin Pits) - Gemănata Pit and Avenul Negru - (Black Pit), 81 and 82 m respectively, deep. The Lumea Pierdută System focused on an main course 1.1 km long and on a secondary course,188 m long, plus a branch occupied by a stagnant lake, 90 m long (Fig. 9). The total length is of 3,322 m, VR -137 m.

Explorations history

In 1952 Mihai Șerban, Iosif Viehmann, Marcian Bleahu and Tibor Jurcsák descended the 81 m well from Gemănata Pit and explored nearly 700 m of galleries. In 1956, another team, led by Marcian Bleahu (Dan Coman, Gheorghe Mantea, Sever Bordea, Josefina Bordea, Corneliu Pleșa and Liviu Munthiu) descended for the first time the 82 m vertical from Negru Pit and made the junction with Gemănata Pit surveying about 1 km of galleries. The map was published only in 1976 when it was no longer relevant. Marcian Bleahu, who undoubtedly was the engine of the explorations in this great network, baptized the limestone plateau with these two pits „Lumea Pierdută“ (The Lost World) after Arthur Conan Doyle’s novel, „Professor Challenger“. The name, totally unknown to the natives, became known and gradually it remained to be used till now. In 1976 the Speleological Clubs „Z“ (Liviu Vălenaș, Gizella Kajtor and József Dezsö) and „Speodava“ (Petru Brijan and Ovidiu Cuc) perfected a collaboration and surveyed minutely the network. The most important advance was achieved on the Secondary Course, the surveyed length (for the whole system) being 2,437 m. Upstream of Negru Pit nothing could be explored, the pit hole being found blocked with snow and ice that year. In 1980 Mircea Sfâșie, together with a group of schoolchildren from Halmeu, all under 15 years (!?), with a rudimentary equipment, descended again in the Negru Pit exceeding the snow blockage and explored a small part upstream, with deep lakes, up to a sump (Sfâșie, 1982). Marcian Bleahu, in 1956 appreciated the vertical of Negru Pit to be 108 m (with this figure, a national record for 14 years), Mircea Sfâșie even to 109 m (Sfâșie, 1982), both values being much exaggerated. The measurements in 1982 reduced the figure to „only“ 82 m. In August 1982 Liviu Vălenaș and Gheorghe Popescu succeded in widening a squeeze where a strong air current used to blow a little upstream Negru Pit and advanced nearly 1 km , first on a fossil gallery and then on the main course up to a 4 m waterfall. It was exceeded in 1983 by Liviu Vălenaș and Nicolae Sasu, terminus being an open sump with the ceiling at only three centimetres from the mirror of the water. After a few months, the same year, the two passed this sump, too, being stopped by a fissure, extremely narrow, out of which the active appeared through a 2.5 m waterfall, at the -58 m depth. This point could no longer be exceeded till now. In the terminal sump downstream, Liviu Vălenaș dived in 1982 but he abandoned it after only 4.5 m because of the improper equipment. The total surveyed in 1976-1983 was 3,322 m (which is still at present). Unfortunately, Negru Pit has become relatively well-known to the public at large lately through two deadly accidents of some tourists who, being negligent, slipped into the 82 m well.

Lithology, morphology and genesis

The system develops in Jurassic (J3) and cretaceous (K) limestone, strongly diaclazed and faulted, developed into a large homocline (Fig. 10). The main fault lines are SE-NW and SW -NE. Practically, all galleries develop on these tectonic lines which can be recognized at the surface, too. But the subterranean course appears through a 2.5 m high waterfall directly from the nonkarstifiable stack belonging to the inferior Jurassic (quartzite sandstones and Hettangian quartzites and less frequently Toarcian marls). It is quite clear that here we have to do with a vadose flowing gallery excavated in these rocks, wrongly considered nonkarstifiable. One more evidence added to questioning the notion of „pseudo-karst“. The

Lumea Pierdută System evidences a genesis initially epiphreatic, then, massively vadose remodeled. Negru Pit and Gemănata Pit were formed in the same conditions, from down upwards, after the massive collapse, opened at the surface. As a testimony that they developed from the bottom up, are several chimneys that climb 40-50 m and end up in a „sack bottom". As for the upstream end of the network, it was dictated by the upstream migration of the sinking stream of Pârâul Sec. There can be seen an almost perfect similitude with the Coiba Mică-Coiba Mare System (Vălenaș, 2019-2020). The gallery, occupied by the 90 m long lake corresponds with the first stream sink of Pârâul Sec. We do not know yet where this paleo-whirpool or paleo-ponor lies but it is certain that it is at an aerial extension towards the upstream sump from the Lumea Pierdută System of 270 m (if it is about the sinking stream from SE) or most probably, at 380 m, the sinking stream from S-SE. Instead, the river active terminus (the 2.5 m waterfall) drains the sinking stream from the current upstream of Pârâul Sec which is at an aerial extension of 430 m. The Lumea Pierdută System has a total length of 3,322 m surveyed, displayed on an aerial extension of 540 m, branching coefficient: 6.1. Out of the total length, 767 m are pits or chimneys, that is 23.1% from the total.

Hydrogeology

Without any discussion, the hydrogeology of the Lumea Pierdută System is one of the most interesting in the Bihor Mountains. The main underground course represents a breakthrough of the plateau Lumea Pierdută between Pârâul Sec and Valea Izvorul Ursului. This underground course is displayed on an aerial extension of 1,580 m and a vertical range of 170 m. We appreciate the real length of this course to a minimum of 2.5 km taking into account its meanders, too, determined by the tectonic structural factor. Out of this theoretical length, only 1,100 m could be explored so far. In the terminal upstream sector of the main course (the portion with the six waterfalls) from the North five low flow tributaries converge draining only the eastern sinkholes of the Lumea Pierdută plateau. The Secondary Course, in exchange, drains the valley of the sinkholes from the NE of Gemănata Pit. From the terminal sump downstream the Lumea Pierdută System, there still remains an air distance of 720 m up to the resurgence at Izvorul Rece and a vertical range of only 10 m. But the relatively high flood wave propagation speeds sustain the idea of a flow, mainly free. Finally, the main active course which disappears upstream into a muolin with sump at -83 m depth, after a drowned course of 200 m, it appears a little upstream the Negru Pit in the gallery occupied by a 90 m long stagnant lake. The respective relation was demonstrated through a colouring made in 1982. Iancu Orășeanu and Paul Matoș (Orășeanu, 2020) made a colouring at the

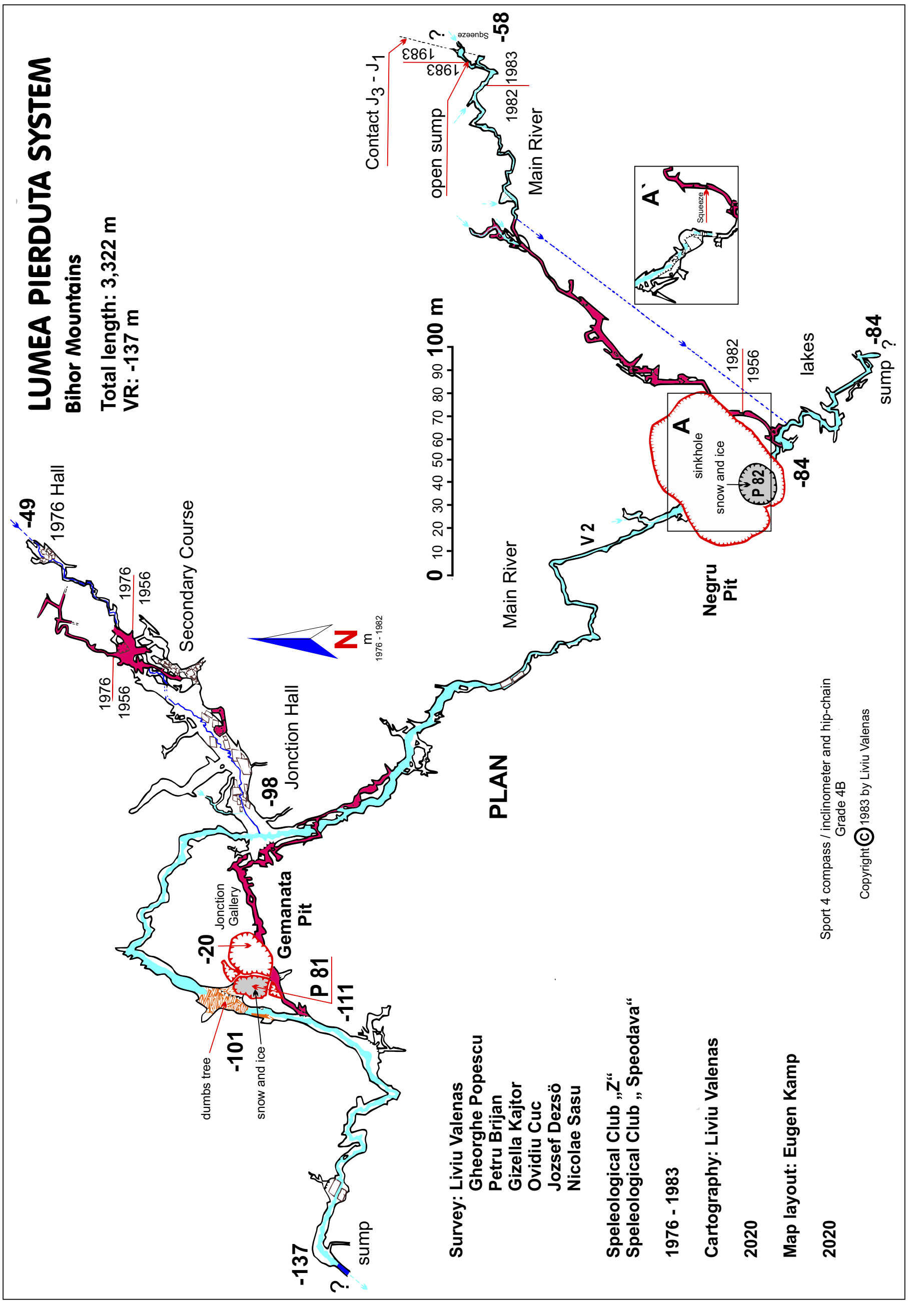


Figure 9. The Lumea Pierdută System, plan view, cartography by Liviu Vălenaș, 2020.

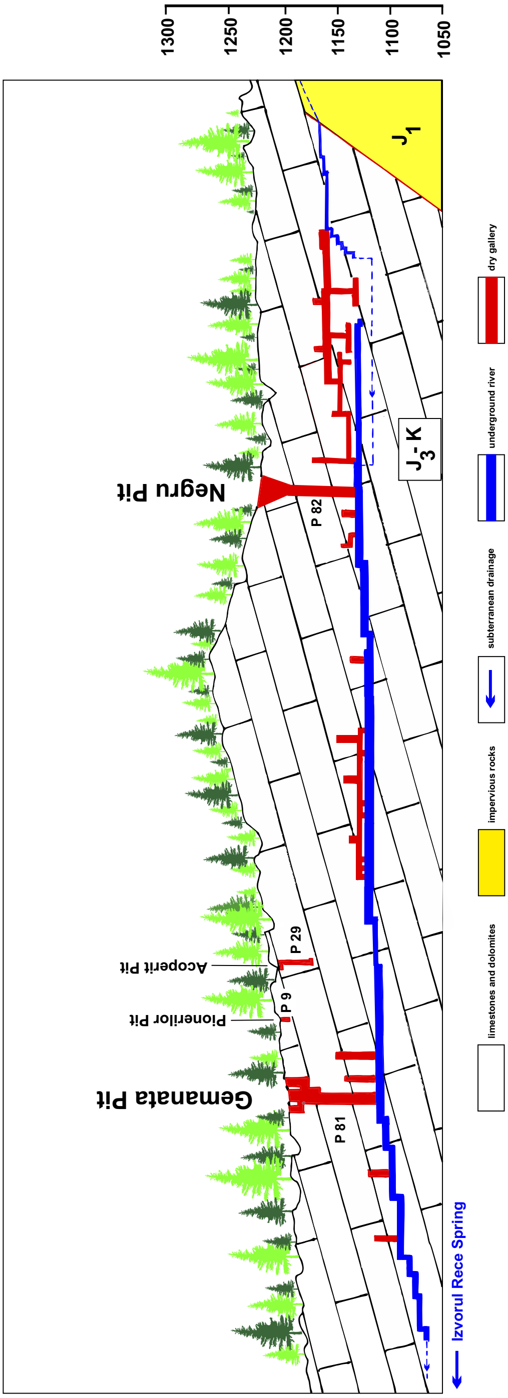


Figure 10. The Lumea Pierdută System, schematic section, graphics by Liviu Vălenaș, 2020.

diffuse sinking stream of the Pârâul Sec on August 10th 1986. This was normally identified in the subterranean course Gemănata Pit and then in Izvorul Rece. The flow speed on the route Pârâul Sec - Izvorul Rece was 34.6 m/hour (Orășeanu, 2020). The medium flow rate of Izvorul Rece is 40 l /s, the temperature between 5.4 - 5.6 C degrees (Orășeanu, 2020). But on July 27, 1978, the author measured a water temperature of 6.1 C degrees in Izvorul Rece. Unfortunately, the authors of the colouring in 1986 never said precisely at what stream-sink of Pârâul Sec they made the respective colouring.

Description

We will make the description in the sense of the hydrological flow, from upstream to downstream. At the point of -58 m, on a clear fault line and on a limestone/ nonkarstifiable J 3- K/J 1, lithological contact, from a fissure, the active appears through a 2.5 m waterfall. The terminal chamber is not more than 3 m in diameter after an open sump, with a open sump and after a meandering course with a succession of other five waterfalls (of 1, 4, 3, 5 and 7 m respectively) the active disappears into a muolin with sump (-83 m). After climbing an antithetical step, a fossil path follows, 215 m long made up of galleries 15-30 m high. The last portion of of the fossil gallery is descending, with some verticals (V5, V15) which, in order to reach the terminus point from -58 m, must be climbed. After a severe squeeze, the main course is met again under the shape of a 90 m long lake heading towards SE. To the SW you can get after only a few meters at the bottom of Negru Pit which has a cone of river deposits and logs. At present, it is no longer possible to cross this natural dam (15 m long) towards Gemănata Pit, a fact that was possible in the 1950s. Negru Pit starts from a big sinkhole, 65 m in diameter, in which the 82 m vertical is inscribed in a hypothetical axis in the middle of the sinkhole.

Between 1956-1983 in Negru Pit there was a large perennial accumulation of snow and ice. After this stopper, the main active appears. After an almost horizontal course (with the exception of a 2 m waterfall) of 359 m long, you can get to the Confluence Hall. From here, it branches towards the NE of the Secondary Course, 188 m long. It ends impenetrably at -47 m depth in the „1976 Hall“. Above this active, a few maze-like upper floors branch, the total length of the Secondary Course being of 838 m, the main active flows almost horizontally (it presents several lakes) on a length of 153 m, up to the basis of Gemănata Pit (point of -101m). Gemănata Pit starts from the surface through four parallel verticals, which unite after 20 m. If you try to climb down directly through the western well, the pit measures 81 m. At the basis of Gemănata Pit, there are large accumulations of logs and detrital material fallen from the surface. Between 1952-1983 there were large

Figure 11. Negru Pit, photo by Attila Czumbil, 2018.

Figure 12. Gemănata Pit, photo by Attila Czumbil, 2018. **Figure 13.** Gemănata Pit, P 81 m, photo by Cătălin Rus-Herdea, 2020.

deposits of perennial snow and ice, too. Between the Confluence Hall and the basis of Gemănata Pit, you can also get through the Connection Gallery (a fossil gallery which avoids the lakes on the Main Course) 91 m long. The Main Course can still be followed on 192 m the terminal downstream sump from -135 m. The Main Course presents several rapids. The terminal sump was dived in 1982 on a length of 4.5 m up to -2 m (-137 m compared to the entrance of Negru Pit). The sump is a relatively low rolling mill with a slope of 20 degrees but continuing in the direction of the resurgence at Izvorul Rece.

Mineralogy
The Lumea Pierdută System is relatively poor in speleothems. Some of them appear in the upper floors above the Secondary Course and mainly in the fossil gallery 215 m long, between Negru Pit and the terminal sector of the main course.

Possibilities of advance
Unlike Peștera de la Căput, the Lumea Pierdută System still has a great potential. The most serious advancement could be made by forcing the downstream sump up to the resurgence at Izvorul Rece, remaining an air length of 720 m. The relatively great speed of flowing (demonstrated by colouring in1986) sustains the idea of an active, partly vadose. Another tempting possibility is that of diving into the sump upstream the Negru Pit, the SE branch, a wide and deep sump. Here, too, hides an important potential of galleries, more than likely with halls and large lakes after the sump. And between the gallery with lakes and the muolin with sump in the upstream sector, there still remains a 200 m long sump to be surveyed. Finally, if it were to enlarge, the technical means of the XXIst century (which we did not dispose of in 1983) the final fissure, maybe we could advance on the main active upstream, too, beyond the point of -58 m. It is certain that the presence of the important air current shows that the network does not end here. And up to the sinking stream in Pârâul Sec there still is an air distance of 430 m. In conclusion, we appreciate the potential of the galleries of the Lumea Pierdută System at least double to the surveyed length so far.

Avenul Acoperit (= The Covered Pit)

The Avenul Acoperit is a fossil cavity, without continuation, with a depth of 35 m (88 m length) situated above Lumea Pierdută System (Figs. 14 - 16).

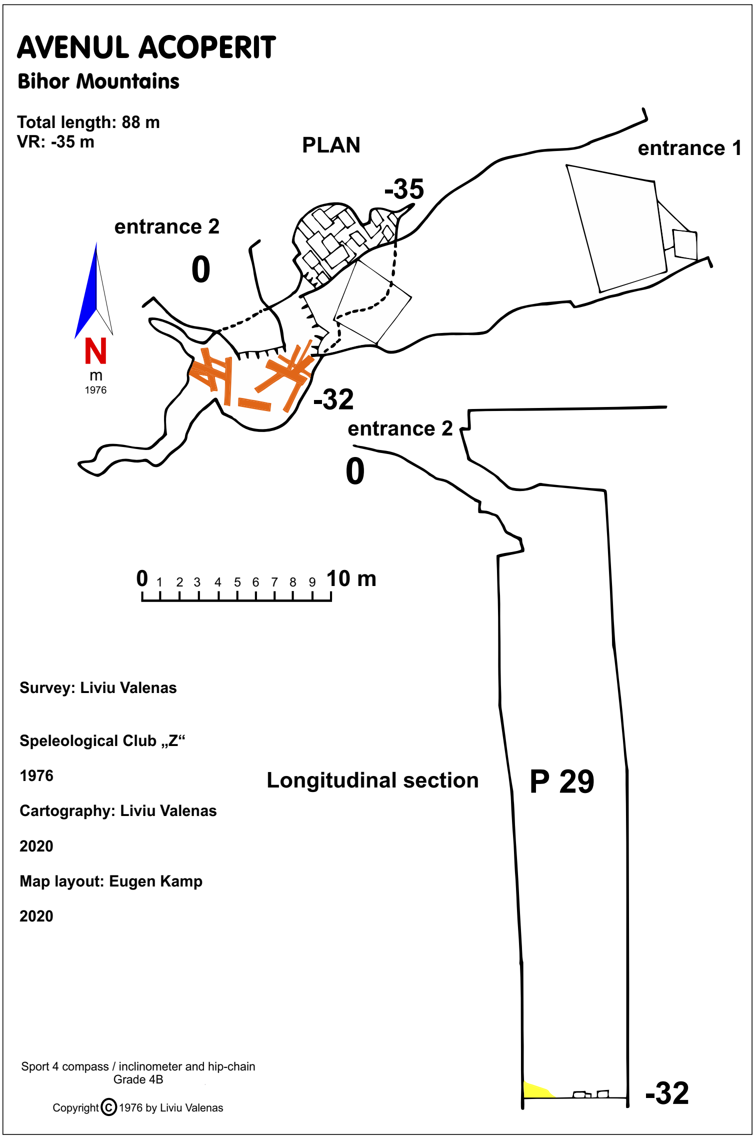


Figure 14. Avenul Acoperit, plan view and section by Liviu Vălenaș.

Explorations history

The Avenul Acoperit was discovered by Marcian Bleahu, Dan Coman and Liviu Mînzăraru in 1953. In 1976 it was precisely surveyed by Liviu Vălenaș, Eleonora Vălenaș, Nicolae Sasu and Ferenc Kulcsár (Speleological Club „Z“).

Figure 15. Avenul Acoperit, the main entrance, photo by Attila Czumbil, 2018.

Figure 16. Avenul Acoperit, the 29 m pit, photo by Attila Czumbil, 2018.

Description

From an entrance 10 m wide and 3.5 m high, there comes a horizontal gallery, 20 m long which ends through a vertical pit of 29 m. At its base, there is a small hall of blocks descending to -35 m.

Morphology

The pit developing in living rock, was initially formed in a phreatic regime, the 29 m pit, which has a ceiling above it is a proof in this respect. After the initial phreatic phase, the pit was vadose modelled. Morphologically it belongs to Lumea Pierdută System but we are not aware which gallery in the underground of this great cave it could correspond.

Peștera Mare de la Izvorul Rece (= The Great Cave at the Cold Spring)

Peștera Mare de la Izvorul Rece is a fossil cave, representing the overflow of the resurgence Izvorul Rece (Fig. 17). It is situated at 18 m vertical range reported to the resurgence having a length of 90 m and a development on the vertical range of 13 m (-4; + 9). We mention that the cave appears in „The Speleologic Inventory of the Bihor Mountains" (Vălenaș, 1977), under the name of Peștera II from Izvorul Rece.

Explorations history

The cave was discovered in 1976 by Eleonora Vălenaș (Speleological Club „Z") and Tiberiu Luscan (Speleological Club „Speodava"), its survey in 1983 being achieved by Liviu Vălenaș, Iuliana Kövári, Lázsló Kuki and Péter Ménesi.

Morphology

The cave was formed in a phreatic regime, and no notable vadose remodelling was found. The 18 m descending of the phreatic surface let the cave suspended in relief, without any flowing.

Description

From a small entrance, a low gallery, 17 m long, gives access through a negative vertical of 3 m to a large hall 25 × 7 × 7 m, full of blocks. Unfortunately, no continuation was found towards the subterranean course between Lumea Pierdută System and the resurgence Izvorul Rece.

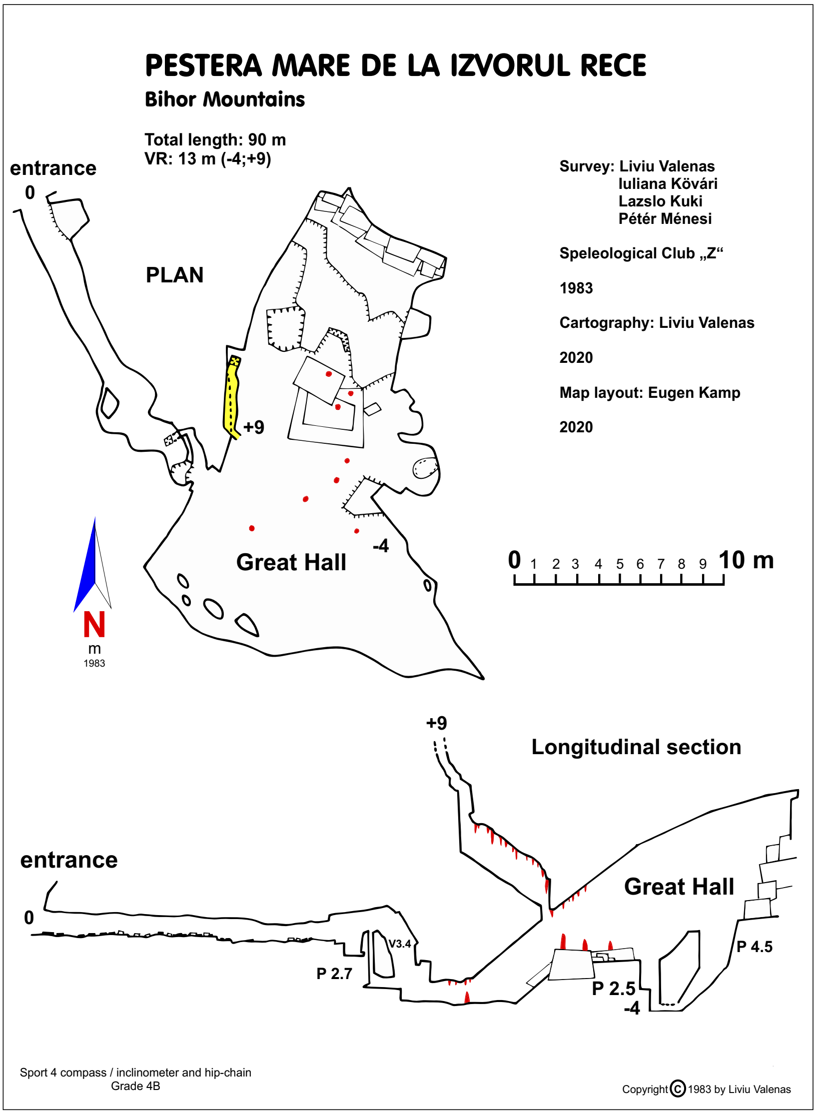


Figure 17. Peștera Mare de la Izvorul Rece, plan view by Liviu Vălenaș.

Peștera de la Iezere (= Iezere Cave)

Peștera de la Iezere is a ponor-cave, situated at 1320 m altitude, it lies in the karstplateau of Iezere - Vârtopașul, above Pârâul Sec, at the limit of three great hydrographic basins : Galbena, Valea Ponoraș and Gârda Seacă (Fig. 18). It is dif-

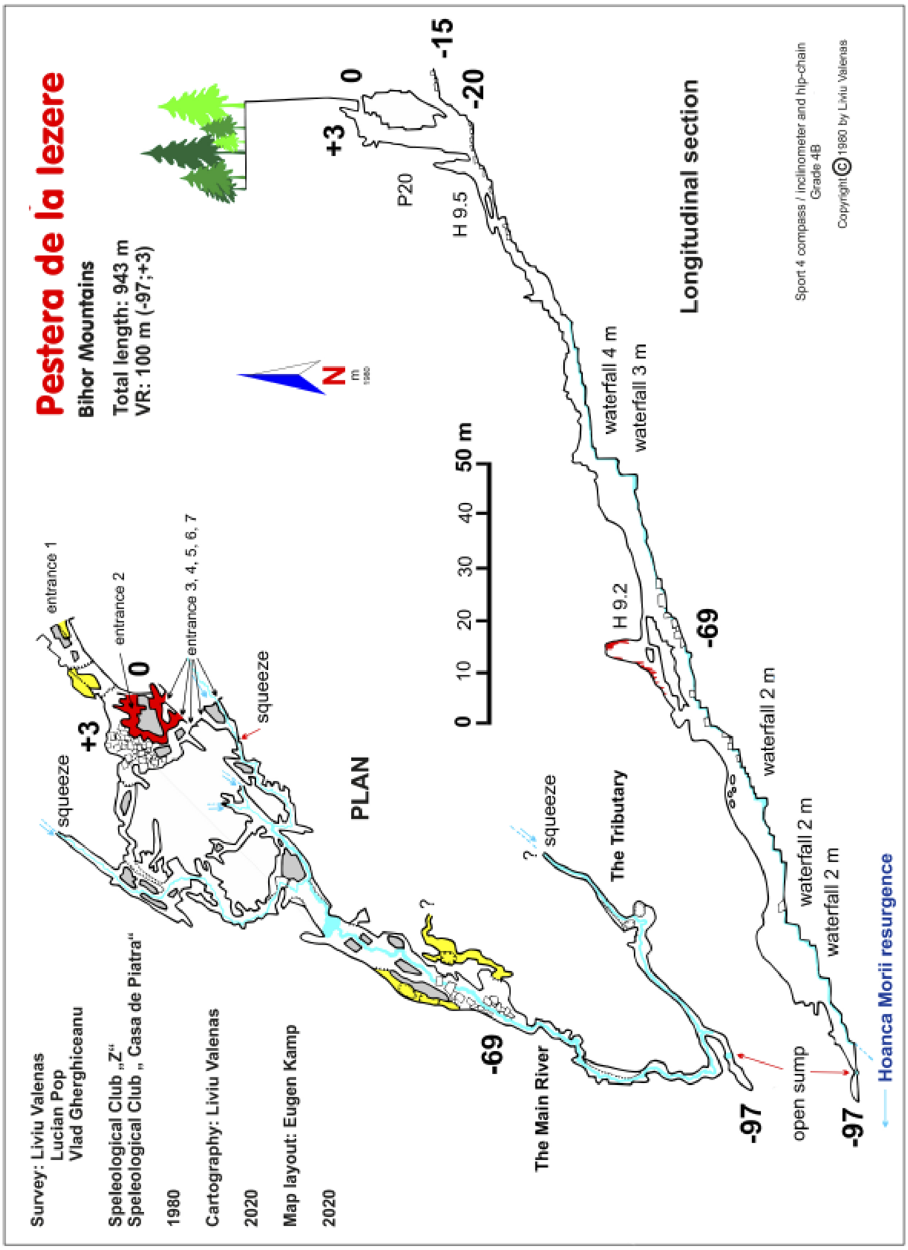


Figure 18. Peștera de la Iezere, plan view and section by Liviu Vălenaș.

ficult to consider this karst zone as belonging to a closed basin or only to a simple plateau. But it certainly contains a small pocket valley which gets lost in Iezere Cave and several big sinkholes, some of lithological contact. Small surface creeks are drained, organizing on the waterproof bundle and also some sinkholes in the neighbouring main entrance. The branching coefficient (5.93) shows clearly that we are dealing with a maze cave, mentioning that this is valid only in the upper portion from the entrance up to -60 m depth. The cavity is focused on an underground river 250 m long. Total length: 943 m, vertical range: 100 m (-97; +3 m), aerial extension: 159 m.

Exploration's history

The cave was discovered in 1861 by the great Austrian geographer Adolf Schmidl. With all this discovery of the middle XIX th century, only after 119 years, in September 1980, Liviu Vălenaș, Lucian Pop and Vlad Gherghiceanu performed a full exploration and the survey of the network. The action took place within a common expedition of the Speleological Clubs „Z" and „Casa de Piatră" – Turda.

Lithology, tectonics, morphology and genesis

Iezere Cave is excavated in upper Jurassic limestones (lower Neocomian-Aptian) strongly diaclazed and faulted. The main faults and diaclases on which the cave develops, have an orientation remarkably parallel, NE-SW, exactly the same as the andokarstic systems in the Casa de Piatră zone and from the Lumea Pierdută. Iezere Cave has developed initially in batiphreatic regime, then massively vadose remodeled.

Hydrogeology

Iezere Cave drains three small surface creeks coming from Liasic (Hettangian - lower Sinemurian) but also losses through sinkholes and probably one more ponor, unidentified so far. The final drainage of the cave has remained an enigma for a long time. Paul Damm and Horia Mitrofan (Damm, Mitrofan, 2005) assumed even an aberration: Iezere Cave would drain through Izbucul Tăuz, at 4.5 km distance! A colouring in 1986 with fluorescein made by Iancu Orășeanu and Paul Damm but afterwards, demonstrated that the resurgence of the cave is in Ponoraș valley, in Peștera de la Hoanca Morii - Hoanca Morii Cave, at 2 km air distance from the terminus -97 m depth in Iezere Cave (Orășeanu, 2020). The vertical range between this terminus and Hoanca Morii Cave is 174 m. The colouring covered the entire distance between the entrance of Iezere Cave and resurgence in only two days, The flow speed on the route entrance Iezere Cave – Hoanca Morii Cave was 15.0

m/hour Also taking into account the relatively great vertical range (174 m); it is evident that for the most part, the course must be vadose.

Description

The main entrance of the cave lies at the bottom of an impressive vertical cliff. The cavity in which the cave appears, resembles with a huge sinkhole. In reality it is about a pocket valley and the vertical wall in which the cave appears, it is nothing else but an antithetical step. In this wall, at a height of 15 m, there are three smaller entrances which give access to a small suspended maze (a small chimney reaches the maximum remontant levels of +3 m) a 20 m deep pit (P 20) flows directly into the lower gallery at point of -20 m. The first portion strongly descending (but without notable verticals) is chaotic and maze-like. The galleries are generally low, full of blocks and alluvial deposits. Apart from the small main course, there appear three more tributaries with a low flow, too, which unite at -39 m, creating a unique underground course. Soon, there appear two spectacular waterfalls in the living rock, 4 m and respectively 3 m high. After the last waterfall, the subterranean course flows on a gallery 2 m wide and up to 10 m high on an average. An upper loop with a 9.2 m chimney completes the landscape. The active gallery descends the steep slope, being fragmented by other 5 smaller waterfalls of 1-2 m. The most important confluence is at -92 m, with a secondary course, parallel with the main active. The tributary could be traversed on 55 m to NE up to a portion where the gallery gets extremely narrow. Immediately after the confluence, the active course disappears into a sandy whirlpool. The gallery becomes fossil after passing a small stagnant open sump at -95.5 m after 11 m more, the gallery ends in a sack bottom (clogging with sand) at -97 m , the lowest point of the cave. But we must underline that the description between -92 m and -97 m markings correspond only to the situation in 1980, it seems that afterwards strong floods changed the morphology of the cave in the terminal sector.

Mineralogy

Iezere Cave is poor in speleothems. They appear especially in the suspended loop at -50 m.

Possibilities of advance

In 1980 there was no longer any possibility of advance: at -97 m the terminal gallery ended in a bottom sack: total clogging with sand. After 2019, Ovidiu Guja informed the author that the aspect of the final gallery seems totally changed, a small upper floor gave access to a severe strait where there is an air blow. The squeeze, totally impenetrable should be enlarged. It is possible that repeated floods after 1990 to have partially cleared the final gallery. Anyway, the potential of the cave is great.

The geochemistry of the karstic waters

Only four water samples were taken in the past from the studied area which allow to draw some interesting conclusions. The analyses of the water samples were done in 1978 by Constantin Marin, from „Emil G. Racovitza" Speleological Institute in Bucharest (Fig. 19). Concerning the water sample from Izbucul Ursului (The Bear Spring), it is immediately recognized that we have to do with an aquifer flowing through triassic dolomite limestones (Anisian) - the presence of the Mg ions. In opposition with this resurgence, Izvorul Rece drains nondolomitized limestones, containing only 0.8 mg M ++. In exchange, the samples no 3 and 4 contain a certain mineralization in Mg++, due to the fact that the waters of Izvorul Rece mix afterwards with those coming from Izvorul Ursului. Surprisingly, the water of Pârâul Ursului, at the entrance to Căput Cave (sample no 3) has concentrations a little higher than at its exit into the affluent gallery in Cetățile Ponorului Cave. The only explanation is a supplementary more diluted water contribution underground. Broadly speaking, almost all water analyses are still aggressive towards limestones.

No	location of samples	lime-stone	date	water flow l/s	t°	pH	Ca ++ mg/l	Mg ++ mg/l	HCO³ -- mg/l	Cl -- mg/l
1	Izbucul Ursului	T_1	July 27, 1978	50	6.8	7.15	57.6	12.9	227.7	1.2
2	Izvorul Rece	J_3	July 27, 1978	75	6.1	7.10	54.4	0.8	159.5	1.4
3	Izvorul Ursului Creek, 40 m upstream the Căput Cave	J_3	July 27, 1978	200	9.5	7.30	54.0	5.4	176.6	0.9
4	Cetățile Ponorului, the tributary from Căput Cave	J_3	July 27, 1978	350	8.1	6.90	51.2	4.7	172.9	----

Figure 19. The chemical analyses of the water samples taken from the closed basin Izvorul Ursului - Pârâul Sec.

Conclusions

The closed basin Izvorul Ursului - Pârâul Sec and the plateau Vârtopașul - Iezere contain an evolved karst with specific shapes. The belonging of the great subterranean drainage systems to a phreatic genesis is an undeniable fact. The elements sustaining the phreatic genesis are extremely numerous: specific underground relief, the horizontality of the principal galleries, uninfluenced by a structural factor. But the descending of the phreatic surface has determined a vadose remodelling, the special case of Lumea Pierdută System. The process is still going on at present, especially in Căput Cave where the drainage of Izvorul Ursului stream towards Cetățile Ponorului Cave organizes at present under the galleries of this cave. Another example is the drainage upstream Negru Pit, more precisely the sump 90 m long. The age of the endokarst and of the exokarst, too, cannot be pushed lower than the Middle Pleistocene.

Acknowledgements

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Morphologie et hydrogéologie des grottes du mont Phou Namthok, Khammouane, Laos

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Introduction

Le club de spéléologie «Z» de Nuremberg, Allemagne, a commencé en 2006 des explorations spéléologiques au Laos. Depuis 2015 elles se sont intensifiées dans le cadre des 7 expéditions spéléologiques internationales déroulées principalement dans la province de Khammouane, au centre du Laos, toutes dirigées par Liviu Vălenaş. Khammouane est la province du Laos avec les plus grandes zones de calcaire et les plus grandes grottes. Entre 2010 et 2020 le Club de Spéléologie «Z» a découvert (ou repris les explorations) 65 grottes, dont 11 de plus de 1 km de développement. Le système Pha Soung est la plus grande des grottes explorées et cartographiées (21.012 m de développement en 2020). Nous avons décidé de publier les résultats des explorations (qui se poursuivront dans les années à venir) par étapes et par des entités géographiques bien définies. La première étude sera consacrée aux grottes du mont Phou Namthok (Le Mont des Torrents).

Tham Dan Makhia

Résumé. Tham Dan Makhia (La Grotte de la Clairière du Haut Bois) est l'une des plus grandes grottes du Laos, avec un développement total de 2.160,4 m. La première partie est une grotte typique pour le Laos, concentrée sur une grande galerie terminée par un lac géant. Le reste de la grotte est relativement atypique pour le Laos, étant un labyrinthe composé de galeries à petites sections, formées exclusivement en régime phréatique. Dans l'ensemble, Tham Dan Makhia est l'une des grottes les plus labyrinthiques du Laos, avec un coefficient de ramification de 10,2. L'insurgence de la grotte provient peut-être d'une polje de 4,5 km de long, située dans le mont Phou Namthok à 6,5 km en ligne droite. On peut déduire de ce chiffre que ce qui a été exploré jusqu'à présent dans cette belle et intéressante grotte n'est qu'une infime partie d'un système souterrain extrêmement vaste.

Localisation

Entrée no. 2 c: N 17 30´ 33. 3, E 104 53´ 28. 3, alt.: 157 m. Entrée no. 3 (la résurgence de la grotte) : N 17 30´ 44. 7, E 104 53´ 27. 5, alt.: 157 m. Tham Dan Makhia se trouve dans la paroi verticale du mont Phou Namthok (Le Mont des Torrents), à 3,250 km sud du village de Ban Phondou.

Données physiques

Développement: 2.160,4 m, dénivellation 33,5 m (-20,5;+13,0), extension 232,3 m, coefficient de ramification 10,2.

Historique des explorations

La grotte était probablement connue depuis un siècle par les habitants du village de Ban Phondou et Ban Nasé, à proximité desquels elle se trouve. Ils ont mis en place des installations simples de pêche dans le grand lac souterrain à -20 m. Les Français Claude Mouret et Jean-François Vacquié ont été les premiers spéléologues à pénétrer dans la grotte en 2013. Il semble qu'ils aient parcouru environ 500 m de galeries. Cependant, ils n'ont pas communiqué les résultats de cette exploration et nous ne disposons pas d'informations concernant une éventuelle topographie réalisée à cette occasion. Ce qui est certain, c'est qu'ils n'ont jamais rien publié. En janvier 2015, ignorant cette première exploration, Liviu Vălenaş, Maliwan Vălenaş et Khamlex Khomxayxana ont repris les explorations dans la grotte et ont topographié 570 m de galeries. Cette exploration a été considérée comme définitive et la grotte entièrement explorée. C'était inexact. La topographie et la description détaillée de la grotte ont été publiées la même année (Vălenaş,

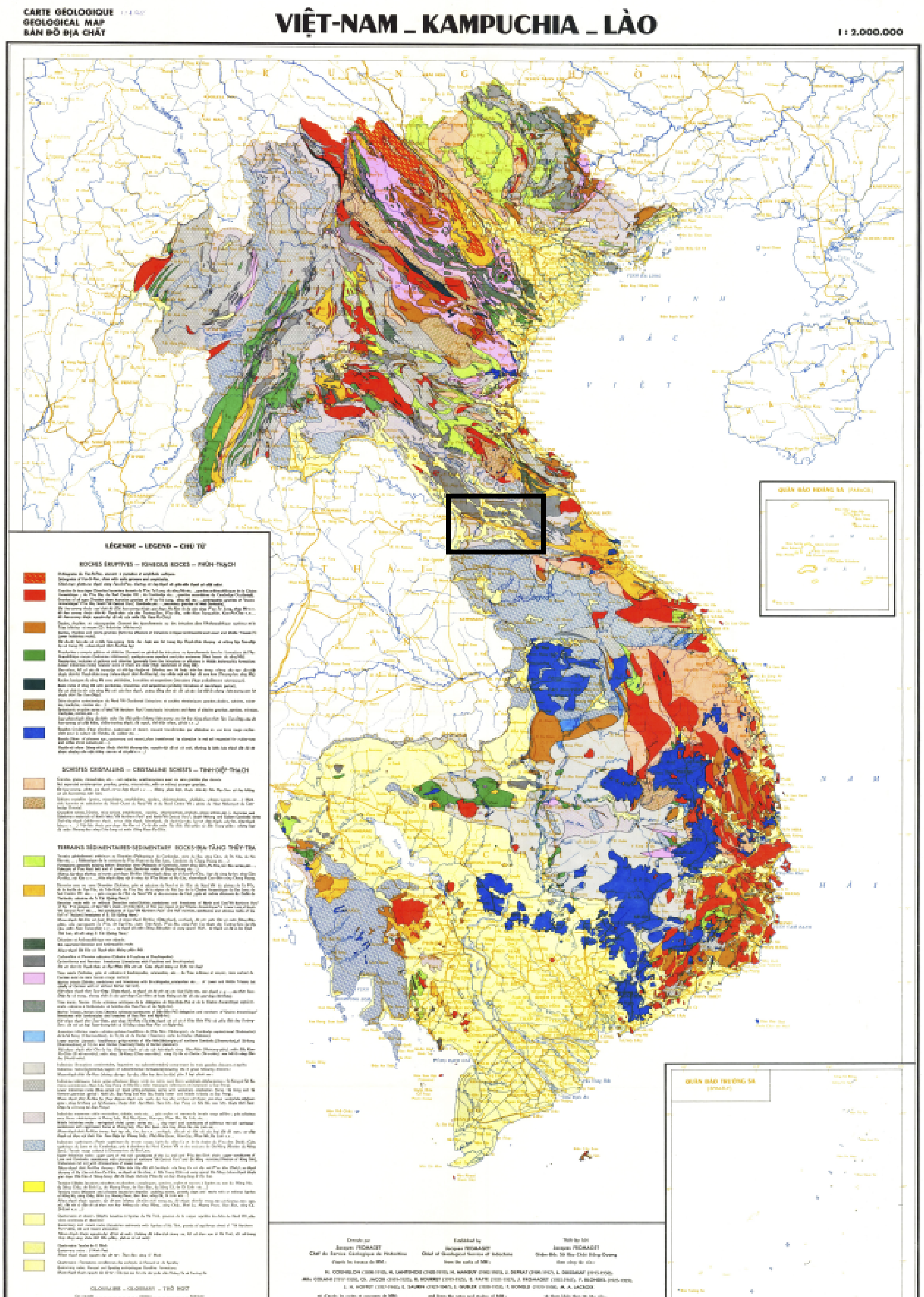

Figure1. Localisation de la province de Khammouane (en cadre noir) de Laos sur la carte géologique de l'ancienne Indochine française (Laos, Vietnam et Cambodge).

2015). En 2017, cependant, nous avons décidé la reprise de l'exploration de la grotte. Jozef Grego et Liviu Vălenaş parviennent à forcer un passage étroit dans la Grande Latérale et ils avancent dans un système labyrinthique aux galeries étroites, qui conduit finalement à la surface par deux entrées plus grandes, l'une de ces entrées étant la résurgence même de la grotte! Le développement passe à 1.340,4 m. En 2018, il y a eu d'autres découvertes inattendues, deux secteurs labyrinthiques, le premier (Liviu Vălenaş Labyrinthe) au nord de l'entrée no. 3, avec un développement de 155,0 m, découvert et exploré par Liviu Vălenaş seul. Entre les entrées no. 1 et 2, Mehdi Boukhal et Liviu Vălenaş découvrent un autre système labyrinthique de 598,1 m de long (Mehdi Boukhal Labyrinthe), avec de nombreux lacs de siphon. Le développement de la grotte atteint 2093,5 m. En 2019 Liviu Vălenaş, Leda Monza et Franco Malacrida parviennent à topographier encore 66,9 m dans le Labyrinthe Mehdi Boukhal, atteignant ainsi le développement actuel de 2.160,4 m. Au cours de la même expédition, Jean Pierre Dégletagne réussit dans la galerie principale les premières prises de vue avec un drone.

Lithologie et genèse

Tham Dan Makhia se développe dans des calcaires carbonifères, fortement faillés. Il existe deux systèmes de failles et de diaclases, un principal orienté SO-NE et un secondaire orienté SE-NO. Les faces de stratification ne jouent pas de rôle important dans la création de la caverne. La genèse de la grotte est épiphréatique. Elle a d'abord fonctionné en régime totalement immergé, l'entrée principale (entrée no. 1) était une résurgence vauclusienne. L'approfondissement de 30 m de la rivière Nam Don a déterminé la fossilisation de la galerie principale (aucune trace notable de remodelage vadeux n'est visible) et une nouvelle résurgence a été activée (entrée no. 3). Avant cette activation, il y a eu une autre phase intermédiaire: la création de la Galerie d'Avancement, les galeries de raccord no. 1 et no. 2, et la Galerie Jozef Grego. Elles aussi fonctionnaient exclusivement en régime phréatique et ont été par la suite abandonnés par tout cours permanent au profit de la résurgence actuelle (entrée no. 3), située près du niveau de base de la rivière Nam Don. On constate donc une expansion spatiale du système de résurgences jusqu'à l'extrémité ouest du mont Phou Namthok. Un phénomène similaire a été trouvé dans un karst typique des zones tempérées d'Europe. Il s'agit de l'expansion spatiale du système Coiba Mica - Coiba Mare dans les montagnes du Bihor, en Roumanie (Vălenaş, 1978).

Hydrogéologie

Tham Dan Makhia a sans aucun doute l'une des plus intéressantes hydrogéo-

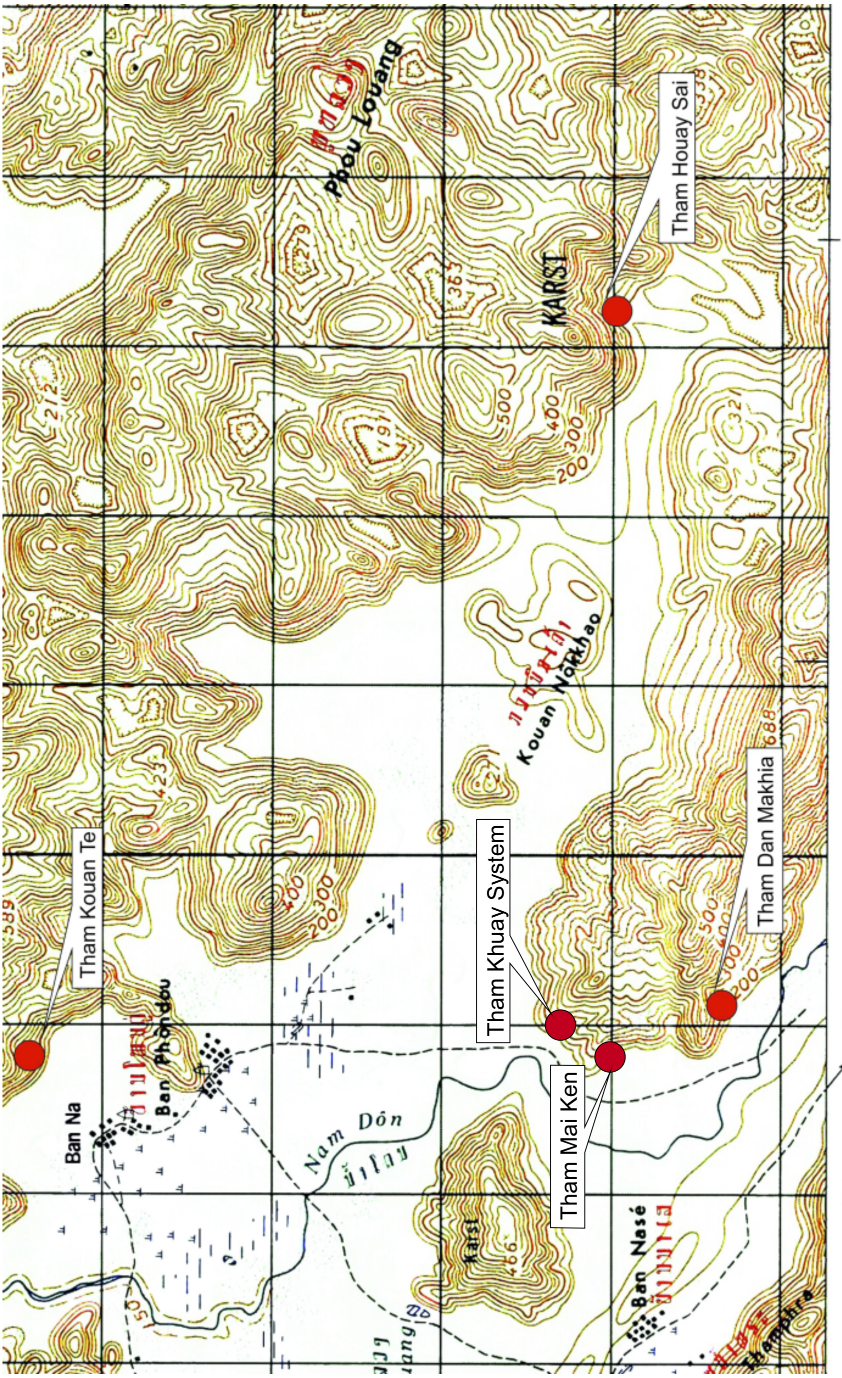

Figure 2. Emplacement des grottes Tham Dan Makhia, Tham Mai Ken et Système Tham Khuay dans le cadre du versant ouest du mont Phou Namthok, carte militaire américaine de 1965.

logies du karst du Laos. Le grand lac souterrain, à -20,5 m (cota de 2019) de 36 x 23,5 m, a une profondeur de 20 m (sondage à fil lesté réalisé par Khamlex Khomxayxana en 2017). Il y a encore une distance en ligne droite de 114,7 m jusqu'au lac de la résurgence (entrée no. 3) Seule une future exploration avec des plongeurs pourrait apporter des données sur ce siphon. Le problème que rencontrent tous les spéléologues et les hydrogéologues au Laos est qu'ils ont étudié et observé le régime hydrologique des grottes seulement pendant les saisons sèches (janvier-avril). Il n'y a pas de données précises sur l'hydrologie et l'hydrogéologie des grottes pendant la saison de la mousson (mai - octobre). Cependant, nous pouvons tirer quelques conclusions, basées sur des informations données par les habitants et à partir des dépôts d'argile sur les parois de la grotte, traces des inondations de la saison des pluies. Il est clair que pendant la saison de la mousson le Grand Lac déborde sur les marches de 5,5 m et 1,6 m et inonde, jusqu'à 8 m de hauteur, à la fois la galerie principale, près de l'entrée no. 1, et la Grande Latérale. Les eaux s'écoulent ensuite à travers le secteur des galeries basses de la Grande Latérale et remontent à la surface, à un niveau supérieur, par les entrées no. 2 et no. 3. Bien entendu, le débit principal est déversé par le siphon du lac de la résurgence de la grotte (entrée no. 3). Il s'agit donc de deux rivières souterraines dans ce secteur pendant la saison humide, celle située entre le lac de résurgence et le Grand Lac et, à un niveau supérieur, le cours qui inonde complètement les galeries de débordement entre la Grande Latérale et l'entrée no. 3. Il est possible aussi qu'il y ait une communication entre Tham Dan Makhia et le Système Tham Khuay pendant la saison humide, à des débits élevés. Nous nous référons au siphon terminal de Tham Khuay I, siphon situé à -22,5 m. Tout comme pendant la saison humide dans le grand système voisin de Pha Soung, où, à des débits élevés, l'eau surgit par au moins 6 résurgences. Dans le Labyrinthe Mehdi Boukhal à Tham Dan Makhia, il y a aussi cing siphons stagnants qui correspondent évidemment à la nappe phréatique. Le fait que dans la Tham Dan Makhia (spécialement dans le labyrinthe Mehdi Boukhal) il y a plusieurs siphons au même niveau nous fait penser à une idée claire: il existe un réseau labyrinthique phréatique noyé en dessous du niveau actuel des galeries fossiles. Autrement dit, il s'agit de deux grottes Dan Makhia, un réseau à présent fossile et un réseau inférieur complètement noyé. Nous n'avons aucune donnée exacte sur ce réseau. Seule une prochaine exploration avec des plongeurs pourrait éclaircir ce problème. Une situation identique existe aussi pour la grande grotte située à proximité, le Système Pha Soung où il y a un niveau phréatique inférieur, certainement beaucoup plus grand. Là aussi en période de mousson une partie de ce labyrinthe est inondée jusqu'à 8 m de haut. A la fin, les eaux qui sortent pendant la saison humide de Tham Dan Makhia se jettent directement dans la rivière Nam Don, qui coule à ce moment-là à proximité immédiate de la résurgence à l'entrée no. 3.

Mais le grand mystère de l'hydrogéologie de Tham Dan Makhia reste l'origine de l'eau du Grand Lac. L'étude des cartes topographiques de la zone indique seulement une connexion possible à partir de la polje, d'une longueur de 4,5 km, située exactement à 6,5 km de distance aérienne Est de l'entrée no. 3 de Tham Dan Makhia. Dans ce cas, nous aurions à faire à la plus longue rivière souterraine de tout le Laos! Seules les marques d'eau pourraient apporter les éclaircissements nécessaires et, bien sûr, une exploration de cette soi-disant énorme rivière souterraine par des plongeurs autonomes.

Description

Dans le versant sud du lobe sud-ouest du mont Phou Namthok, à 30 m de hauteur relative, s'ouvre la grande entrée, l'entrée no. 1, de Tham Dan Makhia, de 20,6 m de large et 10 m de haut. L'entrée se poursuit par une large pente descendante, pleine de gros blocs. A -14,7 m se trouve la Grande Salle, la plus grande cavité de la grotte, avec des dimensions appréciables: 73 m de long, 38 m de large et 32 m de hauteur maximum. Surtout dans la zone près de l'entrée (mais même à l'entrée) Tham Dan Makhia présente les plus belles concrétions grossières. C'est le secteur de grotte le plus riche en concrétions. Depuis le bout de la salle la grotte se poursuit avec une galerie extrêmement spacieuse, avec des largeurs comprises entre 25-30 m. 50 m après un coude à 60 degrés, la galerie revient vers le nord-est. A 156,5 m de l'entrée, une petite verticale de 1,6 m descend, puis après seulement 6,8 m, à la base d'une paroi verticale se trouve le Grand Lac, de 36 m de long, 23,5 m de large et 20 m profondeur. Sa profondeur et ses dimensions sont variables, même en saison sèche. Le 12 février 2017, il se trouvait à -3,5 m de la base du mur vertical, mais le 22 février 2019, il était à -6,0 m (-20,5 m de l'entrée). Après la traversée du lac, il y a une pente boueuse embarrassante, la boue ayant une épaisseur appréciable. Après avoir gravi une petite verticale de 2 m, suit une diaclase qui se rétrécit progressivement. Elle se poursuit 39 m seulement puis l'avancement devient impossible. L'absence de tout courant d'air laisse comprendre qu'il n'y a plus de continuation notable à cet endroit-là. De retour à la galerie principale, près de son premier coude à droite, l'ascension d'un toboggan sur une grande pente mène à une large galerie, orientée vers l' Est, qui se termine après 64,7 m dans une salle basse et chaotique, pleine de blocs. Un énorme bloc la divise en deux fausses galeries, qui se „rejoignent" de nouveau à la fin. Pas de courant d'air là non plus. Avant cette «salle» une poche de la galerie bifurque vers le nord où une cheminée atteint une hauteur de +13,0 m, le point culminant de

Figure 3. Mont Phou Namthok, versant ouest, photographie par Liviu Vălenaş, 2018.

Figure 4. Mont Phou Namthok, versant ouest, photographie par Liviu Vălenaş, 2018.

Figure 5. Dépression Kouan Nakhao, le mont Phou Namthok à droite, photographie par Liviu Vălenaş, 2018.

Figure 6. L'entrée de 20,6 m de large et de 10 m de haut de la grotte Tham Dan Makhia, photographie par Liviu Vălenaş, 2017.

Tham Dan Makhia. La branche la plus importante de la grotte part du deuxième coude de la galerie principale. Vers le sud-ouest, donc parallèlement à la galerie principale, la Grande Latérale va tout droit. C'est une grande galerie qui se termine en pente après 85 m à +10,0 m. Dans la partie finale il existe un étage supérieur, disposé de manière relativement capricieuse, qui communique avec la Grande Latérale par des larges puits ou à travers des fenêtres. De cette galerie, dans son secteur médian, vers l' Ouest, une autre galerie apparaît, d'abord assez large puis sous la forme d'une diaclase de 1 m de large. Un passage bas (H: 40 cm), également orienté vers l' Ouest permet l'accès dans le secteur des galeries relativement basses et étroites découvertes en 2017, la Galerie d'Avancement. Après 41 m on arrive à une première bifurcation importante. A gauche (à l' ouest) commence une galerie aux dimensions modestes (généralement 4 x 2 m), La Galerie de Raccord no. 1, horizontale qui débouche à la surface 70 m après, dans l'entrée no. 2, située à la base d'un grand abri. Pour revenir à la Galerie d'Avancement, après encore 40 m, direction nord, on arrive à la deuxième bifurcation. À l'ouest, la Galerie de Raccord no. 2 se développe, qui après 41 m débouche dans la paroi du magnifique lac de résurgence de Tham Dan Makhia. Le lac, avec des dimensions (en saison sèche, dans les années 2017-2019) de 26 m de longueur et 13 m de largeur maximale, profondeur supérieure à 7 m, se trouve en ligne droite à 114,7 m du Grand Lac. Le lac est situé dans un abri. Dans la paroi nord de l'abri se développent 8 diverticules, d'une longueur comprise entre 3 et 12 m. A 8 m seulement de l'abri, à la base de la même paroi se trouve le Labyrinthe Liviu Vălenaş, avec un développement total de 155.0 m. Deux entrées continuées par des galeries relativement étroites et descendantes donnent accès à une salle basse et confuse de 26 m de long et d'une largeur maximale de 8 m. De là partent plusieurs diverticules qui se terminent tous en cul de sac, avant la jonction avec la Galerie Jozef Grego. Vu que le Labyrinthe Liviu Vălenaş se trouve à 8 m à l'extérieur de l'abri de l'entrée no. 3, ce labyrinthe pourrait être considéré comme une grotte distincte (bien qu'il ait été formé avec le reste des galeries de Tham Dan Makhia). Dans ce cas-là, il s'agirait de 2 grottes, une de 155.0 m de long et une beaucoup plus grande de 2.005,4 m de long.

En revenant à la dernière bifurcation, la Galerie de l'Avancement continue encore sur 23 m avec les mêmes sections moyennes de 2/3 m. Elle arrive à un étroiture sévère en roc vif, de 50 cm de large et 28 cm de haut, où il souffle un fort courant d'air. Jusqu'à présent, seul Jozef Grego, en février 2017, a réussi à le traverser en avançant environ 100 m de plus dans une galerie extrêmement étroite. Il s'est arrêté à un nouveau passage encore plus étroit. Là aussi le courant d'air est présent. Normalement, après le passage terminal il faudrait arriver à une nouvelle entrée, mais il n'est pas exclu que la Galerie Jozef Grego s'ouvre dans un autre secteur labyrinthique. Malheureusement, la galerie finale, longue d'environ 100 m, n'a pas été topographiée de sorte que nous ne savons pas exactement dans quelle direction elle va.

Dans l' abri sud, celui de l'entrée no. 2, plusieurs entrées s'ouvrent (dont une suspendue, Galerie Peter Lenahan) qui débouchent toutes dans un nouveau secteur labyrinthique beaucoup plus grand, le Labyrinthe Mehdi Boukhal, avec un développement total de 598,1 m. Au départ, il se compose de deux salles parallèles longue de 26,7 m et respectivement 17,2 m. Parallèlement à ces salles, une

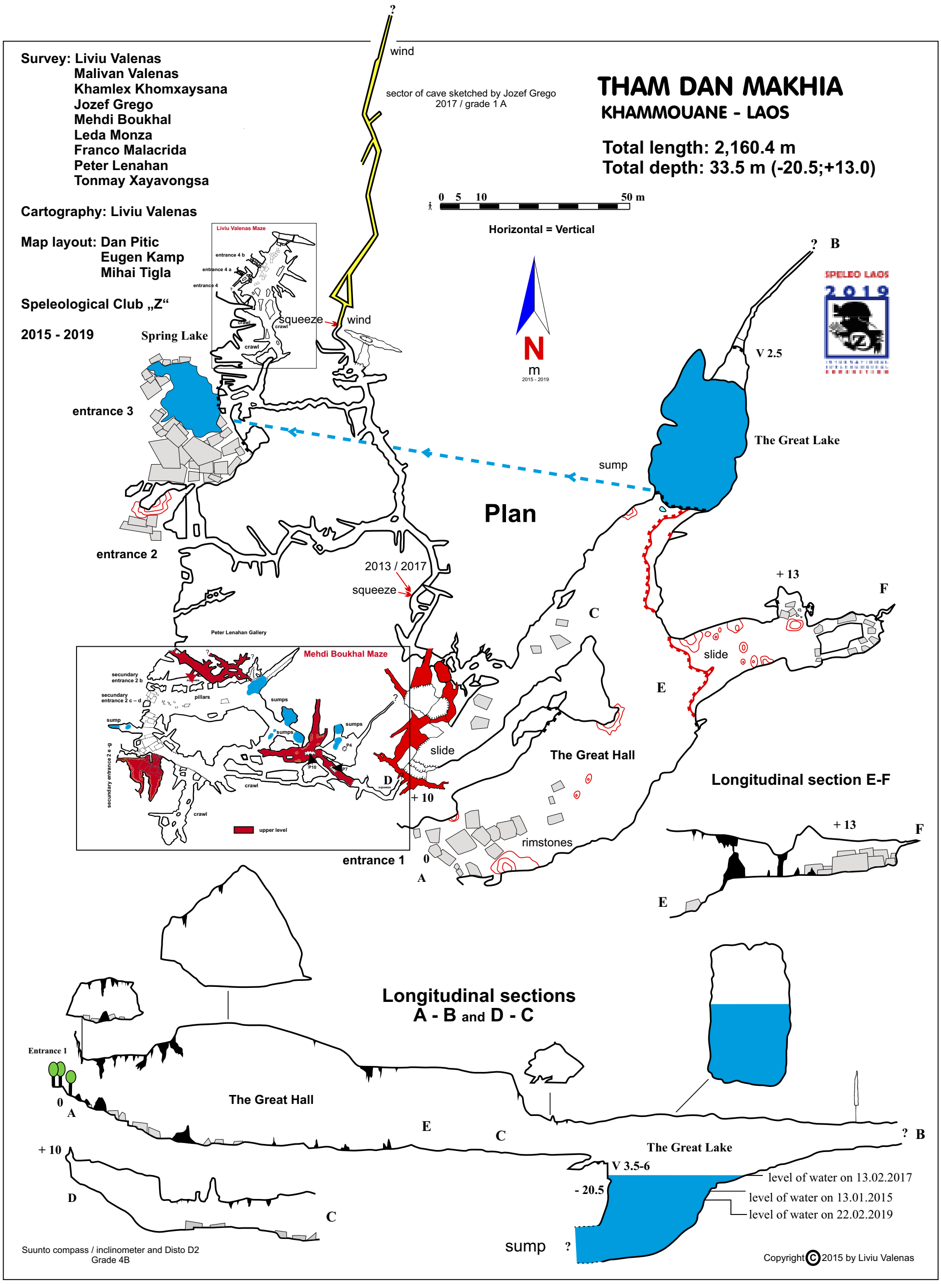

Figure 7. Tham Dan Makhia, plan, sections longitudinales et transversales, cartographie de Liviu Vălenaș, 2015-2019.

Figure 8. Tham Dan Makhia, l’entrée principale (nr. 1) et une partie de la Grande Salle, photographie par Liviu Vălenaş, 2015.

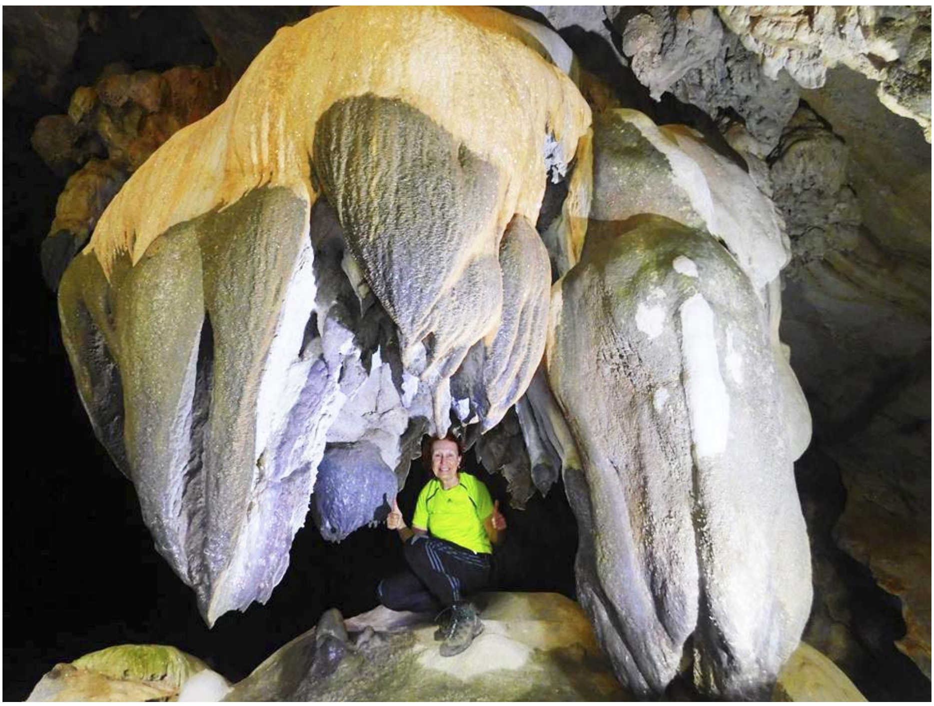

Figure 9. Tham Dan Makhia, «le Baldaquin Chinois» de la Grande Salle, photographie par Jean Philippe Dégletagne, 2019.

Figure 10. Tham Dan Makhia, la Grande Latérale, photographie par Liviu Vălenaş, 2015.

boucle relativement large de 48,4 m de long se développe. Dans la zone où les deux salles et la boucle se rejoignent, il y a 5 lacs de siphon-marmite, de 6 à 10 m de profondeur. Ce sont des lacs stagnants, ils ont à la surface une pellicule d'argile et de calcite. Ils correspondent évidemment avec la surface phréatique et communiquent surement entre eux et probablement même avec le siphon situé entre le Grand Lac et le lac de résurgence. De ces lacs stagnants, au sud, au sud-est et au nord-est, plusieurs galeries argileuses relativement étroites partent. Elles se terminent toutes après 40-60 m en cul de sac. L'une d'elles se termine à quelques mètres seulement du bout de la Grande Latérale. Il faut également mentionner dans ce labyrinthe trois étages supérieurs, concrétionnés, dont un communique avec la surface par deux entrées très étroites. En résumé, Tham Dan Makhia est une grotte extrêmement labyrinthique, les 2.160,4 m se développent sur une longueur aérienne de seulement 232,3 m (le passage final dans la galerie Jozef Grego et l'entrée no. 1). Cependant, compte tenu du fait que la Galerie Jozef Grego n'est pas encore topographiée, la longueur aérienne réelle semble encore plus petite, de seulement 211,8 m. Dans ce cas, le coefficient réel de ramification est plus élevé: 10,2.

Minéralogie

Contrairement aux autres grottes explorées jusqu'à présent dans le mont Phou Namthok, Tham Dan Makhia est bien concrétionnée (stalactites et stalagmites

Figure 11. Tham Dan Makhia, le Grand Lac, photographie par Liviu Vălenaş, 2015.

grossières, colonnes, draperies, vagues, gours, perles de caverne et cristallisations de calcite. Les zones fortement concrétionnées alternent avec des galeries argileuses ou en roc vif, où toute concrétion est absente. Ici les formes de corrosion formées en régime phréatique abondent.

Climatologie

La grotte a des températures comprises entre 21,0 et 22,5 degrés C, humidité: plus de 93%. Tham Dan Makhia, ayant plusieurs entrées, est fortement ventilée.

Figure 12. Tham Dan Makhia, l'entrée nr. 3 et le lac de la résurgence, photographie par Liviu Vălenaş, 2018.

Figure 13. Tham Dan Makhia, Mehdi Boukhal dans le lac de la résurgence, photographie par Liviu Vălenaş, 2018.

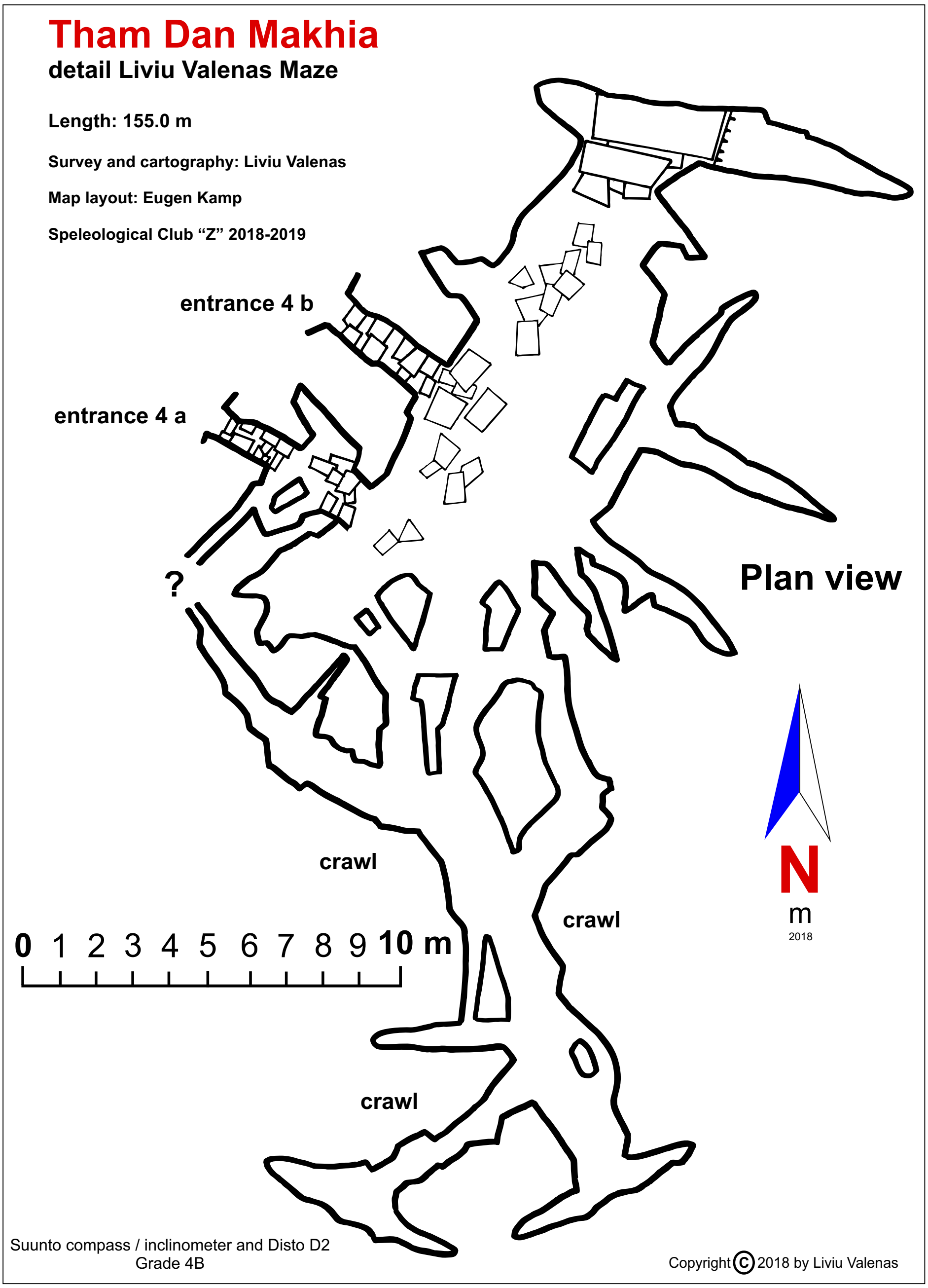

Figure 14. Tham Dan Makhia, le Labyrinthe Liviu Vălenaş, cartographie de Liviu Vălenaş, 2018-2019.

Figure 15. Tham Dan Makhia, l'entrée dans le labyrinthe Mehdi Boukhal, photographie par Liviu Vălenaş, 2019.

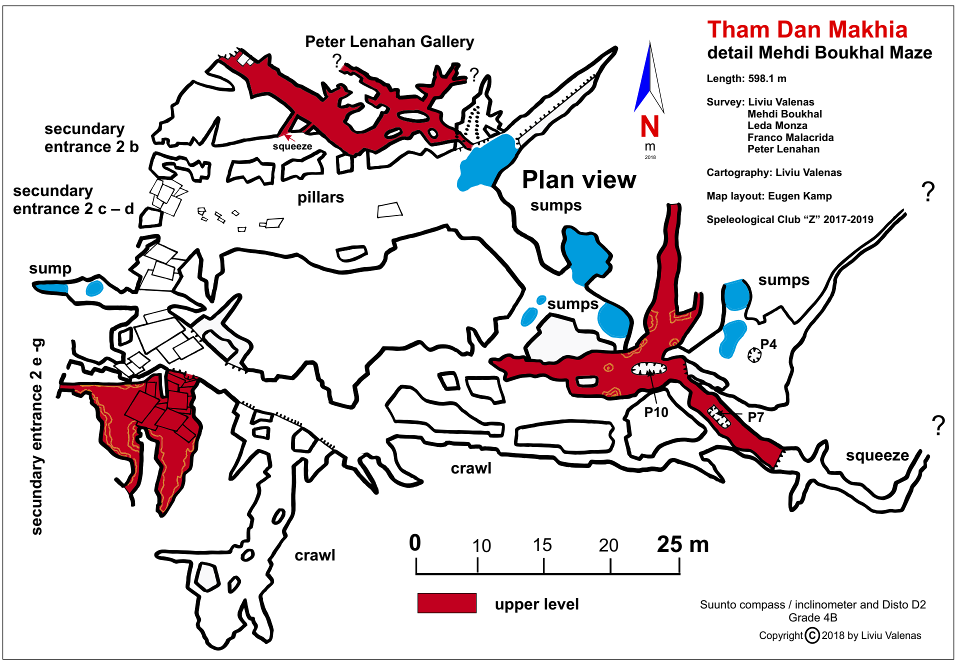

Figure 16. Tham Dan Makhia, le Labyrinthe Mehdi Boukhal, cartographie de Liviu Vălenaș, 2017-2019.

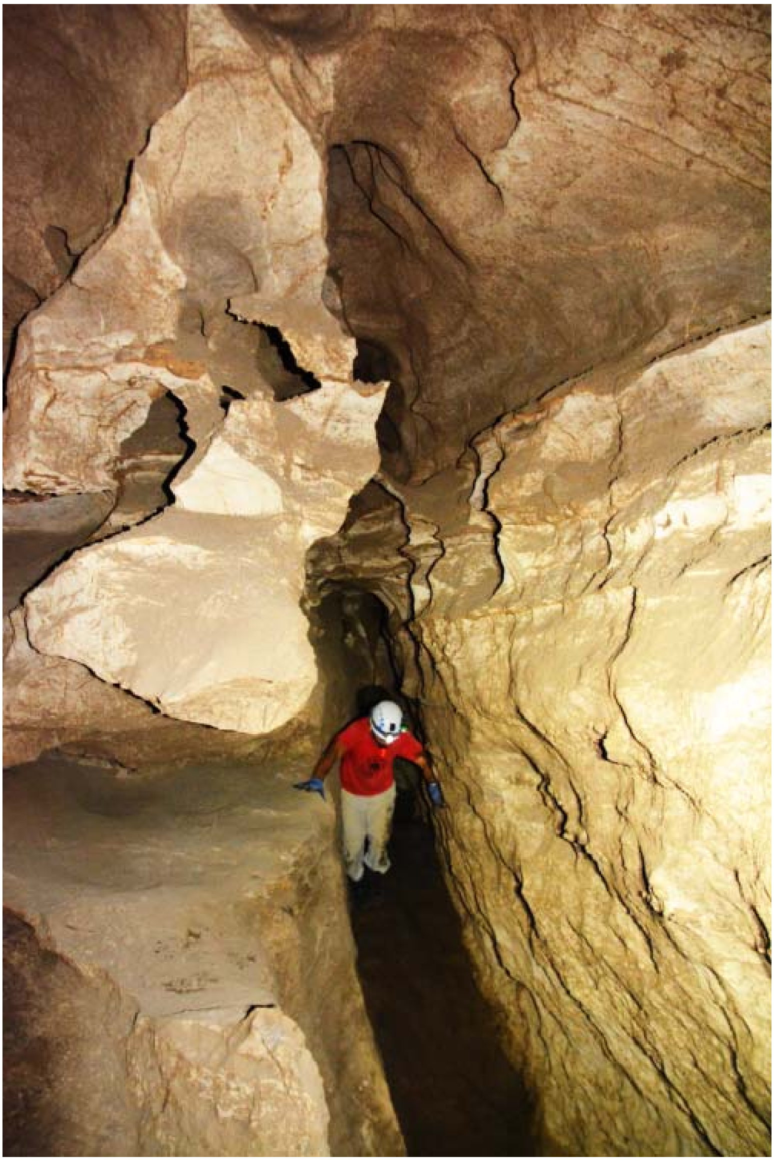

Figure 17. Tham Dan Makhia, diaclase et formes phréatiques dans le Labyrinthe Mehdi Boukhal, photographie par Liviu Vălenaş, 2018.

Biospéléologie

Tham Dan Makhia abrite plusieurs chauves-souris isolées, mais une véritable colonie n'a pas été observée pendant les années 2015-2020. Des centaines de poissons de Nam Don restent piégés dans le lac de la résurgence et le Grand Lac pendant la saison sèche, en particulier des silures. Ils attendent d'être libérés avec les premières crues qui commencent pratiquement en juin - juillet.

Paléontologie

En 2018 plusieurs ossements, fortement concrétionnés, ont été découverts dans la petite salle supérieure terminale de la Grande Latérale, accessible par une verticale négative de 2 m. On estime qu'ils appartiennent à un mammifère de taille moyenne, probablement un herbivore, de la dernière période du Pléistocène. Les os n'ont pas encore été déterminés.

Archéologie

Dans la même petite salle des fragments fortement concrétionnés d'un récipient en céramique ont été découverts. Nous pensons que la petite salle a été intentionnellement choisie comme lieu de culte bouddhiste, probablement à l'apogée du royaume du Laos, sous le légendaire roi Sethirathat (qui a régné entre 1548-1571) et les fragments appartiennent à la même période.

Possibilités d'avancement

Tham Dan Makhia a un potentiel absolument énorme. La seule façon de continuer à explorer à grande échelle reste les plongées dans le Grand Lac. La jonction avec le lac de résurgence ne pose probablement pas de problème majeur, mais la plongée la plus intéressante doit se faire en amont de ce lac, direction Est. Une autre possibilité est le forçage du terminus dans la Galerie Jozef Grego, où il y a un courant d'air. C'est possible qu'il débouche à la surface dans une nouvelle entrée.

Tham Khuay System

Résumé. Tham Khuay System (Le Système de la Grottes des Buffles) est l'une des plus intéressantes grottes découvertes en 2020 au Laos par l'expédition spéléologique internationale SPELEO LAOS 2020, organisée par le Club de Spéléologie «Z». Avec son développement de presque 1,5 km, elle est aussi l'une des grottes importantes de la province de Khammouane. Le système, développé sur une longueur aérienne de 248,7 m, est représenté par deux grottes relativement distinctes du point de vue de la morphologie. Tham Khuay I est une grotte avec des galeries larges et une grande entrée principale. En échange, Tham Khuay II est un réseau labyrinthique, avec de nombreux tubes phréatiques parallèles, bon nombre de ces tubes étant extrêmement étroits.

Localisation

Tham Khuay I: N 17 31´ 3. 5, E 104 53´ 48. 7, alt.: 157 m. Tham Khuay II: N 17 31´ 11. 7, E 104 53´ 25. 4, alt.: 156 m. Tham Khuay System se trouve dans la paroi verticale du mont Phou Namthok (Le Mont des Torrents), à 1,930 km Sud - Sud-Est du village de Ban Phondou.

Données physiques

Développement: 1.430,7 m, dénivellation: -22,5 m, extension: 248,7 m, coefficient de ramification: 5,75.

Historique des explorations

La grotte a été explorée et topographiée dans le cadre de l'expédition SPELEO LAOS 2020 par Liviu Vălenaş, Khampeng Xayavongsa et Paul Mackrill (février 2020).

Lithologie et genèse

La cavité se développe en calcaires carbonifères massifs. Les calcaires sont fortement faillés et diaclasés, les failles principales sont orientées NO-SE et NE-SO. Mais la majorité des tubes phréatiques se développent sur le système de failles principal NO-SE, ce qui explique ce remarquable parallélisme. La grotte s'est certainement formée en régime épiphréatique. Dans Tham Khuay I il y a un remodelage vadeux, dans Tham Khuay II les traces en sont minimes. Tham Khuay I a d'abord fonctionnée comme une résurgence vauclusienne. La descente des nappe phréatiques, provoquée par la soudaine augmentation en profondeur du lit de la rivière Nam Don, a fossilisé en grande partie la grotte, du moins pendant la saison sèche. Quant à Tham Khuay II, nous pensons que c'est en partie le résultat d'un système totalement immergé formé par la rivière Nam Don. Mais la galerie-salle de 50 m de long, qui se termine en pente descendante à -21,1 m, semble être liée à l'actif qui débouche dans le siphon terminal de Tham Khuay I.

Hydrogéologie

Tham Khuay I est une grotte - résurgences. Pendant la saison humide, une rivière souterraine longue de 125,8 m coule depuis le siphon terminal situé à -22,5 m. Elle inonde une bonne partie de la grotte, à la fin les eaux se jettent dans la vaste plaine alluviale de la rivière Nam Don. Par rapport au niveau de la plaine alluviale de Nam Don, le miroir d'eau du lac de siphon se trouve à une profondeur de 8,5 m, ce qui correspond à la nappe phréatique de la plaine de Nam Don, en saison sèche. L'origine du cours souterrain Tham Khuay I est totalement inconnue. Il peut également provenir de la polje de 4,5 km de long située à 6,5 km à l'est-sud-est.

Figure 18. Tham Khuay I, la salle de l'entrée principale (nr. 1), photographie par Liviu Vălenaş, 2020.

Plus vraisemblablement, cependant, il provient d'une fuite en amont de la dépression (en fait une poche allongée de la plaine de Nam Don), Kouan Nákhao (La Dépression de la Mare des Rizières), à 4,5 km distance aérienne à l'est. Tham Khuay II n'a pas de cours permanent. La galerie-salle qui descend à -21,1 m est près du niveau du siphon terminal de Tham Khuay I. Il est évident que Tham Khuay II est partiellement inondée pendant la saison des pluies. En plus, une partie des tubes phréatiques situés à proximité des entrées 8 et 9 sont inondés pendant la mousson directement par les eaux débordées de la rivière Nam Don.

Description

Tham Khuay I part d'une grande entrée horizontale de 29,6 m de large et 3 m de haut, située à la base d'une paroi verticale. Elle donne accès à une salle assez grande, longue de 27 m et large de 28 m, légèrement en pente avec de nombreux blocs. De là commence vers le sud-est une grande galerie sinueuse, dont le plafond descend en continu, jusqu'à une petite salle terminale de 6 m de haut occupée par un lac de siphon, dont les dimensions sont de 9 x 6 m. La partie terminale de la galerie, y compris le lac du siphon, sont dans l'obscurité totale, mais ceci ne représente pas un obstacle pour les buffles, attirés par un bain dans le siphon terminal. Même le plafond qui descend dans certaines parties jusqu'à

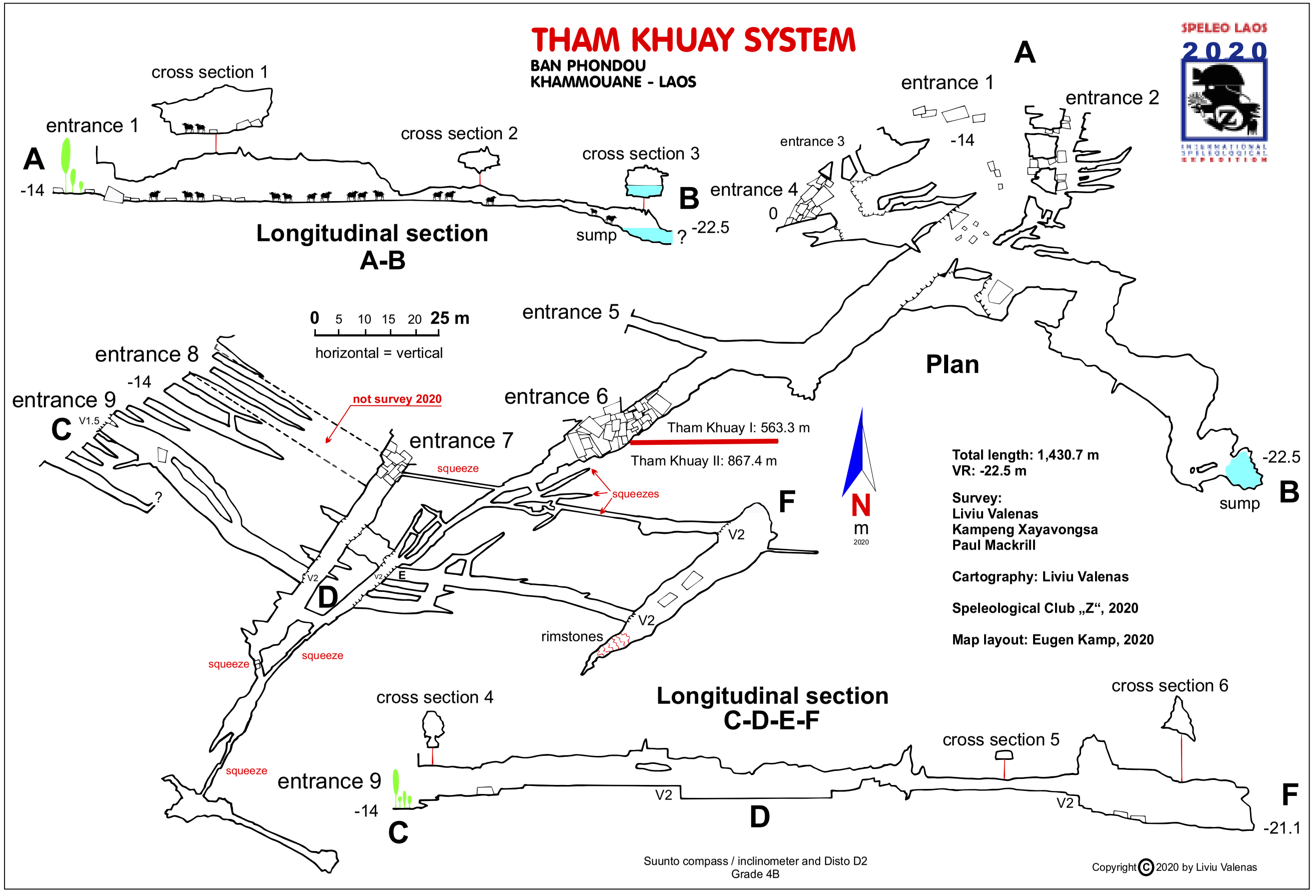

Figure 19. Le Système Tham Khuay, plan, sections longitudinales si transversales, cartographie de Liviu Vălenaş, 2020.

Figure 20. Tham Khuay I, la grande galerie latérale, photographie par Liviu Vălenaş, 2020.

Figure 21. Le siphon terminal de Tham Khuay I, photographie par Liviu Vălenaş, 2020.

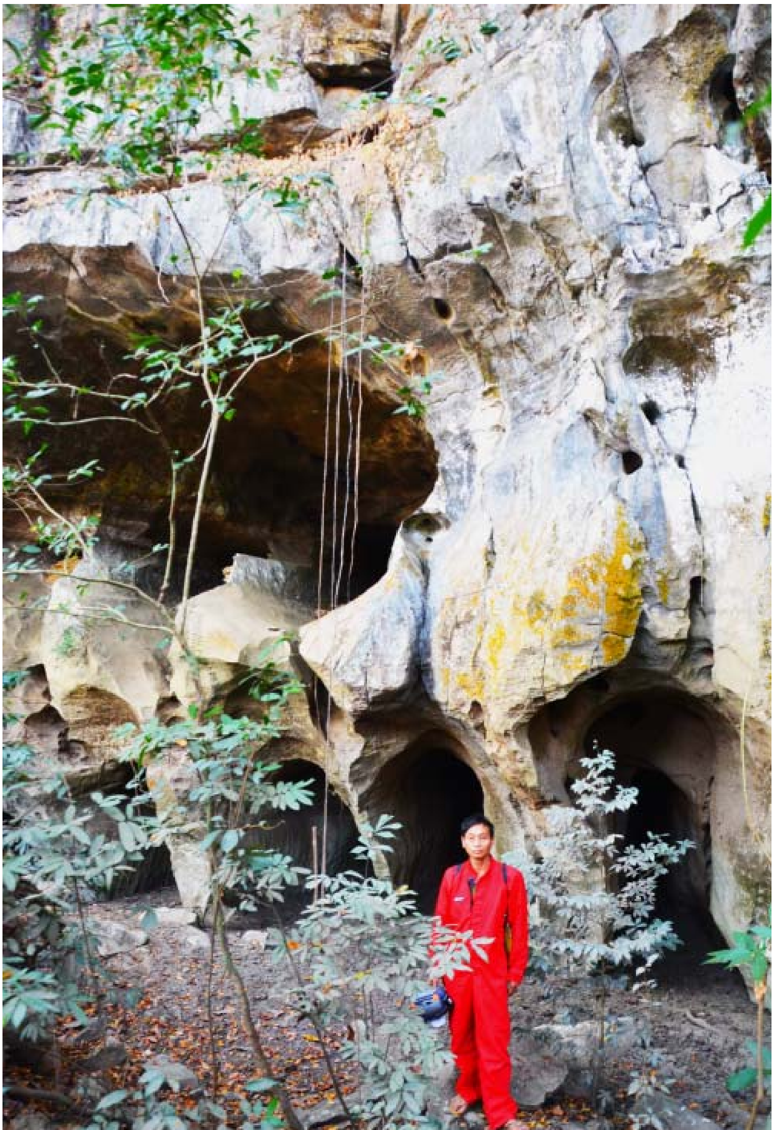

Figure 22. Tham Khuay II, les tubes phréatiques parallèles et l’entrée no 9, photographie par Liviu Vălenaş, 2020.

1,6 m du sol ne les empêche pas d’accéder au lac attrayant du siphon. Depuis la salle d’entrée, sur la gauche, un petit système labyrinthe constitué en partie de tubes souterrains orienté Ouest-Est se ramifie. Une galerie rectiligne plus large, orientée Sud-Nord, mène à l’entrée no. 2, avec les dimensions de 4,5 x 4 m. A seulement 16,3 m de l’entrée (dénivelé -6,0 m) il y a une importante bifurcation sur la droite. Au sud-ouest une grande galerie de 67,6 m de long se ramifie. Elle mène à l'entrée no. 6, en pente ascendante élevée, pleine de blocs. De cette galerie, une galerie légèrement plus étroite (2 x 2 m) bifurque également vers l'ouest et mène à une autre entrée, no. 5. Dès l'entrée principale no.1 commence à droite un système légèrement labyrinthique, relativement déroutant, qui fait une grande boucle et traverse deux branches près du plafond de la grande galerie qui se dirige vers le sud-ouest. De cette boucle, deux autres entrées s'ouvrent, no. 3 et no. 4, la dernière assez large et pleine de blocs. En saison sèche la grotte est un lieu de prédilection des dizaines de buffles pour se reposer à l'ombre. Ils parcourent tranquillement toutes les galeries de la grotte. Ils appartiennent aux habitants du village de Ban Phondou.

Tham Khuay II part également de la base d'une paroi verticale où s'ouvrent sur une longueur de 46 m pas moins de 13 tubes souterrains, 2 légèrement suspendus dans la paroi, les autres au niveau de la plaine alluviale de la rivière Nam Don. Une montée ascendante de 1,5 m permet l'accès au tube principal qui mène au secteur plus profond de la grotte. Le tube se ramifie en deux branches parallèles, qui se rejoignent ensuite. Après 55 m, le tube débouche par une verticale négative de 2 m dans une large galerie de 61 m de long, orientée Nord-Est - Sud-Ouest. Vers le nord-est, il fait surface dans une entrée pleine de blocs, l'entrée no. 7. Vers le sud-ouest après une portion très basse, il continue avec une salle longue de 14 m. De là, une galerie en forme de L se poursuit, au début extrêmement étroite, puis un peu plus large, se terminant en cul de sac après 72,5 m. De la galerie orientée NE-SO, une petite galerie de 6 m de long bifurque. Elle permet d'accéder à une galerie quelque peu parallèle, de 76 m de long, qui mène aussi, après une grande pente ascendante à l'entrée no. 6. De cette galerie, deux tubes d'eau phréatique dont un plus large et l'autre extrêmement bas et étroit débouchent dans une galerie de 50 m de long, une galerie salle en pente descendante, se terminant à -21,1 m par un siphon sec en argile. C' est la plus large galerie de Tham Khuay II, quelque peu en dissonance avec la morphologie du reste de la grotte. Enfin, nous devons mentionner que, étant donné le plafond effondré sur une longueur de 15 m dans la zone de l'entrée no. 6, les puristes pourraient considérer qu'il s'agit de deux grottes distinctes: Tham Khuay I, avec un développement de 563,3 m et respectivement Tham Khuay II avec un développement de 867,4 m. Nous pensons que malgré un simple accident tectonique (l'effondrement du plafond sur une longueur de 15 m) il s'agit d'un seul système souterrain unique par une morphologie et une genèse identiques et non de deux grottes séparées.

Spéléothème

Si l'on fait abstraction de quelques concrétions (dont quelques gours) dans la galerie-salle qui descend à -21,1 m, le système Tham Khuay est dépourvu de toute concrétion.

Climatologie
Tham Khuai II: 21,2 degrés C, humidité: 90% (12 février 2020). Le système Tham Khuay, ayant plusieurs entrées, est fortement ventilé.

Possibilités d'avancement
A Tham Khuay II il y a quelques tubes souterrains qui n'ont pas encore été topographiés, la «réserve» de galeries pourrait continuer encore 200 m. Mais la vraie possibilité d'avancement, la plus tentante est de forcer le siphon terminal, ce qui pourrait permettre l'accès à plusieurs kilomètres de nouvelles galeries.

Tham Mai Ken

Résumé. Tham Mai Ken (La Grotte du Bois Nonpourri) est un labyrinthe fossile formé de tubes développés relativement de manière parallèle.

Localisation

Tham Mai Ken se trouve dans la paroi verticale du mont Phou Namthok (Le Mont des Torrents), à 2,300 km sud du village de Ban Phondou.

Données physiques
Développement: 304,0 m, dénivellation: +15,0 m, extension: 83,7 m, coefficient de ramification: 3,63.

Historique des explorations
La grotte a été explorée et topographiée dans le cadre de l'expédition SPELEO LAOS 2020 par Liviu Vălenaş et Khampeng Xayavongsa (février 2020).

Lithologie et genèse
La cavité se développe en calcaires carbonifères massifs, avec des intrusions de silex. Les calcaires sont fortement faillés et diaclasés, les failles principales sont orientées NO-SE et N-S. Mais la majorité des tubes phréatiques se développent sur le système de failles principal NO-SE, ce qui explique ce remarquable parallélisme. La grotte s'est formée surement en régime épiphréatique. Aucun remodelage vadeux n'est à observer. La grotte s'est formée par l'arrosage du paquet de calcaire du versant droit de la rivière Nam Don. Le processus de dissolution continue encore à présent, mais seulement pendant les crues de la saison hu-

Figure 23. Tham Mai Ken, les entrées no. 10-13, photographie par Liviu Vălenaş, 2020.

mide. Nam Dom n'a pas réussi à créer dans ce secteur une vraie grotte, mais un labyrinthe de tubes phréatiques qui n'avancent pas plus de 30 m dans le versant. Tham Mai Ken présente un parallélisme remarquable dans le secteur d'entrée depuis Tham Khuai II, qui se trouve à seulement 370 m NE.

Hydrogéologie

Pendant la saison humide, des moussons, pendant la période des grandes crues, la grotte est inondée par la rivière Nam Don.

Description

Au pied de versant abrupt de la montagne Phou Namthok, orienté SO-NE, se trouvent les 13 entrées de la grotte. L'entrée principale (no.10), qui est en fait un abri large de 23,4 m, présente 10 tubes phréatiques développés sur des diaclases parallèles orientées NO-SE. La largeur de ces tubes varie de 12 à 2 m et leur longueur maximale est de 25 m. Le secteur nord-est de la grotte (les entrées no. 1 à 9) est un peu différent, les tubes phréatiques sont plus longs et communiquent par des boucles (dont une très étroite) orientées parallèlement à la paroi verticale dans laquelle se trouve la grotte.

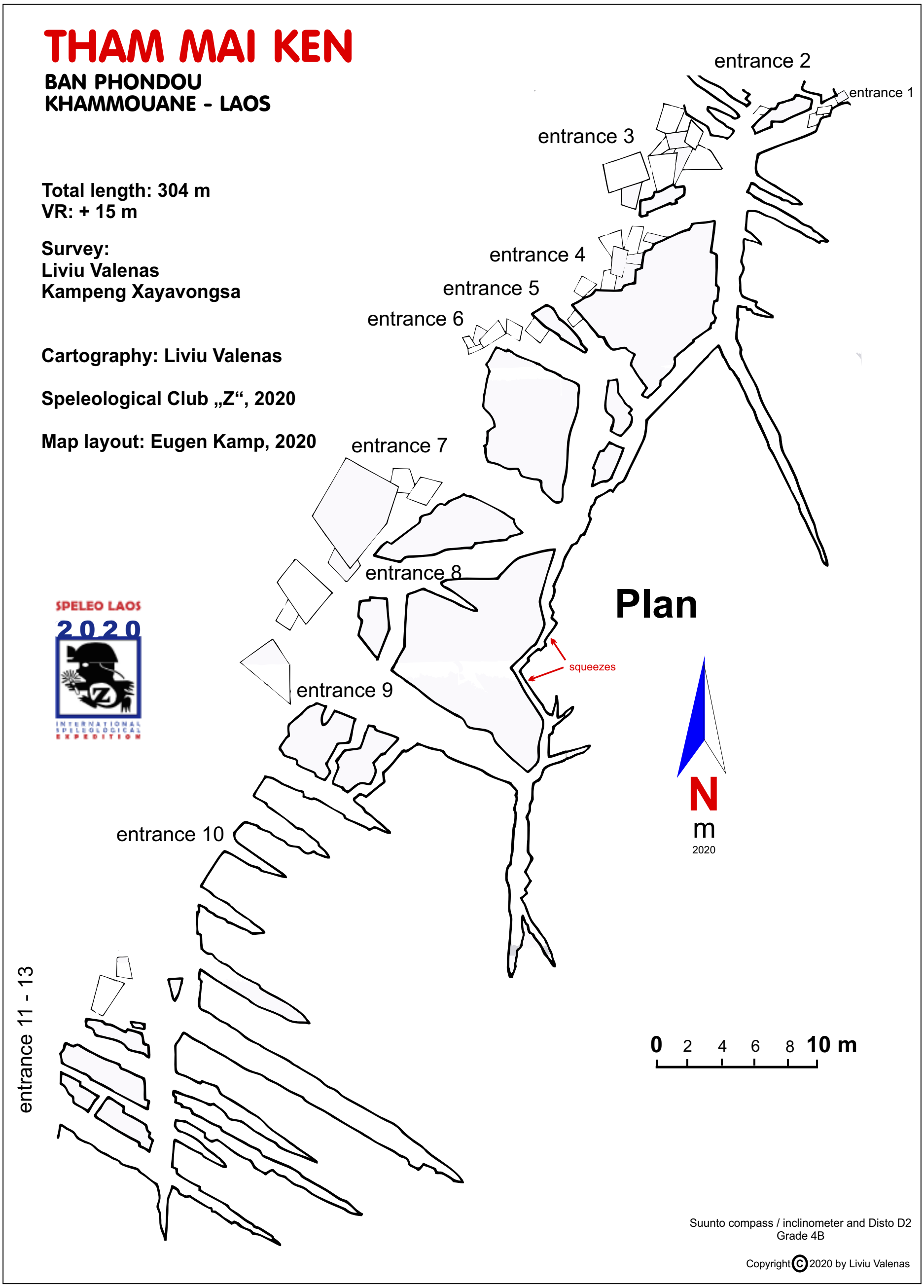

Figure 24. Tham Mai Ken, plan, cartographie de Liviu Vălenaș, 2020.

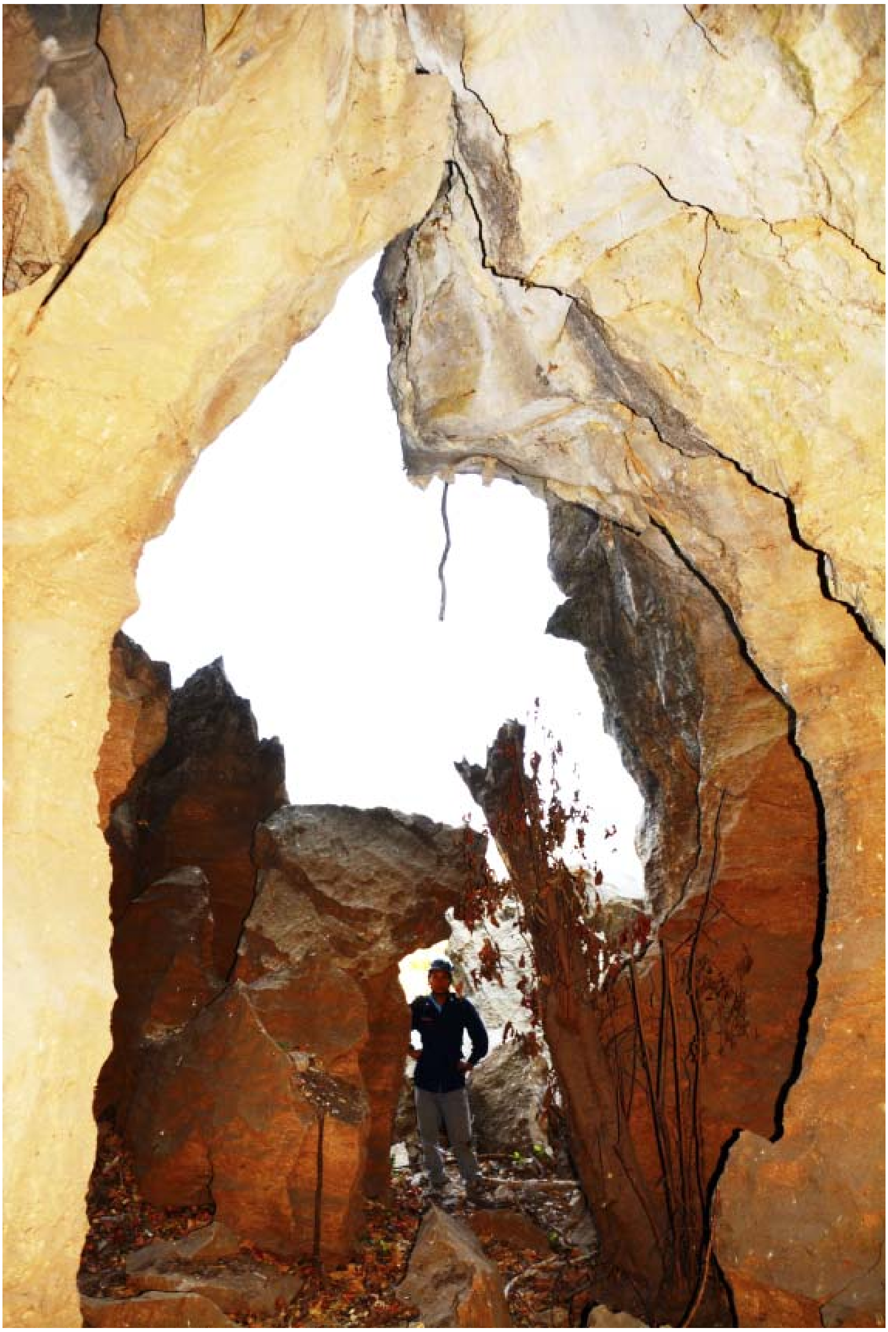

Figure 25. Tham Mai Ken, l'entrée no 3, photographie par Liviu Vălenaş, 2020.

Conclusions

Les trois grottes explorées dans le mont Phou Namthok représentent un endokarst évolué, mais avec des genèses différentes. Tham Dan Makhia est la grotte la plus complexe, échelonnée sur trois niveaux, le niveau le plus bas étant toujours en régime totalement immergé, marqué par des siphons particulièrement profonds. La descente par étapes (dictée par les oscillations climatiques) de la rivière Nam Don a été le facteur déterminant de la formation de plusieurs étages de la grotte Tham Dan Makhia. Tham Mai Ken, en revanche, semble être un ancien aquifère d'eau phréatique, œuvre exclusive de la rivière Nam Don, la grotte étant à l'origine formée sous le lit de cette grande rivière. Idem, une bonne partie du système Tham Khuay a la même origine, le reste représente un drain de premier ordre d'une insurgence qui n'a pas encore été identifiée. La grotte la plus ancienne et la plus complexe de la région (et qui est le drain principal du mont Phou Namthok) est Tham Dan Makhia. Nous apprécions l'âge de cette grande grotte comme étant formée à partir du Pléistocène moyen. On attribue le même âge à la galerie principale de Tham Khuay I. Les autres galeries sont encore plus récentes, formées au Pléistocène supérieur.

Petit glossaire
Ban: village
Don: coudé, à méandres
Houay: ruisseau
Nam: ruisseau, eau, lac
Pha: mont de calcaire à parois verticales
Phou: mont
Tham: grotte, abri

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Crocodylian remains from the late Paleocene of Jibou, Romania

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Abstract. Here we report the presence of a planocraniid crocodyliform from the late Paleocene of Jibou (N-W Romania) representing one of the geologically earliest fossil records of this group from Europe. The recovered cranial and postcranial remains resulted probably from an attritional assemblage and may have belonged to a single planocraniid taxon. The morphological traits of this taxon (cf. *Boverisuchus*) include among others an interlocking occlusion in the premaxilla, a flat cranial table with upturned orbital margins, a large exposure of the supraoccipital on the dorsal skull table, procoelous presacral vertebrae, keeled paramedian osteoderms lacking an anterior process, and mediolaterally compressed teeth possessing fine and irregularly distributed serrations on the mesiodistal carinae of the tooth crowns. The planocraniid crocodyliforms identified from the Paleocene of Romania mark an important paleogeographic link between the Chinese, European and North American occurrences. The lacustrine taphonomic context in the Jibou fossil locality is suggested by the presence of strictly limnic ostracods and gastropods, as well as other freshwater preferring groups including teleostei fish and dortokid turtles. The planocraniid crocodyliforms might have acted as top predators in these freshwater habitats.

Keywords: Crocodylia, Jibou, Paleocene, Planocraniidae, Romania.

Introduction

Crocodylomorpha, is a clade of pseudosuchian reptiles which also includes crocodiles, the only representatives of the clade that have survived to the present day. Their first occurrence (i.e., *Trialestes*) is known from the Late Triassic (Carnian) of Argentina (Irmis et al. 2013; Sues, 2019). The first representatives were of moderate size, reaching lengths of maximum 2.5 m (Nesbitt, 2011), being by far smaller than the subsequent Mesozoic dinosaur-eating crocodiles *Deinosuchus riograndensis* Colbert & Bird, 1954 (Brochu, 1999, 2003 and references therein; Cossette and Brochu, 2020) or *Sarcosuchus imperator* Broin & Taquet, 1966 (Sereno et al., 2001), both exceeding 10 m in length.

Throughout their evolution, crocodylomorphs reached various sizes, but from a morphological viewpoint they did not record major changes, actual representatives sharing similar physiognomies with their ancient forerunners. This is an illustrating example of conservatism tendencies in evolution. Crocodylomorph fossils were found in the Mesozoic and Cenozoic sedimentary deposits on nearly all continents, which constitutes proof of their worldwide distribution.

In Romania, knowledge regarding the paleontology of this group is still lacking. Evidence about the first stages of their evolution are missing both in this country, and in the neighboring ones. Triassic deposits are generally extremely scarce in vertebrate fossils, and the vertebrate localities (e.g., Lugașu de Sus, Peștiș in Bihor District; Agighiol, in Tulcea District) of this age yielded other groups of reptiles, but not crocodilians: placodonts, tanystropheids, notosaurs or ichthyosaurs (Simionescu, 1913; Jurcsák, 1982; Huza et al., 1987; Popa et al., 1992; Posmoșanu, 2008, 2013). Such a situation is predictable if we are considering the group's origin and evolution, since the Triassic rocks where the fossil vertebrates originated from are too old (Anisian) compared to the first occurrence of these reptiles, in the Late Triassic. A similar situation refers to areas situated nearby Western Romania, in Hungary, where systematically comparable Triassic reptiles were reported from younger deposits (Ladinian), in the Villány area (Segesdi and Ősi, 2021).

After the Triassic, the whole territory of present-day Romania has been covered by the Tethys Ocean, and the possibility to find fossil crocodiles is weak. Terrestrial sequences are extremely few, and are related to the early Cimmerian tectonic phase, but fossil vertebrate remains are missing in such deposits.

Therefore, the geologically oldest crocodile in Romania is the one reported from Săndulești, near Turda town, unearthed from the Săndulești Formation (late Oxfordian – early Beriassian). According to Dragastan et al. (1987), this limestone level is related to a carbonate platform, once located on the distal area of a shelf, nearby the continental slope. Probably, the platform recorded the emerging episodes of the late Cimmerian tectonic pulse (middle Jurassic – early Cretaceous), followed by karst genesis. However, the intensity of these processes was weaker in the Western Transylvanids (Săsăran, 2006) compared to the inner Dacids, considering this type of relief and the related accumulation of bauxites in the karst deposits (Ianovici et al. 1976; Cociuba, 2000). In the Early Cretaceous (Beriassian) of the area there was a Tethys Ocean archipelago where a lake system occurred under tectonic control, that is to say, a transition from marine (carbonate platform) to terrestrial environments took place. Săsăran (2006) interpreted the Cretaceous environments from Săndulești as related to a continental slope, nearby the shelf ridge, with Stramberk-type limestone with reefs erected by various organisms, microbialites included. The geological age specified by Săsăran is ”Upper Jurassic-Lower Cretaceous” (Săsăran, 2006: 41), without any other detail.

The crocodile from Săndulești was reported by Nițulescu (1936), former Prof. Ion Popescu-Voitești's assistant at the geological University of Cluj, who noticed these fossils in an interwar collection once curated at the main office of the limestone quarry by someone named Gărduș. Nițulescu assigned these fossils (an isolate tooth and some rib fragments inside a limestone block, unprepared) to ”*Teleosaurus suprajurensis* Schlosser, 1881”, junior synonym of *Dakosaurus maximus* (Plieninger, 1846). Unfortunately, he did not illustrate these fossils, neither the crocodiles, nor the invertebrates stored in the same collection (corals, brachiopods, sea urchins, cephalopods, crustaceans) or the fish *Asterachantus ornatissimus* Agassiz, 1837 assigned based on a dentary plate of 36 mm in length vs. 16 mm width. If we exclude the rib fragments, the single piece on which the species assignation was based on, is a single isolated tooth. However, he did not describe useful characters for a correct assignation that would refer to the large size, the serrated margins of the tooth and its strong lateral compression, all diagnostic for this genus. In this situation, Nițulescu's brief description remains problematic and should be kept in mind as such. A justified question concerns the level where the fossil originated from. The fossils from the old Săndulești collection resulted from fortuitous finds carried on by the quarry workers and the technical staff. Until Nițulescu's paper, the single fossil vertebrates ever mentioned from this locality exclusively referred to fish teeth (*Sphaerodus maximus* Wagner, 1863) that Koch (1900) reported in his list of taxa.

If the assignation of this crocodile is however valid, it is important to say that there is extremely scarce data about the life and behavior of this crocodile, while it is rather unclear whether it was an exclusively marine, or a terrestrial animal that episodically intruded the marine realm, a presumed scenario that remains to be solved regarding other fossil crocodiles as well in Transylvania (e.g., Sabău et al., 2021). This crocodile was a large sized one, reaching 4.5 m in length (Fraas, 1902; Steel, 1973), being probably among the top predators of the ancient ecosystem. However, in the already mentioned context it is not possible to establish the origin level, and currently it is impossible to establish whether the invertebrates and the hybodont shark (which has concordant time span distribution with the crocodile) were found together with the crocodile remains in the same level, or originated from different ones, which would mean different ecosystems. Trying to estimate the geological age of the crocodile from Săndulești, it is very likely that it could originate from Upper Jurassic rocks. Săsăran's (2006) data for the new Săndulești limestone quarry could constitute the base for the credibility of this suposition.

The value of Nițulescu's contribution, even with its gaps, remains essential for the vertebrate paleontology of Romania, since he enriched the list of fossil taxa. Nonetheless, the Săndulești finds were of short fame among the contemporary paleontologists and geologists, even more so among the next generations. Nițulescu's paper was briefly mentioned by Rugonfalvi (1939), but it was completely ignored by the authors who made fossil vertebrate lists of taxa, such as Simionescu and Barbu (1943) or Macarovici and Turculeț (1982). On our turn, one of us (VAC) strived to retrieve these fossils, but seemingly the Săndulești collection was lost.

A very long time span completely devoid of data concerning crocodiles is between the Săndulești find and the following, geologically younger taxa. Newer materials originate only from the latest Cretaceous. The explanation for this lack of discoveries may be related to the specific paleogeography, with dominance of deep marine environments, where the terrestrial influences were either completely absent, or very faint. Evidence could however exist related to the mid-Cretaceous tectonic pulse ("Austrian"), but crocodiles of this age are lacking from the fossil record.

From the latest Cretaceous (Maastrichtian) terrestrial deposits of Romania a diversity of crocodylomorphs was reported, discoveries originating from only a few sedimentary basins, such as Hațeg (Venczel and Codrea, 2019 with references therein) from the Sânpetru and Densuș-Ciula Formations, Rusca Montană (Codrea et al., 2012) or from the Șard Formation, in the Metaliferi sedimentary area (Delfino et al., 2008; Codrea et al., 2010). All of these belong to the paleogeographic unit known as the ”Hațeg Island”. The common denominator of these associations of crocodylomorphs refers to the trophic chains, where the top predator was the eusuchian *Allodaposuchus precedens* Nopcsa, 1928 (Delfino et al., 2008, Codrea et al., 2010, Solomon and Codrea, 2015, Narváez et al., 2019), while the smallest was *Aprosuchus ghirai* Venczel & Codrea, 2019 (Venczel and Codrea, 2019).

Besides the mentioned taxa that mark extreme forms of the latest Cretaceous of Transylvania, there were also other representatives. One of the small sized *Theriosuchus* like taxa was assigned to *Sabresuchus* (=*Theriosuchus*) *sympiestodon* (Martin, Rabi & Csiki, 2010) by Tenant et al. (2016). Another crocodile from the Maastrichtian formations of Transylvania is the alligatoroid *Acynodon* (Martin et al., 2006; Solomon and Codrea, 2015), a small, extremely specialized taxon, with a significantly short snout. The diet of *Acynodon* is rather unclear (Delfino et al., 2008). In Romania, this form is known only based on isolated teeth, from the Hațeg basin (cf. *Acynodon* sp., in Martin et al., 2006; *Acynodon* sp., in Solomon and Codrea, 2015). Another genus known from the ”Hațeg Island” is *Doratodon* (Martin et al., 2006). Not far from Romania, *D. charcaridens* (Bunzel, 1871) is known from the ”Senonian” deposits of the Grünbach Formation (lowermost Campanian, Muthmannsdorf, Austria; Buffetaut, 1979 considers this species valid), but also from Hungary (Csehbánya Formation, Iharkút, late Santonian; Rabi, 2008).

Crocodylomorphs crossed the Cretaceous/Paleogene (”K/T”) boundary, but in the lowermost Cenozoic their taxa renewed. In Romania, data about the earliest representatives are known from the Jibou Formation (NW Transylvania; Maastrichtian-Lutetian; Codrea and Godefroit, 2008; Baciu, 2003). Apart from an isolated tooth found in a drill core sample at Someș-Odorhei (Sălaj County; Posewitz, 1906) that could have originated from a Cretaceous representative, all other evidences are originating from the Rona Limestone Member (Thanetian-?Sparnacian; Hofmann, 1879; Codrea and Săsăran, 2002; Baciu, 2003). Gheerbrant et al., (1999) mentioned in a list of taxa two types of crocodylomorphs, cf. *Doratodon* and Crocodylidae s.l. indet., without any description and illustration. If the assignations were correct, it would demonstrate that *Doratodon* survived until the end of the Paleocene.

Knowledge about the Cenozoic basalmost representatives of crocodylomorphs is extremely poor, with scarce data throughout Europe. In such context the Paleocene terrestrial vertebrates from Romania are of outstanding value, as they are unique for the entire Eastern Europe. This study is focused on crocodylian fossils collected from Paleocene lithostratigraphic units, at Jibou and Rona localities, in Sălaj County. The fossils consist of isolated specimens representing fragmentary cranial and postcranial remains that were probably part of an attritional assemblage. The skeletal parts reached the burial place probably after a high energy transport, like a flash flood, causing the disarticulation and fragmentation of most specimens. The available remains probably have belonged to a single group of eusuchian crocodylomorphs, which based on several unique characters (e.g., mediolaterally narrow but dorsoventrally deep snout and labiolingually compressed tooth crowns bearing finely serrated crests) may be attributed to Planocraniidae Li, 1976, a group never reported previously from the eastern part of Europe. However, the present report may correspond to one of the geologically oldest fossil records (late Paleocene) from the whole continent.

Geological setting and age of the lithostratigraphic units

Situated in central Romania, the Transylvanian Depression is the widest in the country, being surrounded by the Carpathian Mountains. Geologically it resulted from the evolution of succeeding overlaying sedimentary basins as defined by Balintoni et al. (1998), who specifies four Permian-Mesozoic and three Cenozoic basins. Krézsek and Bally (2006) discuss about four sedimentary megacycles for this area, which were closely related to and influenced by the Alpine Orogenesis of the Carpathians.

In the latest Cretaceous (Maastrichtian; Codrea and Godefroit, 2008 and references therein), after the ceasing of the extensional processes, the basin’s basement located nearby the northeastern margin of the Apuseni Mountains was uplifted, and terrestrial sedimentary deposits began to accumulate on the emergent surface. During the Paleogene megacycle, after the „Laramide” tectogenesis, freshly eroded sediments originating from the newborn relief of the Carpathians accumulated in subsidiary sag basins associated with a foreland area (Hosu, 1999). As a result, the Paleocene-lower Eocene sequence is characterized by terrigenous sedimentary rocks that begin with the alluvial fan deposits of the Jibou Formation (Maastrichtian-Lutetian; Fig. 1).

The Jibou Formation coined by Hofmann (1879; Fig. 2), also known as the “Lower Variegated Red Shales” in older stratigraphic nomenclature (a detailed historical evolution of its name, in Mészáros and Moisescu, 1991), exposed on large areas and with remarkable thickness of strata (+1500 meters at the type section), is constantly present in all three sedimentary areas (Gilău, Meseș and Preluca; Rusu, 1970, 1987; Popescu, 1976) on the NW side of the Paleogene Transylvanian basin and is characterized by facies uniformity. In the Gilău and Preluca areas at the same stratigraphic level, the counterpart clastic Stejerea

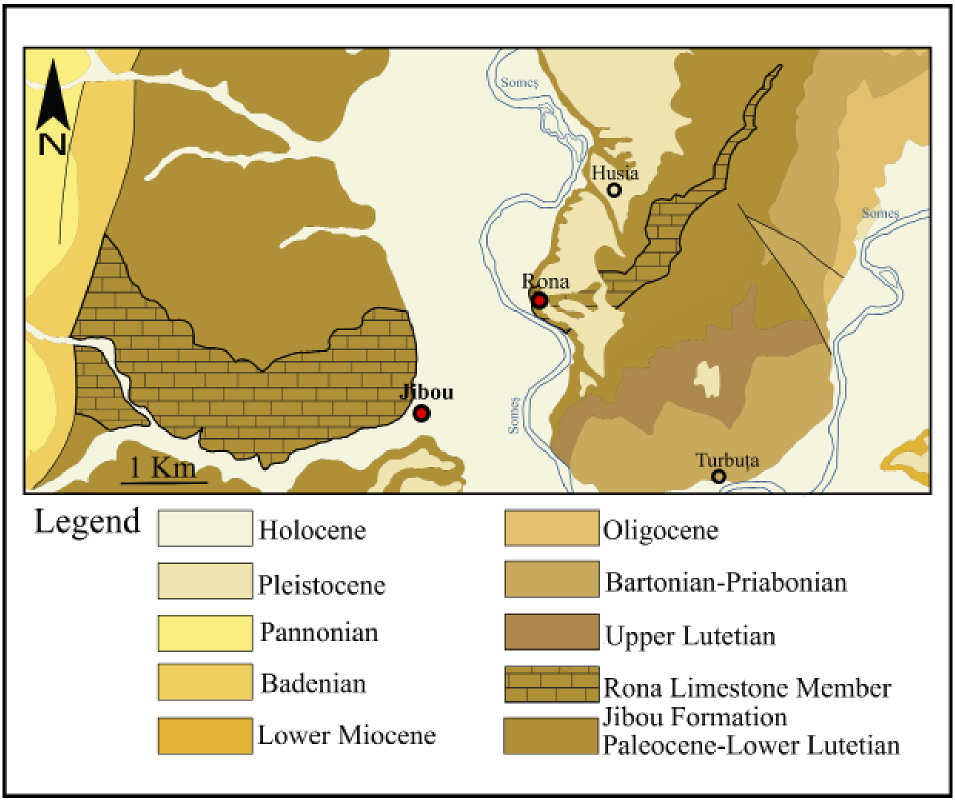

Figure 1. Geological map of the Jibou-Rona area, in Sălaj County (after the Geological map 1:50 000, folio 29b Jibou and folio 29a Zalău), modified.

Formation is present (Rusu, 1987; Codrea et al., 2010). The area of interest for this study is situated in the Meseș sedimentary area, between Jibou and Rona localities, in Sălaj County (Figs. 1 and 2). The studied formation presents the overlay of retrograde alluvial fan deposits that cover directly the post-"Laramide" unconformity surface of the metamorphic basement represented by the Someș Lithogroup (Fig. 3), and possibly the subsequent Mesozoic sedimentary deposits with a tectonically controlled thickness across the sedimentary basin (Hosu, 1999).

Proust and Hosu (1996) mentioned a specter of four alternating lithofacies composed of conglomerates, sandstones and red silty shales. In the lowermost section of the terrigenous deposits a layer of conglomerates is present, composed of metamorphic clasts and red silty-arenitic matrix. In the Gilău sedimentary area a level of interspersed pyroclastic deposits is present at the base of the mentioned formation (Mureșan, 1980), which has never been found in the proximity of the Jibou-Rona area. Further above, there are fluvial red-bed deposits with intertwined channel-fill deposits involving silty-conglomeratic sediments, and over-bank deposits with red silty clays related to fluvial plain environments, all composing the alluvial fans (Proust and Hosu, 1996; Hosu, 1999; Codrea and Hosu, 2001). Hosu (1999) also mentions a level of kaolinite at the basal part of the formation, and specifies the quartz rich composition of the red arenites. The striking red colour of these deposits was explained by Voitești (1935) on one hand, as a result of the Cretaceous lateritic soils that were transported in the Transylvanian basin from the nearby Gilău Mountains during rainy seasons. On the other hand, Hosu (1999) has a different explanation focusing on the mineralogical composition of sediments. He related the red color to diagenesis of the ferrous minerals and migrations of pigments.

Another peculiar feature of the studied formation is the presence of restricted lake deposits, as interbeddings in the red-beds succession. We refer to the Agârbiciu Dolomites (part of the ”Inferior marine series”, sensu Mureșan, 1980), the Horlacea Limestone Member (Rusu, 1995), and the Hășdate Limestones. But by far, the most important lacustrine deposits from the perspective of areal distribution, thickness and fossiliferous content are the ones of the Rona Limestone Member (Codrea and Săsăran, 2002), first mentioned by Hauer and Stache (1863), but described in detail by Hofmann (1879). The initial description of strata was based on an outcrop located on the geographic right shore of the Someș River, in Rona locality (Fig. 4). Hofmann considered these deposits as exclusively Eocene, based on some fossil mollusks. About three decades ago, new outcrops became available for study as a consequence of the botanical garden enlargement works in Jibou locality. Consequently, the team realized that 2/3 of the lake deposits have been unknown until that point (Codrea and Săsăran, 2002). The Rona Member lake deposits having a thickness of about 250 meters start with marls, mudstone layers, and sandstones, followed by organically rich shales and limestones, with final layers of red-greenish shales and channel-fill deposits (Codrea and Hosu, 2001).

Hofmann described the red shales of the Jibou Formation as being completely devoid of any fossil material and he also mentioned some *Chara* remains in the freshwater limestones of the Rona Member. Indeed, at first glance the red shales seem to be devoid of fossil remains, but in truth these are not completely lacking, the fossils are plain and simple uncommon. Historically, the oldest vertebrate remains were reported by Baron Nopcsa (1905), who collected the fossil remains of the dinosaur „*Rhabdodon priscus*” (formerly known as ”*Mochlodon suessi*”) together with indeterminate chelonian and crocodile remains

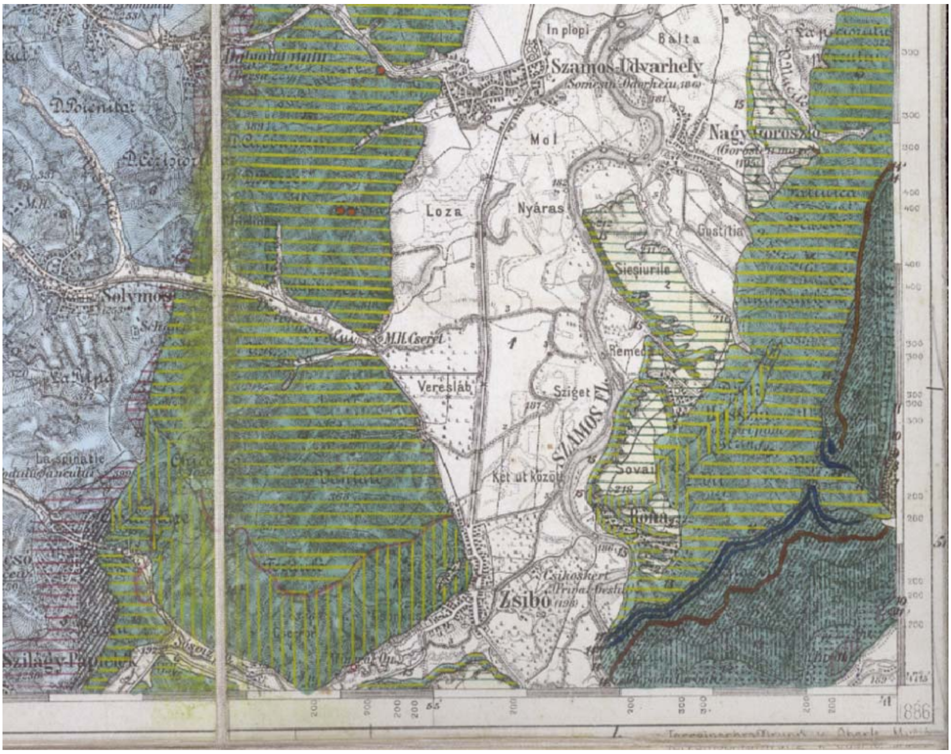

Figure 2. Historical geological map of the Jibou (= Zsibó) area 1: 75 000 by Hofmann et al. (1888).

from Someș-Odorhei locality, near Rona. Based on these, he established Danian age for the basal part of the Jibou Formation. Later, this contribution was either forgotten, or ignored by the followers. Codrea and Godefroit (2008) collected from the same level the remains of the ornithopod dinosaur *Zalmoxes shquiperorum*, a discovery that confirmed the uppermost Cretaceous (Maastrichtian) age for the lowest portion of the Jibou Formation. Concerning the uppermost boundary of the Jibou Formation, Mészáros and Diószegi (1988) reported an assemblage of five nannoplankton taxa and some ostracods, which from their point of view emphasized a middle Eocene age for the rocks from Giurtelecul Șimleului outcrop. From the same locality, Codrea and Fărcaș (2002) reported the presence of turtles assigned to "*Paleochelis*" s. l., and *Neochelis*. Later, Vremir (2013) completed the list with cf. *Ronella* and other taxa with questionable systematic assignments. The presence of these fossils in the top of the Jibou Formation is indicative for an Ypresian-Lower Lutetian age.

Regarding the Rona Member, from the basal part of the freshwater

Figure 3. Lower boundary of the Jibou Formation at Dumbrava, Cluj County; the red waved line is marking the unconformity of the terrestrial sedimentary rocks with the underlying metamorphic Someș Lithogroup as basement of the Transylvanian basin.

Figure 4. The Rona Limestone Member outcrop located on the Someș's left shore, at Rona locality; based on these rocks Hofmann (1879) described the lithology of this member.

sequence a palynological association was reported by Petrescu and Codrea (2003 a, b), Codrea et al. (2003) and Petrescu (2003), indicating a late Thanetian age. Baciu (2003) concluded the same age based on charophytes, to which Gheerbrant et al. (1999) added studies based on gastropods and ostracods, with similar results. Considering vertebrates, Gheerbrant et al. (1999) together with Codrea and Hosu (2001) outlined an association with participants such as the dortokid turtle *Ronella botanica*, crocodylians (cf. *Doratodon* sp.) and multituberculate mammals, such as cf. *Hainina* sp., cf. *Paschatherium* sp., a.o.

(Gheerbrant et al., 1999; Codrea and Hosu, 2001). Gaudant et al. (2005) added the Amiidae fish genus *Cyclurus* to the association from the late Paleocene. The above-mentioned taxa are indicative for a paleoecosystem established close to the Paleocene lake at Rona. Petrescu and Codrea (2003 a, b) interpreted a subtropical climate based on specific plant communities.

From a tectonic point of view, strata in the Jibou area have a monoclinal placement, with a dip angle of about 15°-20° SSE on the left shore of the Someș River, whereas on the right side the strata are dipping only about 5° SSE, with a decreasing value towards the center of the sedimentary basin (Hofmann, 1879). According to Koch (1894), at Someș-Odorhei an anticlinal aspect of the deposits can be noticed, which does not continue over the Someș valley, on the right bank of the river, and which is the result of the uplift of the underlying metamorphic substratum that is continuing underground, below the Meseș Mountains. The Paleocene-Eocene boundary is not easy to draw, since the deposits of both ages are parts of a continuous terrestrial sedimentation, in the same facies. During the Eocene, the continental sedimentation has been replaced by a marine one, after deepening of the basin and transgression of the marine waters.

Material and methods

The crocodile fossils were collected from two localities, both exposing the Rona Member of the Jibou Formation, in Sălaj County: in Jibou (Jb), from the rocks cropping out in the Botanical Garden, in the concentration levels B2 and B4 (in Gheerbrant et al. 1999), and from Rona (Ro), from outcrops located on the right bank of the Someș River.

The fossil bones and teeth were found scattered in the rock as isolated pieces. Therefore, they were collected inside blocks of various size, without using plaster jackets. When necessary, the vertebrate fossils were reinforced with professional polymers. The majority of teeth were retrieved by washing-sieving large amounts of sediments (24 tons in total, during successive field missions), the majority originating from the level B4. The sieves were disposed as washing tables with 0.3 and 0.5 mm meshes. For washing, usual garden pumps were used.

The bones were cleaned of the matrix rock in the Laboratory of Paleotheriology and Quaternary Geology of the Babeș-Bolyai University in Cluj-Napoca (abbreviated: LPQG BBU) using classical laboratory gear: needles, chisels, Air-Scribe, scalpels, under frontal magnifier or binocular magnifier. The small teeth were retrieved from the washed-sieved sediment concentrate with tweezers, under binocular magnifier Nikon SMZ 1000. When the teeth and bones were fissured, they were reinforced with professional polymers (mowillite) dissolved in acetone, at various concentrations.

The fossils are stored in the LPQG BBU collection. The registry numbers are following the formula: PJb(Ro)BxCr – x, where P means Paleocene, Jb (Ro) the name of the vertebrate locality, Bx the concentration level, Cr from crocodile, x the registration number.

The photographs were captured with a Nikon D-7000 camera and Nikon AF S Micro Nikkor 60 mm lens, and a lighting system. For the small teeth the photos were captured with the same camera mounted on a Nikon SMZ 1000 binocular magnifier. All photos were processed using the CombineZP software by Alan Hadley, using the overlaid images technique. Images were lastly processed in Adobe Photoshop CC 2019 and Adobe Illustrator CC 2019 computer programs. Common English terms and the standard anatomical orientation system are used throughout this paper; the anatomical nomenclature of crocodylians follows Brochu (2013).

Systematic paleontology

Class Reptilia Laurenti, 1768

Order Crocodylia Gmelin, 1789

Suborder Eusuchia Huxley, 1875

Family Planocraniidae Li, 1976

The family Planocraniidae, following Brochu (2013) and Sues (2019), represent a clade of eusuchian crocodylians that include *Planocrania datangensis* and all crocodylians more closely related to it than to *Alligator mississippiensis*, *Crocodylus niloticus*, *Gavialis gangeticus*, *Borealosuchus sternbergii*, *Thoracosaurus macrorhynchus*, *Allodaposuchus precedens*, or *Hylaeochampsa vectiana*. Li (1976) assigned the group Planocraniidae based on the basal taxon *Planocrania datangensis* Li, 1976, which has been recovered from the Paleogene red-bed deposits of the Nongshan Formation from China. Later, Li assigned a new species to the group, *Planocrania hengdongensis* Li, 1984, again originating from Paleogene red-bed deposits of the Lower Lingcha Formation from China, both of these fossils are considered unique specimens to this day (Li, 1984). The members of Planocraniidae possess a moderately long, mediolaterally narrow and dorsoventrally deep rostrum, whereas the tooth crowns are labiolingually compressed and bear finely serrated cutting edges, some can have hoof-like ungual phalanges (Brochu, 2013; Sues, 2019). Brochu (2013) and Narváez et al. (2015) found *Borealosuchus* and Planocraniidae as successive sister taxa to Brevirostres which includes Alligatoroidea and Crocodyloidea.

The fossil record of Planocraniidae is restricted to the Paleogene of China, the Paleocene-Eocene of the United States, Western Europe: Eocene of France, Lutetian of Germany, Italy, and Spain (Kuhn, 1938; Li, 1976, 1984; Brochu, 2013; Sues, 2019), the Indian subcontinent (Eocene of Nepal and Northern India; Panadés I Blas et al., 2004; Sah and Schleich, 1990), Eocene of Kazakhstan (Rossmann, 1998) and lastly Romania (this report).

Genus *Boverisuchus* Kuhn, 1938

Previously, the genus *Boverisuchus* was widely known as "*Pristichampsus*", but the type material, on which the species name *Pristichampsus rollinati* (Gray, 1831) is based, is lacking diagnostic characters at species level (Langston, 1975), and therefore Brochu (2013) regarded it as a *nomen dubium*. Both the American and European members of the genus *Boverisuchus* (i.e., *B. vorax*, known from the Bridger Formation, Wyoming, USA and *B. magnifrons*, known from Geiseltal near Halle, Germany) are restricted to the middle Eocene; another taxon name *Weigeltisuchus geiseltalensis* Kuhn, 1938 (the holotype known from Geiseltal near Halle, Germany), is presently considered a junior synonym of *B. magnifrons* (Brochu, 2013).

Cf. *Boverisuchus* sp.

Material examined: one fragmentary left premaxilla [PJb(Ro)B4Cr-1]; one frontal [PJb(Ro)B4Cr-2]; one fragmentary frontal + parietal [PJb(Ro)B4Cr-3]; one posterior fragment of supraoccipital + parietal [PJb(Ro)B4Cr-4]; one squamosal [PJb(Ro)B4Cr-5]; one posteroleft fragment of neurocranium [PJb(Ro)B4Cr-6]; one fragmentary quadrate [PJb(Ro)B4Cr-7]; one fragmentary surangular + articular [PJb(Ro)B4Cr-8]; three fragmentary angulars [PJb(Ro)B4Cr-9/1-3]; one fragmentary dentary [PJb(Ro)B4Cr-10]; one scapulocoracoid [PJb(Ro)B4Cr-11]; two fragmentary humeri [PJb(Ro)B4Cr-12/1-2]; one fragmentary femur [PJb(Ro)B4Cr-13]; osteoderms [PJb(Ro)B4Cr-14]; vertebrae [PJb(Ro)B4Cr-15]; isolated teeth [PJb(Ro)B4Cr-16].

Description of the material

Premaxilla: The only premaxilla [PJb(Ro)B4Cr-1] is badly preserved missing its anterior and posterior margins; it displays some deformation on the anterolateral part of the labial surface (Fig. 5A, B). The specimen appears mediolaterally narrow, dorsoventrally deep and shallowly bent medially with its labial surface bearing a sculpture consisting of numerous small pits. The narial margin is slightly elevated on the posterior part, whereas the medial margin is gently curved medially indicating that the external naris was longer than wide. The bony margin delimiting the incisive foramen is broken off, therefore the size of that structure is unclear. Remnants of the premaxillary teeth are still present in the third and fourth alveoli, but their tooth crowns are broken off. The fourth premaxillary tooth is larger than the third and their shaft is slightly compressed labiolingually. Remnants of the second and fifth alveoli are partially preserved, whereas the first alveolus is broken off. The occlusal pits left by the dentary teeth are situated between the third and fourth alveoli and between the fourth and fifth alveoli, both pits being placed in line with the premaxillary tooth row; a partially preserved pit is situated lingually to the second alveolus.

Frontal, parietal, supraoccipital: The specimen PJb(Ro)B4Cr-2, represents a partially preserved frontal with its left posterolateral part missing (Fig. 5C, D). Due to its heavily built bony structure, it may have belonged to a mature individual. The bone's reconstructed shape approaches an elongated triangle with the medial part slightly depressed, whereas its lateral part is upturned near the orbital margins. The anterior process, about the same length as the remaining posterior bony part, is relatively narrow and subparallel, exposing laterally the sutural surfaces with the prefrontals. The dorsal anteriormost surface of that process displays the sutural imprints left by the paired nasals; the articulation appears as a simple acute point. The dorsal sculpture consists of enlarged and deep pits on the posterior half of the bone, whereas on the anterior process the pits tends to become elongated or replaced by shallow grooves. The posterior margin of the frontal exposes the sutural surface with the parietal that is more or less transversal, whereas on the right posterolateral side, there is a well-defined and deep contact surface with the postorbital.

The specimen PJb(Ro)B4Cr-3, representing a significantly smaller individual, preserves a fragmentary frontal and also the right anterolateral part of a parietal (Fig. 5E, F). The main difference between the PJb(Ro)B4Cr-2 and PJb(Ro)B4Cr-3 specimens is that the orbital margin is more deeply curved in the latter, that may be interpreted as an ontogenetic variation (i.e., in younger individuals the orbital spaces are relatively larger). The frontoparietal fusion line

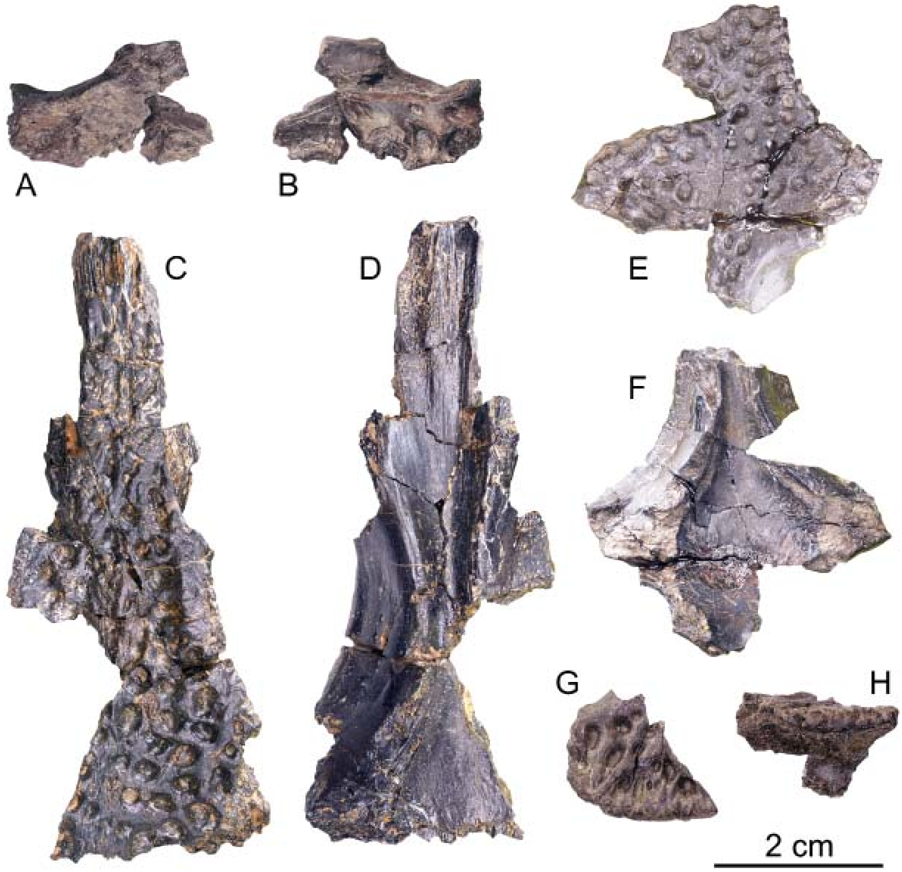

Figure 5. Cf. *Boverisuchus* sp. Left premaxilla (A, B), frontal (C, D), partial frontal + parietal (E, F) and partial supraoccipital + parietal (G, H) in lateral (A), medial (B), dorsal (C, E, G), ventral (D, E) and posterior (H) views.

is transversal and does not enter into the supratemporal fenestra. The reconstructed width of the parietal between the supratemporal fossa appears narrower than that of the interorbital width. The dorsal sculpture consisting of rounded pits on the frontal and parietal is similar, and there is no overhang above the parietal's medial supratemporal margin.

The specimen PJb(Ro)B4Cr-4, represents a fused fragment of a supraoccipital and posterior parietal fragment. The posterior margin of the supraoccipital projects downward into the occipital surface, whereas the dorsal part is exposed as a strongly sculptured, triangular flange, where it is fused anterolaterally with the parietal's posterior process.

Squamosal: The specimen PJb(Ro)B4Cr-5 is a nearly completely preserved squamosal of a large individual, excepting the postero-medial margin of the dorsal side, which is broken off. The dorsal surface is more or less flat and strongly sculptured with rounded or irregular deep pits. The surface of the postorbital-squamosal suture passes medially. The anteromedial margin of the squamosal circumscribes the lateral side of a relatively small supratemporal fossa; the posterolateral corner of the bone appears relatively long and shallowly bent ventrally. In lateral view, the dorsal and ventral rims of the squamosal groove for the insertion of the external ear musculature is more or less parallel, whereas the posterior margin of the otic aperture is flush with the lateral margin of the squamosal's ventral process. The ventral surface displays on the anteromedial part the articulation surface with the quadratojugal, whereas posteriorly the sutural surface with the exoccipital.

Neurocranial fragment: The posteroleft fragment of neurocranium [PJb(Ro)B4Cr-6], preserves a partial exoccipital, a small portion of the basioccipital, a small part of the basisphenoid and a partial quadrate. Despite of numerous cracks and shifts of bony margins that modified the morphology of the cranial surface, several important anatomical features could be identified, as it follows: close to the margin of the foramen magnum a single larger foramen may correspond to the exit of the paired hypoglossal nerves (cranial nerve XII); anteroventrally to the latter structure there is a paired foramina in a common recess, that may correspond to the exit of the glossopharyngeal and vagus nerves (cranial nerves IX-XI); the lateral carotid foramen is situated posteroventrally to the exit of the cranial nerves IX-XI and above to the basisphenoid exposure; the metotic crest in form of a sharp bony lamella extends laterally to the carotid foramen parallel with and closely above the exoccipital-quadrate contact line; the ventral surface of the quadrate ramus bears a prominent knob that serves as an attachment scar to the posterior mandibular adductor muscle.

Quadrate: The fragmentary quadrate [PJb(Ro)B4Cr-7] preserves the right distal quadrate ramus of a mature individual. It exposes an elongated articular surface with the quadratojugal, whereas the passage of the cranio-quadrate canal is preserved in form of a shallow groove starting from the posteromedial margin of the quadrate-exoccipital articulation contact. The foramen aereum is located near the posteromedial margin of the quadrate ramus. The medial hemicondyle is ventrally deflected and somewhat smaller than the lateral hemicondyle. Despite some distortion observed on the dorsal side of the quadrate condyle, the surface of the quadrate is projected dorsally between the hemicondyles.

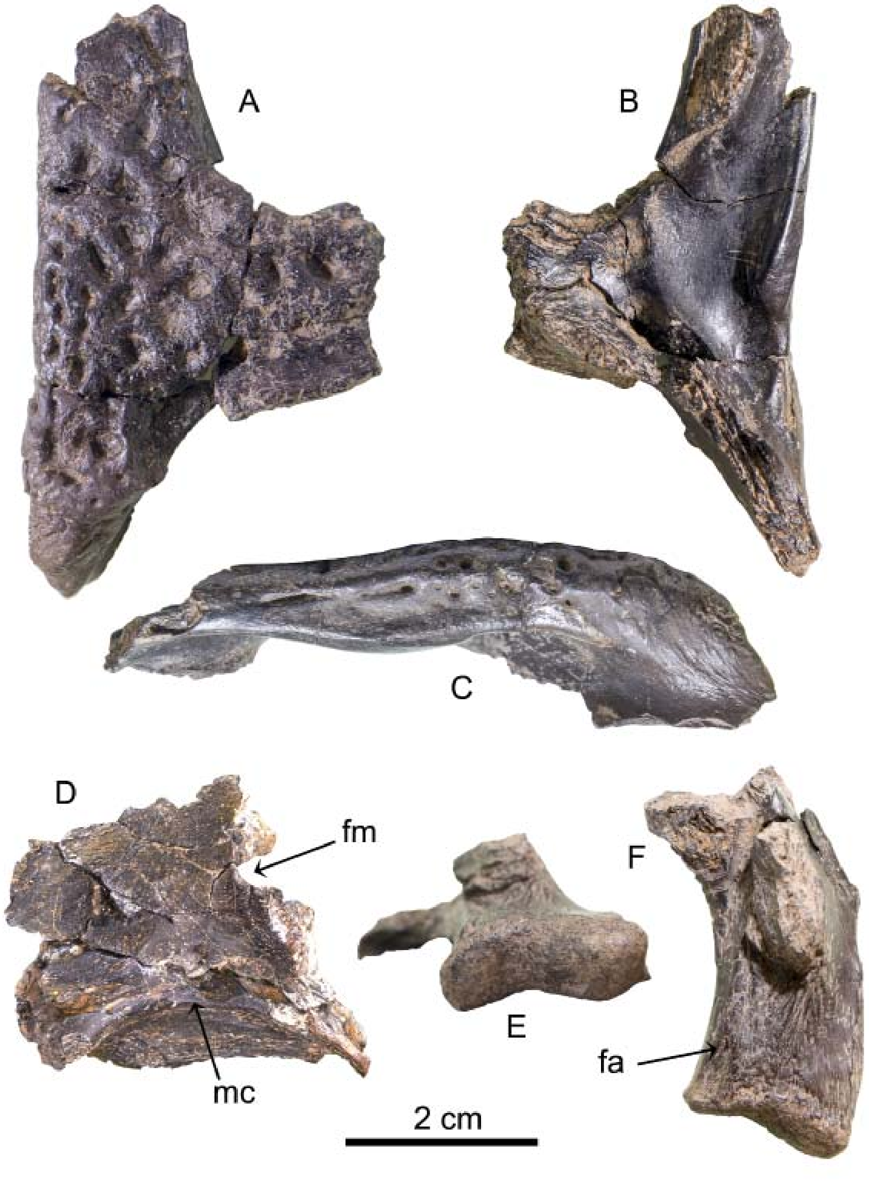

Figure 6. Cf. *Boverisuchus* sp. Left squamosal (A-C), Fragmentary neurocranium (D) and right quadrate in dorsal (A, F) ventral (B), lateral (C) and posterodorsal (D, E) views. Abbreviations: fm - foramen magnum, mc - metotic crest, fa - foramen aereum.

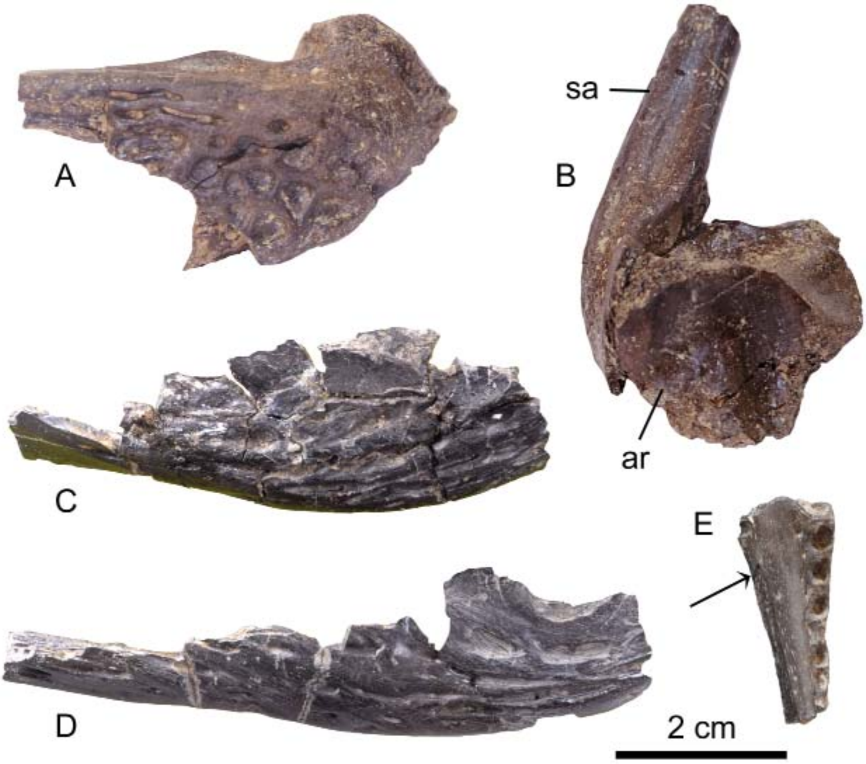

Figure 7. Cf. *Boverisuchus* sp. Partial mandible (A, B), left partial angulars (C, D) and right anterior dentary fragment (E) in lateral (A-C) and dorsal (B, E) views. Abbreviations: ar - articular, sa - surangular; arrow points to the anterior limit of the imprint of the splenial.

Posterior mandible fragment: The specimen PJb(Ro)B4Cr-8, consists of a fragmentary articular and surangular preserving mainly the section with the glenoid fossa. The articulation between the articular and the surangular appears simple, flush against each other with an anteroposterior orientation. The surangular extends dorsally to the tip of the lateral wall of the glenoid fossa delimiting laterally the latter structure. Due to damage, the posterior extent of the surangular remains unknown. The tip of the retroarticular process is damaged, but its remnants suggest that it had a posterodorsal orientation.

Angular: Three fragmentary left angulars [PJb(Ro)B4Cr-9/1-3] were available for study. The specimens are strongly damaged with their labial surface strongly sculptured by a network of elongated grooves; their convex and smooth ventral margin displays several foramina. Each angular preserves a short section of the

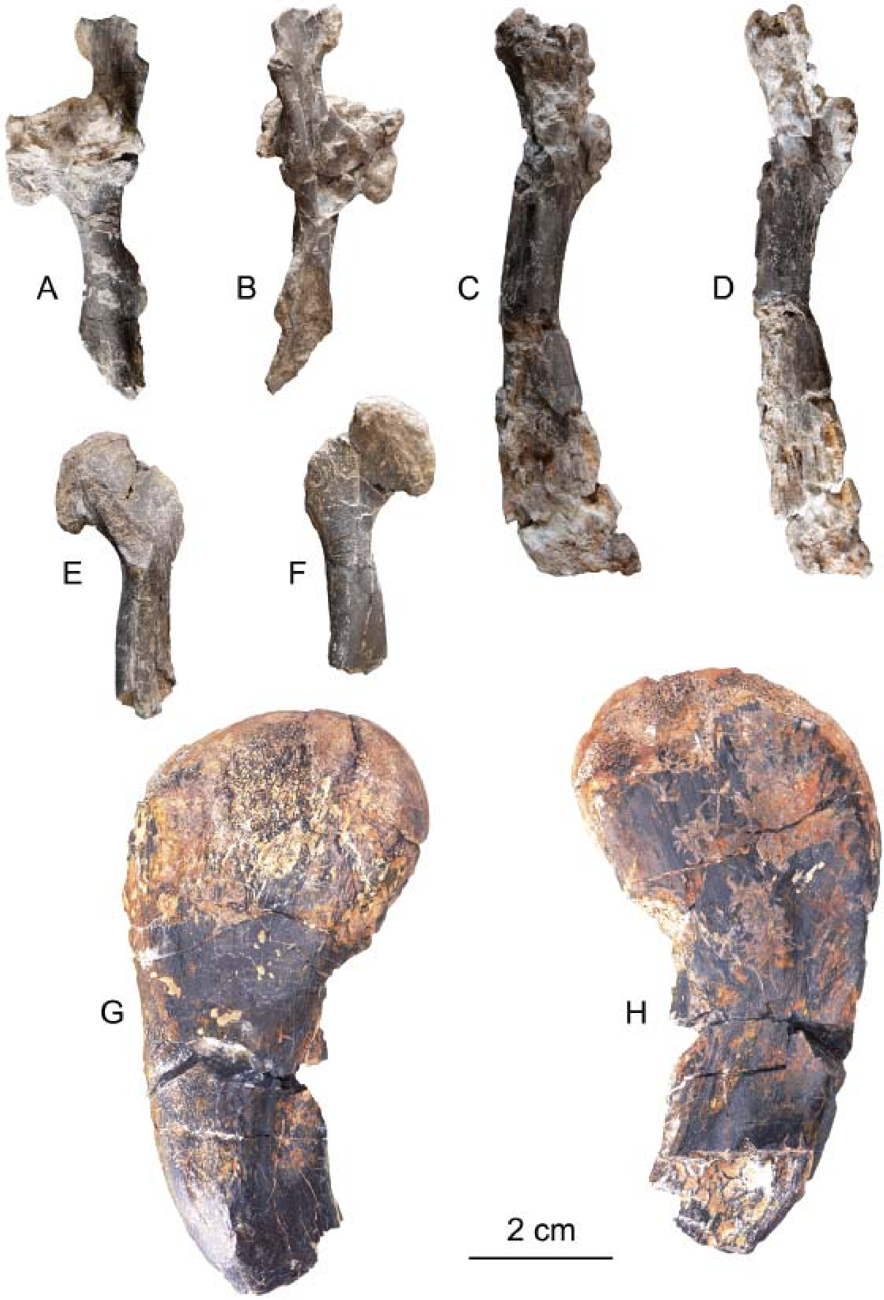

Figure 8. Cf. *Boverisuchus* sp. Right scapulocoracoid (A, B), humerus (C-F) and femur (G, H) in medial (A, D, F), lateral (B, C, E), ventral (G) and dorsal (H) views.

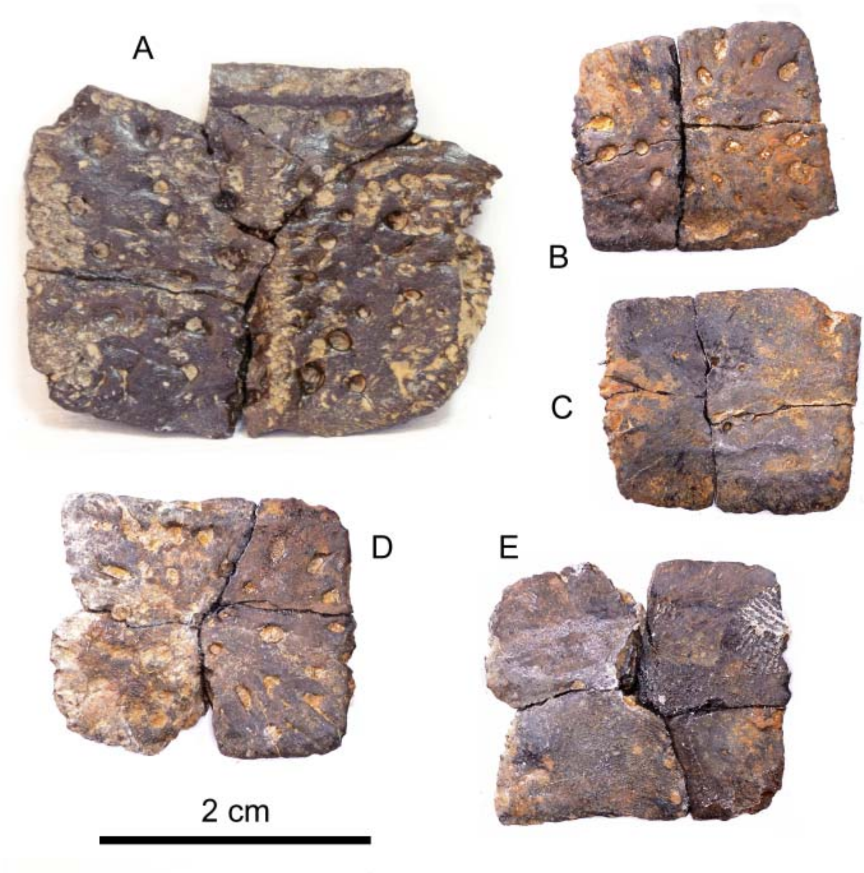

Figure 9. Cf. *Boverisuchus* sp. Dorsal (A) and ventral osteoderms (B-E).

intact external mandibular fenestra suggesting that the external mandibular fenestra was of modest size. Imprints left by the surangular on the dorsal margin of the angulars indicate that the surangular-angular suture contacted the external mandibular fenestra at its posterior angle.

Dentary: The specimen PJb(Ro)B4Cr-10 represents a fragmentary right anterior part of a dentary that might have belonged to an immature individual; the anteriormost margin with the symphysys, the posterior shaft and the medial margin are broken off. Anteriorly, the dentary is widened bearing on its mediodorsal limit the imprint of the splenial and ventrally to the latter the lateral margin of the Meckel's groove. Six alveoli are preserved in the specimen, of which the posteriormost two are nearly confluent. The dorsal surface of the dentary lacks any sign of occlu-

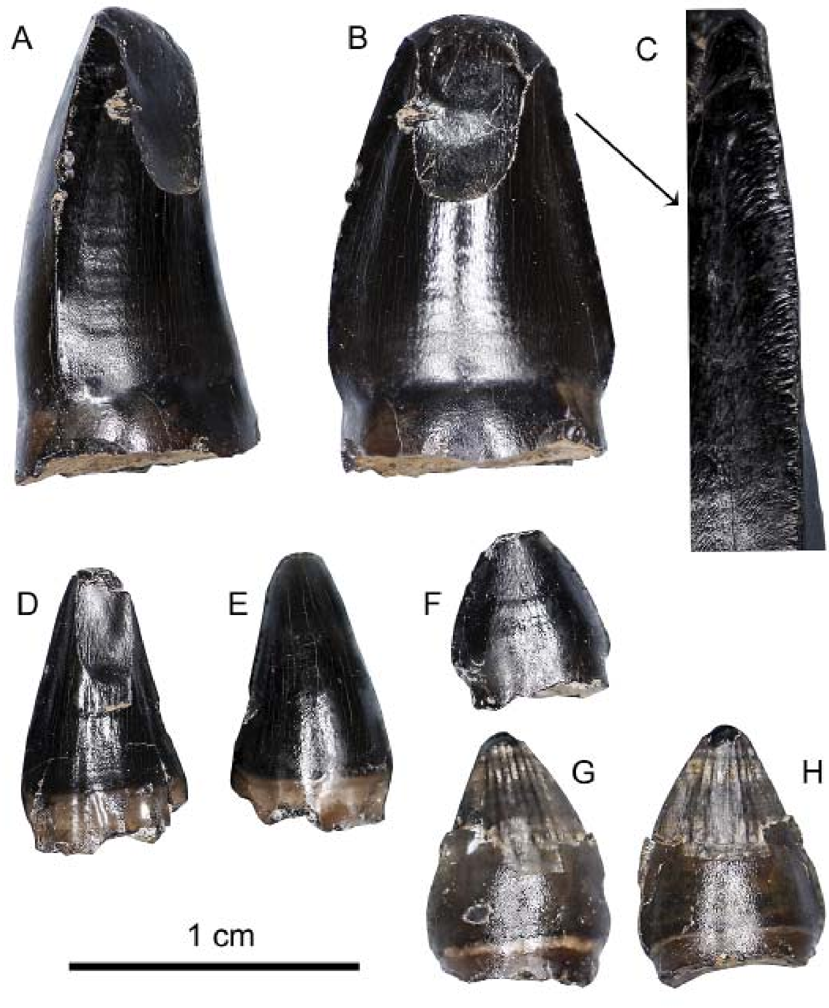

Figure 10. Cf. *Boverisuchus* sp. Isolated teeth. Arrow points to tooth carina with enlarged view preserving finely serrated margin.

sion from the premaxillary or maxillary teeth. The tooth row appears linear and the alveoli have a moderate labiolingual compression. In the second alveolus a replacement tooth is preserved with its crown compressed laterally and provided with smooth mesiodistal carinae.

Vertebrae: The available vertebrae are strongly damaged preserving various parts of the procoelous centrum, neural arch and apophyses.

Scapulocoracoid: In lateral view, the right scapulocoracoid specimen [PJb(Ro) B4Cr-11] is positioned vertically being readjusted from its originally angled position during the taphonomic process. The scapular blade is broken off distally but its remnants suggest that it flared dorsally, whereas the deltoid crest of the scapula appears relatively wide and twice longer than the diameter of the glenoid fossa. The scapulocoracoid facet anterior to the glenoid fossa appears uniformly narrow. The coracoid also flares distally with a distinct ridge on its lateral surface.

Humerus: The two available specimens preserve rather limited morphological information. PJb(Ro)B4Cr-12/1 has both its extremities strongly crushed with the deltopectoral crest also slightly deformed. However, the latter structure suggests that the deltopectoral crest was well-developed emerging abruptly from the humeral proximal end. PJb(Ro)B4Cr-12/2 preserves its proximal end only, but the deltopectoral crest is completely broken off.

Femur: The proximal part of a sigmoid shaped left femur [PJb(Ro)B4Cr-13] may have belonged to an extremely large, mature individual. A deep pit on the dorsal side of the proximal epiphysis connected to several fracture lines may represent a bite mark produced by scavengers. The fourth trochanter on the ventral side is relatively short and prominent, flanked by a deep pit serving as the insertion surface for the M. pubo-ischio-femoralis internus.

Osteoderms: The dorsal osteoderms are more or less rectangular and provided with a prominent keel; the dorsal sculpture consists of deep rounded pits of various sizes. The anterior margin is smooth lacking any trace of convexity or embayment; the ventral surface is also smooth. The ventral osteoderms appear single and lacking a ventral keel. However, on some osteoderms a short thickening of the ventral surface is present. The sculpture consists of rounded or elongated pits, distributed irregularly on the ventral surface.

Isolated teeth: The main character of the available teeth is that their tooth crowns are mediolaterally compressed and provided with mesiodistal keels that frequently bear finely serrated margins. Three morphotypes have been identified: 1) the caniniform morphotype, that is large and shallowly curved, three to four times higher than wide at its base, and provided with mesiodistal keel bearing finely serrated edges; sometimes the cutting edges remain smooth; 2) the lanceolate morphotype, that is moderately high, the mesiodistal carinae are more or less symmetrically developed preserving variably fine serrations and 3) the low crowned morphotype, that is compressed mediolaterally and is wider than high; the mesiodistal carinae are present but usually do not preserve serrated margins. The tooth base, preserved in few specimens, is slightly constricted and below that point is of the same width as the tooth crown. However, from a morphological viewpoint some tooth specimens can be of intermediate form, as it is well presented in Fig. 10, where for instance specimen A-B is not typically "caniniform" and the "low crowned" specimen G-H is actually higher than wide.

Comparisons and comments

In the premaxilla of Planocraniidae the distribution of the occlusal pits is different in the European members (i.e., in *Boverisuchus magnifrons*, the dentary teeth occluded between the premaxillary alveoli) and in those of American members (i.e., in *B. vorax* the occlusal pits are situated lingually to the premaxillary alveoli; Brochu, 2013) with the exception of the Uintan planocraniid, where the occlusal pits are positioned between the alveoli (Busbey, 1986; Brochu, 2013). If our interpretation is correct, the morphology of the Jibou planocraniid should be intermediate between those of European and American members.

The frontal and parietal appear as azygous bones without signs of sagittal crests or division on their dorsal surfaces. As noted by Langston (1975), persistent median division is apparent between the paired frontals and parietals in *Boverisuchus vorax* (at least in FMNH PR 399). Upturned orbital margins, observed in both the available frontal specimens from Jibou are similar to members of *Boverisuchus* and *Planocrania datangensis*, but this condition is lacking in the earliest gavialoids, crocodyloids and alligatoroids (Brochu, 2013). The presence of palpebrals has been documented by Li (1976) in *Planocrania datangensis*, but there is no sign of articulation surface on the frontals from Jibou. Nevertheless, we cannot exclude the presence of palpepbrals in the Jibou specimens, because these bones should have been in contact mainly with the prefrontals, as demonstrated by the type material of *P. datangensis* (Li, 1976: fig. 1). On the anterior process of the larger frontal specimen, the exposed articular surfaces for the prefrontals and nasals indicate that the prefrontals were largely separated by the frontal. On the other hand, the frontal is excluded from the supratemporal margins by the parietal and postorbital. Larger dorsal exposure of the supraoccipital in the PJb(Ro)B4Cr-4 specimen may be reminiscent of *Boverisuchus magnifrons* (Kuhn, 1938), nevertheless, the parietal was not excluded by the supraoccipital from the posterior margin of the skull table.

In the dentary fragment the presence of the imprint of the splenial indicates that it did not contact the mandibular symphysis and the Meckel's groove passed below the anterior limit of the splenial. In the members of *Boverisuchus* and *Planocrania datangenis* the splenials are in contact medially, whereas in *P. hengdongensis* the splenial does not extend to the mandibular symphysis (Brochu, 2013).

The scapulocoracoid specimen preserved both the scapula and the coracoid and their proximal bony surfaces indicate that these were not completely ossified. Nevertheless, lithostatic pressure aligned the bones from their original angled position. The scapulocoracoid facet appears uniformly narrow anterior to the glenoid fossa.

The dorsal osteoderms possessed dorsal keels, but their anterior margins were smooth and without an anterior lamina, similar to alligatoroids, crocodyloids and planocraniids (Brochu, 2013). All the available ventral osteoderms represented single units without signs of suture at their margins. Composite ventral osteoderms are typical in the members of some alligatoroids, like *Diplocynodon* (Rio et al., 2020).

The isolated teeth are highly variable in shape and size, but all are laterally compressed and provided with finely serrated edges on their mesiodistal keels. On the other hand, many specimens possess strongly worn keels or apical margins and the serrated edges are not preserved. The serrations are highly variable and irregular and always significantly smaller than those seen in the members of *Boverisuchus* (Brochu, 2013). The presence of serrated edged teeth have been reported in *Planocrania datangensis* (Li, 1976: fig. 2) and also in *P. hengdongensis* (Li, 1984), but as stated by the latter author, these are less evident on the mesiodistal keels and are usually lacking from the apical part of the tooth crowns. This condition seems to be present in the Jibou specimens. Probably, the earlier identification of "*Doratodon*" from the Rona Limestone Member of Jibou by Gheerbrant et al. (1999) was based mainly on the ziphodont nature of the recovered isolated teeth.

Paleobiogeography

The presented fossil material is of peculiar interest, since Planocraniid remains have never been signaled from Eastern Europe, while taking into account the geological age of the Jibou Formation, where our fossils originated from, we can pronounce it being one of – if not the oldest European apparition of the group.

Li (1976, 1984) assigned the type species of *Planocrania*, from the Paleocene Nongshan Formation, Nanxioing sedimentary basin and the lower Lingcha Formation's Paleocene deposits in the Hengdong sedimentary basin, from China. The Lingcha Formation is composed of fossiliferous red-bed deposits with a fluvial aspect, which shows similarities with the Transylvanian Jibou Formation's red-beds. While the Chinese deposits yielded numerous well-preserved, complete cranial bones, our material from Jibou is rather fragmentary, which somewhat affects the observation of morphological characters.

Other ziphodont crocodile teeth have been reported from the Paleocene-Lower Eocene of Northern India (Panadés I Blas et al., 2004; Gupta and Kumar, 2013), the Eocene of South Nepal (Sah and Schleich, 1990) and Kazakhstan (Rossmann, 1998). The only intermediary area where planocraniid remains have been discovered and which seems to connect Asia to Western Europe through its similar aged fossiliferous sedimentary deposits and similar fossil remains is the Transylvanian region (Gheerbrant et al., 1999; Gaudant et al., 2005; De Lapparent et al., 2004). In Western Europe Planocraniid remains were found in the Middle Eocene (Lutetian, possibly also the Paleocene) of Germany, the Lutetian of Italy, the Eocene of France (Brochu, 2013; Kotsakis et al., 2004) and some remains that could possibly belong to the same group, from the Paleocene of Belgium (Groessens-Van Dyck, 1986). Regarding Northern America, relative fossils originate from the Bridgerian (Ypesian-Lutetian) of Wyoming, with appearances of extremely fragmented remains throughout the Paleocene-Uintan (Lutetian). The oldest presence of a Planocraniid in America has been recorded in the basal Paleocene of the Bighorn Basin, from the Puercan Mantua Lentil, based on a single ziphodont tooth assigned by Bartels (1980), while sadly the tooth has not been illustrated, today it is considered lost, as stated by Brochu (2013). Other planocraniid fossils have been signaled from the Eocene of Western Texas (Busbey, 1986), some problematic materials have been reported from Australia and Africa, while other ziphodont crocodylid remains originate from the Eocene of Jamaica (Brochu, 2013).

Regarding the origin and dispersal of Planocraniids, one of the possible scenarios refers to the much discussed and largely accepted Asiatic origin of the group, where they migrated from towards Europe, North America and later to India, in the Paleocene. Scotese (2014) has remarkably useful paleogeographic maps for the Danian and Thanetian (55.8 Ma) illustrating water to landmass ratio at +40m and +120m ocean level. From his illustrations we conclude two possible migration routes, especially at times when ocean levels were low and landmasses arose from the water, creating continental bridges and dispersal routes for various tetrapods, including crocodiles. Both of our speculated routes start in Asia and extend towards Europe. While the first one follows a northern path, across the – at the time closed – Turgai Strait (Western Siberia) which permitted passage of land fauna towards Northern Europe and later towards Southern Europe (France and Italy). The second scenario envisions a southern path, again starting from Asia, but this time, from the South-Western side with continuation on an elongated insular type archipelago, with a North-West direction, towards the region of today's Turkey, continuing towards Bulgaria, the ex-Jugoslavian countries, then to the West, towards the Alps and Italy. The latter is the pathway that could have intersected the present Transylvanian Depression.

Paleoecology

Even though postcranial remains are quite scarce for the presented material, the cranial morphological characters allow us to believe that the planocraniid crocodile from Jibou-Rona was acquainted with terrestrial locomotion, rather than supporting aquatic adaptations. We assimilate this supposition of the Planocraniid etiology to their known hoof-like limb extremities instead of them being claw-like and a general rather slender build. Based on this strong physiological factor, we can suppose that individuals were capable of quick terrestrial locomotion, maybe even running after their prey while on the hunt.

The diet of these organisms remains yet obscure, but if we are referring back to the Paleocene fauna of Jibou, it should not be hard to imagine that these planocraniid crocodiles could have feasted on small sized terrestrial tetrapods like multituberculates (eg. *Hainina*), small reptiles like lizards and even chelonians (eg. *Ronella botanica* – proved by some unpublished bite marks). There are no proofs yet, but we should not ignore the possibility that the crocodiles could have made short incursions into the Rona Lake, and they could have completed their diets with amiid fish. In the absence of evidence regarding this matter, this detailed supposition is nothing but guessing, as of yet.

For the Paleocene of Transylvania, a warm, subtropical climate was characteristic (showed by a study of pollen and spores by Petrescu and Codrea, 2003 a,b), with specific fauna composed of Juglandaceae and Fagaceae in the proximity of the Rona Lake. The subtropical type climate could have permitted the development of serious floods, which could have been responsible for the transportation of fossil material in the lacustrine basin, since the crocodiles most likely lived in the lake's proximity. The fragmented aspect of the presented material undoubtedly indicates transportation of the bones before deposition of sediments and fossilization.

Concluding remarks

Abundant fragmentary cranial and postcranial remains of eusuchian crocodyliforms, recovered from the fossil locality of Jibou, suggest that all these isolated bones may have belonged to a single planocraniid taxon. This group of crocodylians is for the first time identified in Romania, while it represents one of the geologically earliest fossil records in Europe. The only other Paleocene occurrence from Europe is a possible planocraniid, which has been reported from the Paleocene of Walbech, Germany (Berg, 1969).

The planocraniid crocodyliforms from the Paleocene of Jibou complete the list of a peculiar terrestrial vertebrate assemblage that included dortokid turtles (*Ronella botanica*), multituberculates (cf. *Hainina*), palaeoryctid proteutherians (*Aboletylestes*), hyopsodontid condylarthrs (cf. *Paschaterium*), undetermined eutherian mammals, anurans, lizards and possible snakes (Gheerbrant et al., 1999). The occurrence of ostracodes and gastropods closely associated with limnic environments, along with teleostei fish, dortokid turtles and crocodiles (Gheerbrant et al., 1999), suggest the presence of freshwater habitats in the area, where the crocodiles might have acted as top predators.

The presence of planocraniid crocodyliforms in the Paleocene of Romania represent an important paleogeographic link between the Chinese, European and American occurrences. Nevertheless, the planocraniid from Jibou shows closer affinities to Chinese planocraniids (e.g. finely serrated teeth in the Chinese and Romanian forms vs. more robust serrations in the European and American *Boverisuchus*), and it may represent a new taxon.

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Sporadic notes on the land snail (Gastropoda) fauna of the North Bihor Mountains, Romania

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Abstract: During a sum of fifteen-day fieldwork in 2007, 2008, 2009, 2010 and 2015 in the North Bihor Mountains, we collected 258 samples of 62 terrestrial and freshwater snail and a bivalve species. *Drobacia banatica*, *Ruthenica filograna*, *Strigillaria vetusta*, *Vitrina pellucida* were found to be relatively frequent. However, *Alopia bielzi*, *Cochlodina marisi*, *Ena montana*, *Merdigera obscura*, *Euomphalia strigella*, *Fruticola fruticum*, *Laciniaria plicata*, *Orcula jetschini*, *Aspasita triaria* are considered rare.

Keywords: constancy, distribution curves, manual singling, mass sampling, number of individuals, Mollusc fauna

Introduction

The Bihar Mountains (Munţii Bihorului) are the most prominent and highest part of the Apuseni Mountains in the Western Romanian Carpathians. That mountain range comprises of the Codru Moma Mountains in the west, the Pădurea Craiului Mountains in the northwest, the Vlădeasa in the northeast, and the Gilău Mountains in the east. Its highest peak is Cucurbăta Mare (1849 m a.s.l.). The northern part mainly consists of karst-forming limestone, whereas the southern part consists of crystalline shales. The two subunits are separated by the Arieş and Crişul Băiţa Valleys.

The massif is part of Apuseni Natural Park, it is 25 km long from northwest to southeast, and has a width of 14 km. The area is characterized by an extraordinary diversity of karstic formations, such as caves, canyons and gorges. The Padiş–Cetăţile Ponorolui karstic plateau, with its 54 km² limestone outcrop, is a significant exokarst formation in Europe (Ponta 1998, Ponta & Onac 2018).

The annual rainfall in the Bihor Mountains reaches 1400 mm. The mean annual temperature is 2°C. The average in January is between -5 and -9 °C, and in July ranges between 8 and 16 °C. The Bihor Mountains are the source of the rivers Someșul Cald, Crişul Negru, Crişul Pietros and Arieş.

Although the species diversity is high, the area has not been investigated intensively yet. Data on malacofauna were published in monographs of Csiki (1918), Soós (1943) And Grossu (1981, 1983, 1987), and in some additional papers by various other authors (Mocsáry 1972, Lupu 1966, Varga 1983, Boeters, et al. 1989, Bába & Sárkány-Kiss 1999, 2001, Sîrbu & Benedek 2004, Domokos & Váncsa 2005, Sîrbu 2006, Váncsa 2006, Falniowski et al. 2009, Ferhér et al. 2009, Lengyel & Páll-Gergely 2010, Deli & Domokos 2011, Deli & Subai 2011, Domokos 2013, 2015, 2016, Farkas & Deli 2015, Domokos & Lennert 2016, Domokos et al. 2018).

Material and method

Snail specimens were collected by manual singling (S) and mass sampling (M – 3dm³). At one occasion, flotsam material of ca. 2 litres was collected from the Sighiştel brook. Apart from this, aquatic molluscs were only occasionally collected.

The collected shells were cleaned and dried, and were identified based on their morphology using the following sources: Soós (1943), Grossu (1981, 1983, 1987, 1993), Kerney et al. (1983), Richnovszky & Pintér (1979), Deli & Subai (2011), Nordsieck (2007), Welter-Schultes (2012).

The nomenclature of check list was composed following MolluscaBase (*http://www.molluscabase.org*). Shells are deposited in the private collection of the senior author.

Description of the sampling sites in chronological order

Between 2007 and 2015, 25 sites were sampled in Apuseni Mountains Natural Park:

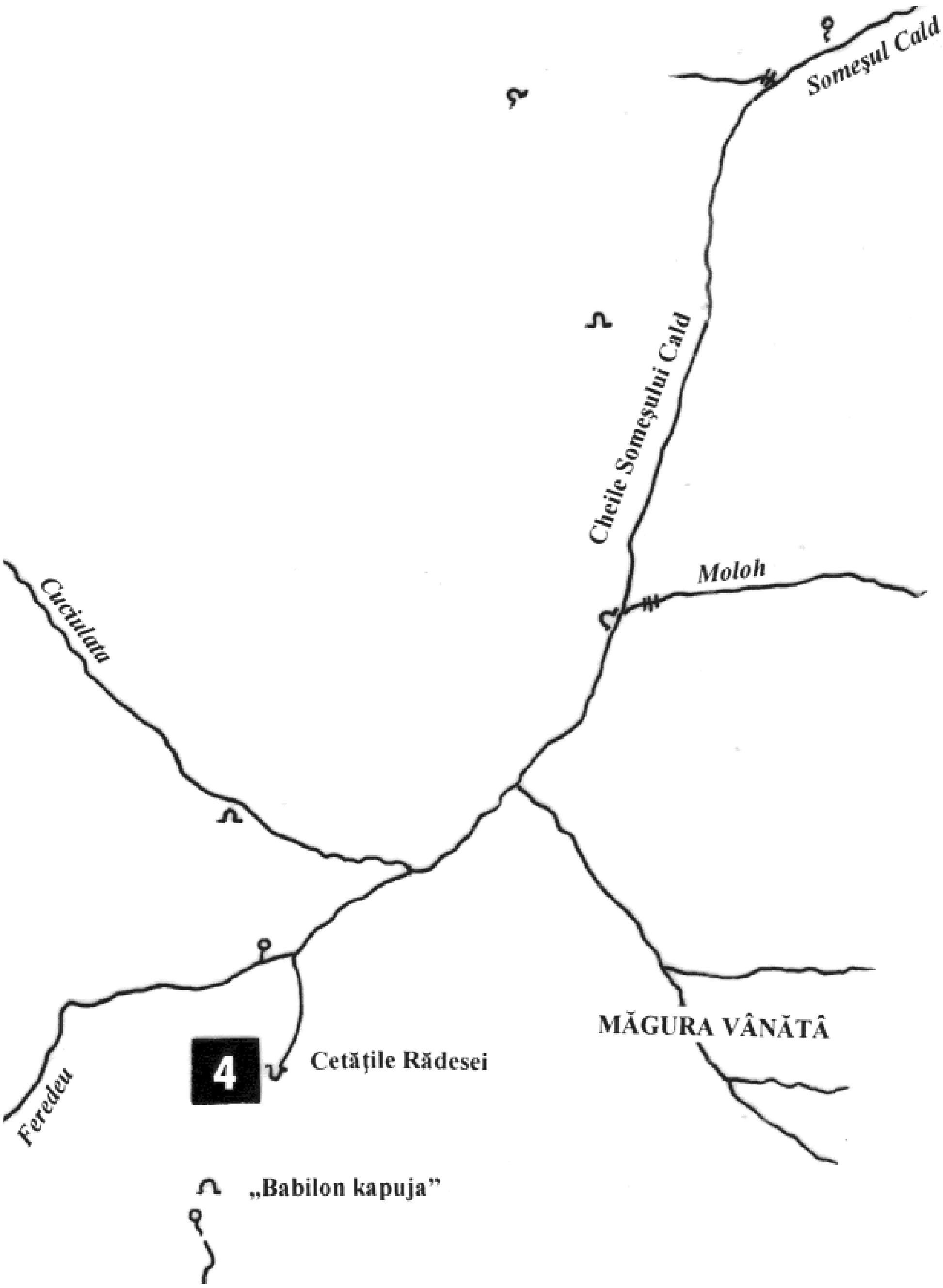

Figure 1. Hydrographic sketch map of sampling sites in the North Bihor Mountains (see text).

1. Alba county, Gârda de Sus, Peştera Gheţarul de la Scărişoara, 1060 m a.s.l., western side of pothole entrance, detric rock covered by moss and forest litter (M), 5. IV. 2007.
2. Bihor county, Pietroasa, Vale Bulz, Left side of the brook, 540 m a.s.l., under bushes (S), 10. VI. 2007.
3. Bihor county, Pietroasa, Cetăţile Ponorolui, cave near Dolina 3., 1000 m a.s.l., moss and forest litter-covered cliffs facing north and south (M), 11. VI. 2007.
4. Bihor county, Cheile Someşului Cald, „Babilon kapuja", 1250 m a.s.l., stones facing south, and ground covered by great burdock (S), 12. VI. 2007.
5. Bihor county, Pietroasa, gorge east of Cabana Cetăţile Ponorului, 1050 m a.s.l., stones (S), 12. VI. 2007.
6. Bihor county, Pietroasa, Valea Seacă, rock wall west of Cabana Cetăţile Ponorului, 1050 m a.s.l., forest litter and moss (S), 13.VI. 2007.
7. Bihor county, Pietroasa, Izbuc Ponor, 1140 m a.s.l., hill-side facing northeast, covered with decaying plant material (S), 13. VI. 2007.
8. Bihor county, Pietroasa, Valea Brădeţanului, 0.5 km N of the Izbuc Ponor, 1200 m a.s.l., the left side of the brook, great burdock-covered bank, (S), 13. V. 2007.
9. Bihor county, Sighiştel, Cheile Sighiştelui, around a cave-spring, 380 m a.s.l., rock ledges covered by forest litter and moss (M), 29. IX. 2007.
10. Bihor county, Pasul Vârtop, 1230 m a.s.l., 7 km W of the settlements Arieşeni, dell leading to Groapa Ruginoasa, great burdock near the current (S), 29. IX. 2007.
11. Bihor county, Chişcău, cliff wall near Peştera Urșilor (cave) (S) VII. 2008.
12. Bihor county, Pietroasa, Staţiunea Boga, downhill near Cascada Oşel (S), (leg. Sarkadi, L.) VIII. 2008.
13. Alba county, Gârda de Sus, Valea Ordâncușa, Poarta lui Ionel, ca. 800 m a.s.l., great burdock, moss (S) (leg. Sarkadi L.) X. 2008.
14. Bihor county, Chişcău, near ramp of the Peştera Urșilor (cave), 482 m a.s.l., hillside faces north, covered by rock-vegetation, occasionally with bushes, (M), 9. IV. 2009.
15. Bihor county, Chişcău, rock-glacier leading to the Peştera Urșilor (cave), in the vicinity of the ramp, 470 m a.s.l., (S). 9. IV. 2009.
16. Bihor county, Pietroasa, Valea Bulzului, Piatra Bulzului, 580 m a.s.l., south-exposed rock wall, woody and shady biotope with humid leaves (M), 1. XII. 2009.
17. Bihor county, Pietroasa, Staţiunea Boga, downhill near Peştera Dracului, humid leaf litter, (M), 1. XII. 2009.
18. Alba county, Gărda de Sus, Peştera Gheţarul de la Scărişoara, 1060 m a.s.l., western side of the path leading to the cave, detrital rock covered by moss and forest litter, (M), 25. IV. 2010.

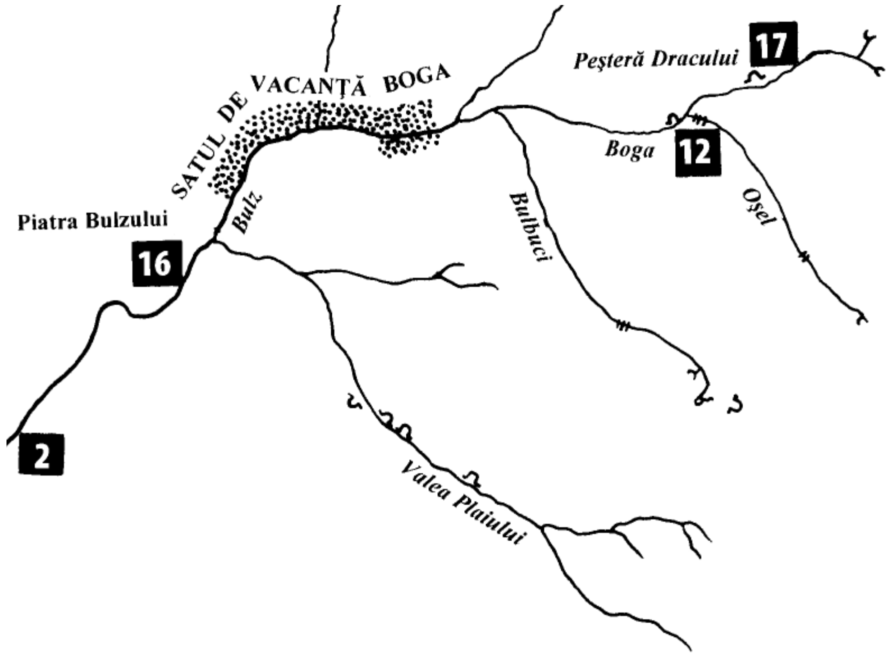

Figure 2. Hydrographic sketch map of sampling sites in the North Bihor Mountains (see text).

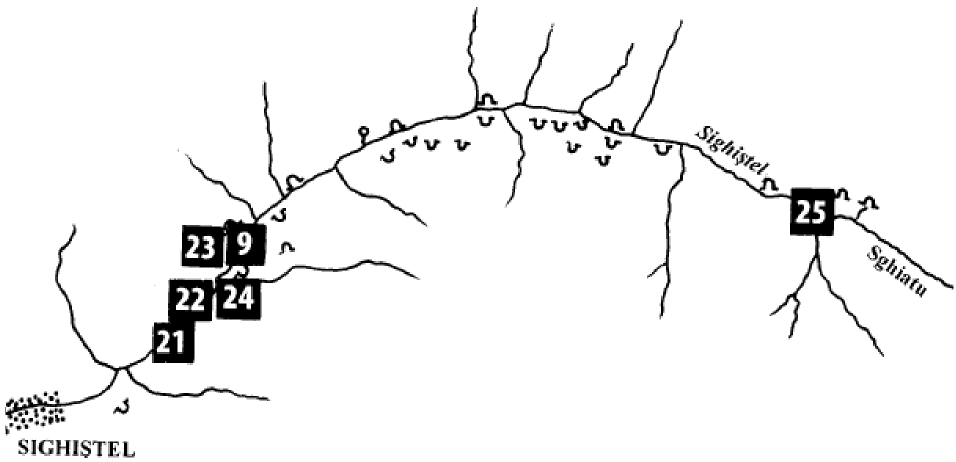

Figure 3. Hydrographic sketch map of sampling sites in the North Bihor Mountains (see text).

19. Bihor county, Chișcău, Giuleşti, under Dealul Vârsecilor, Valea Seaca after confluence with Ţiganul (brook), 800 m a.s.l., base of rock wall, beech forest, humid leaf litter (S), 6. XI, 2010.

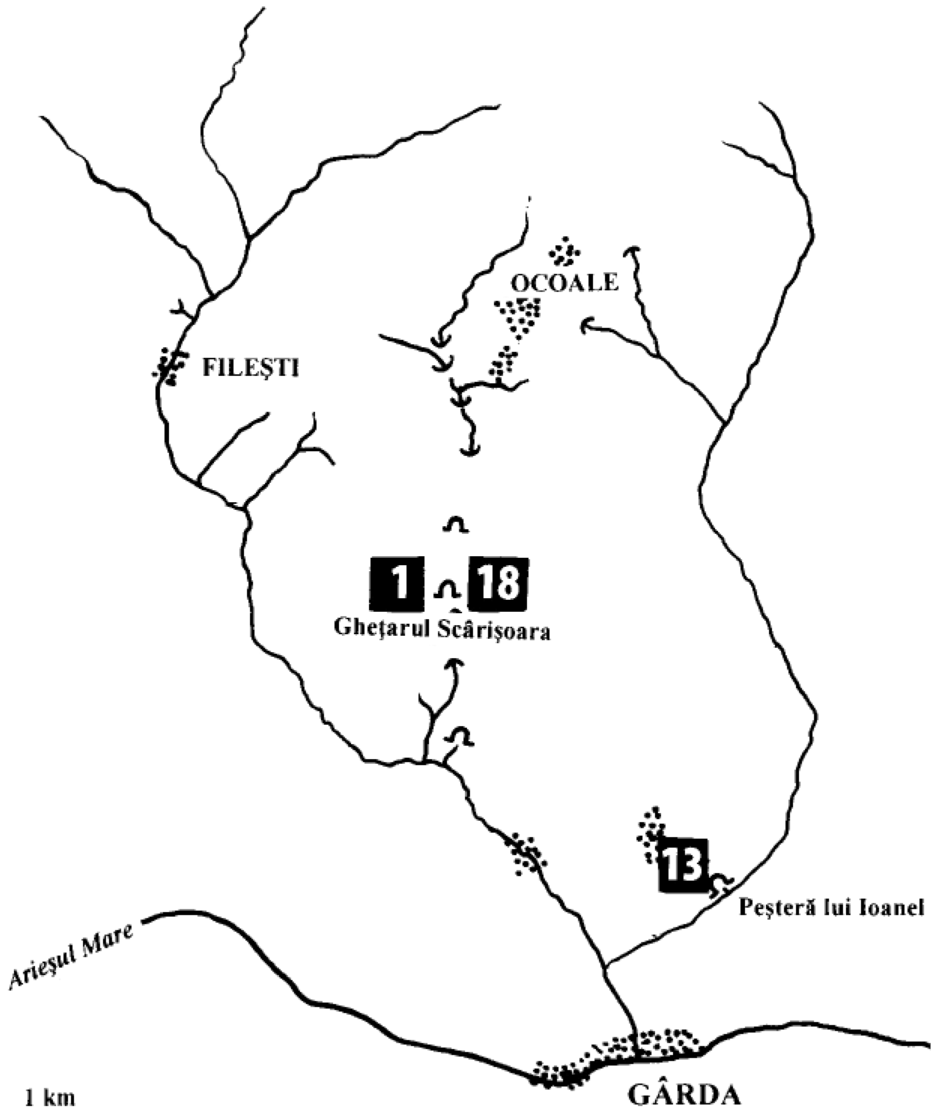

Figure 4. Hydrographic sketch map of sampling sites in the North Bihor Mountains (see text).

20. Bihor county, Chișcău, Giuleşti, Valea Nucşoara, rock-glacier, 1000 m a.s.l., wet and shady biotope (M),6. XI. 2010.

21. Bihor county, Sighiştel, Cheile Sighiştelului, banks of the brook at the beginning of the gorge (S), 7. XI. 2010.

22. Bihor county, Sighiştel, Cheile Sighiştelului, flotsam material collected at begin-

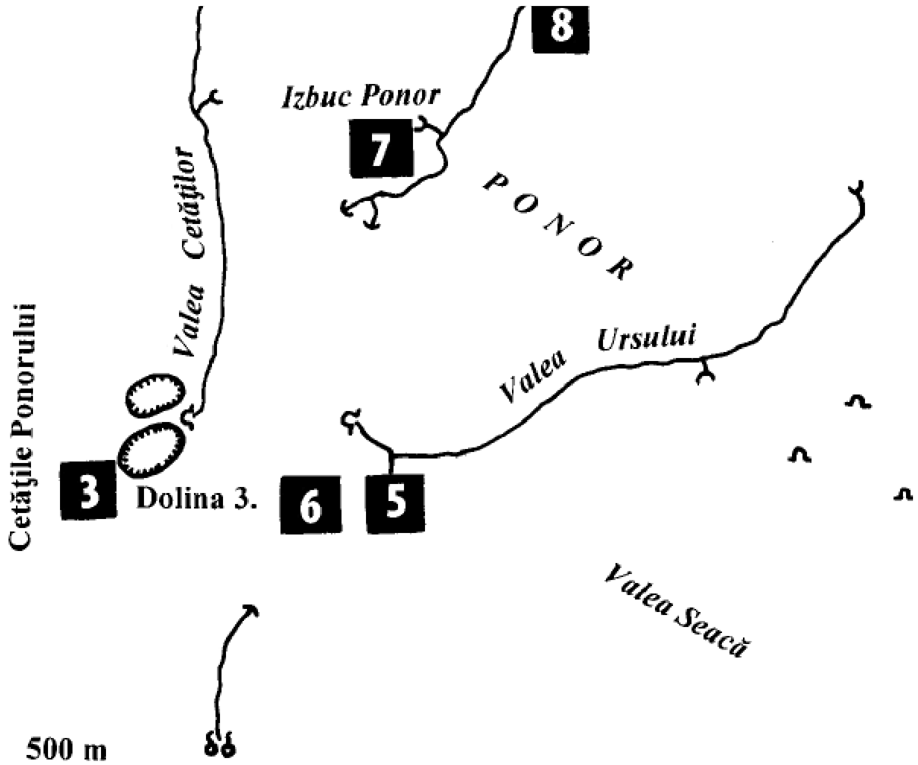

Figure 5. Hydrographic sketch map of sampling sites in the North Bihor Mountains (see text).

ning of gorge, 7. XI. 2010. 10. Quantity of the sample: 2 dm³.

23. Bihor county, Sighiştel, Cheile Sighiştelului, base of southeast-exposed rock wall at beginning of gorge, 380 m a.s.l., , beech, hornbeam (M), 7. XI. 2010.

24. Bihor county, Sighiştel, Cheile Sighiştelului, base of northwest-exposed rock wall at beginning of gorge, 380 m a.s.l., beech, hornbeam (M), 7. XI. 2010.

25. Bihor county, Sighiştel, Cheile Sighiştelului, 600 m from end of gorge 600 m a.s.l., great burdock (M) 13. IX. 2015.

Results and discussion

Our investigations resulted in 62 species: 58 terrestrial snails, four freshwater snails and one bivalve. Altogether 258 samples were collected (see checklist and Tables 1./A, 1./B, 2/A, 2/B). Some rare and interesting species were found, such as *Alopia bielzi*, *Aspasita triaria*, *Cochlodina marisi*, *Ena montana*, *Merdigera obscura*, *Euomphalia strigella*, *Fruticicola fruticum*, *Laciniaria plicata*, and *Orcula jet-*

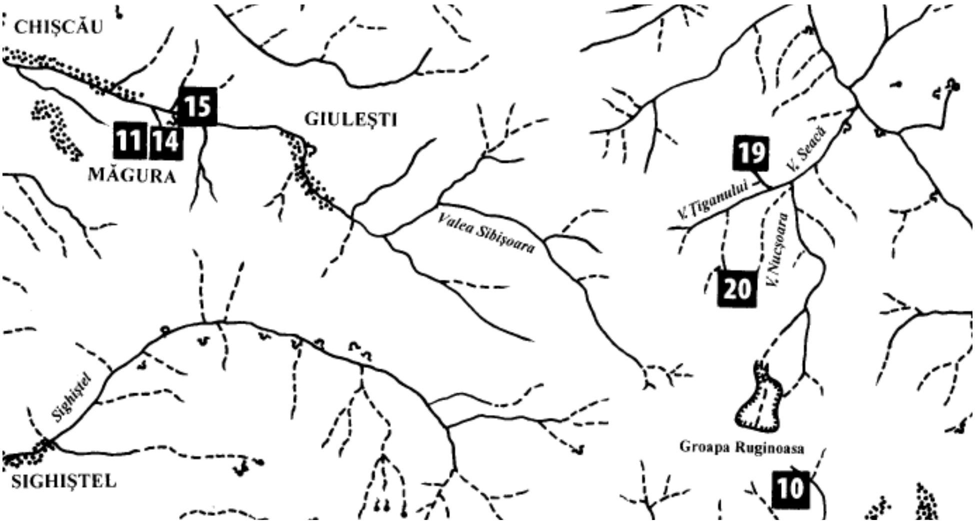

Figure 6. Hydrographic sketch map of sampling sites in the North Bihor Mountains (see text).

schini. Drobacia banatica, *Ruthenica filograna*, *Strigillaria vetusta* (Figs. 7–10.), and *Vitrina pellucida* are relatively frequent in the northern Bihor Mts.

Based on the collected specimens it could be stated that the following species are very variable in terms of shell morphology: *Drobacia banatica* (Fig.11.), *Granaria frumentum*, *Ruthenica filograna*, *Strigillaria vetusta* (Lengyel & Páll-Gergely 2010, Domokos 2013, 2016).

Annotated checklist of the molluscs of the Bihor Mountains

CLASS GASTROPODA

SUBCLASS PULMONATA

Aciculidae

Platyla banatica (Rossmässler, 1842)

Platyla microspira (Pini, 1884)

Platyla polita (W. Hartmann, 1840)
All these species are reported by Lengyel & Páll-Gergely (2010).
Of the three species only *P. microspira* was relatively frequent (constancy: 24%, number of collected individuals: 34), collected from Cheile Sigiştelului (380 m a.s.l.) and Peştera Gheţarul de la Scărişoara (1060 m a.s.l.).

Arionidae

Arion circumscriptus G. Johnston, 1828
In absence of living individual anatomical examination is not possible, therefore this species was identified on the basis of morphology and colour.

Camaenidae

Fruticicola fruticum (O. F. Müller, 1774)
Very rarely examined in the region by the present author. This species was collected only from rock-glacier in Valea Nucşoara.

Chondrinidae

Chondrina arcadica clienta (Westerlund, 1883)

Granaria frumentum (Draparnaud, 1801)

Clausiliidae

Alinda biplicata (Montagu, 1803)
It is a relatively rare species (number of collected individuals: five, constancy: 12,5%) here and elsewhere in Romania (Lengyel & Páll-Gergely 2010, Miklós Szekeres, pers. comm.).

Alinda stabilis (Pfeiffer, 1847)

Alopia bielzii (Pfeiffer, 1849)
An isolated occurrence of the subspecies *Alopia bielzi tenuis* (E.A. Bielz, 1861) was found on the south-southwestern cliffs of the Piatra Bulzului (Deli & Domokos 2011)

Cochlodina laminata (Montagu, 1803)

Cochlodina marisi (A. Schmidt, 1868)

Laciniaria plicata (Draparnaud, 1801)

Ruthenica filograna (Rossmässler, 1836)
This species is frequent in the Western Carpathian Mountains (Domokos 2015, Domokos & Lennert 2007, 2009, Domokos, Lennert & Márton 2010, Erőss

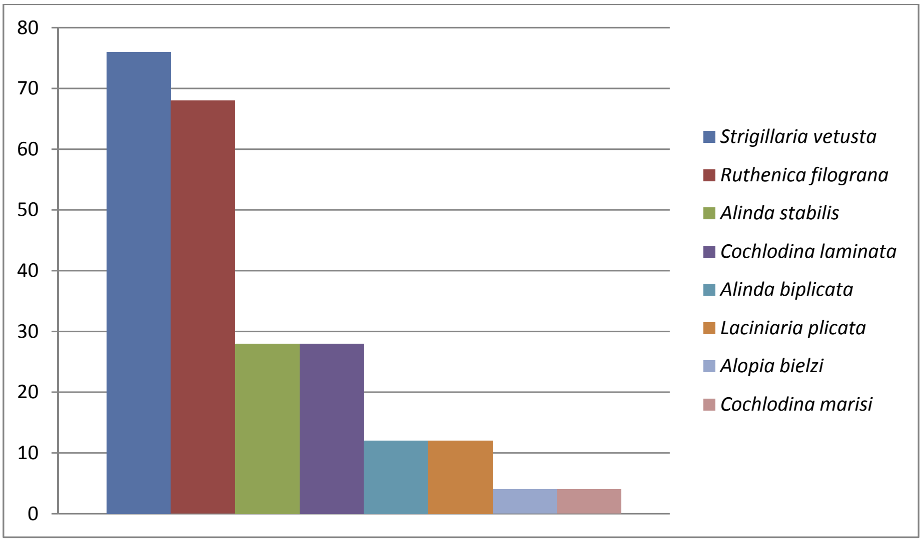

Figure 7. Number of individuals of clausiliid species in the Bihor Mountains.

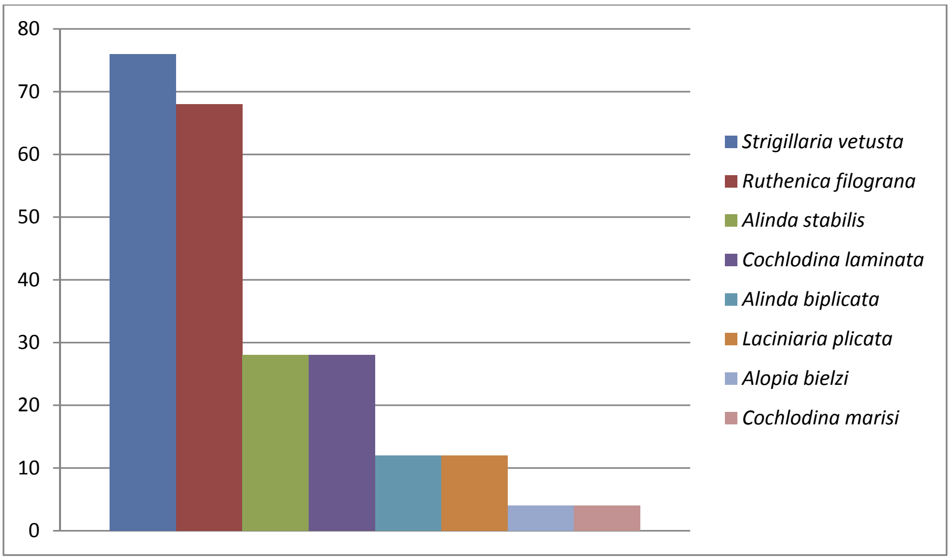

Figure 8. Constancy of clausiliid species in the Bihor Mountains.

2015), and very variable in terms of shell morphology (Domokos & Lennert 2009, Domokos, Lennert & Márton 2010, Lengyel- Páll-Gergely 2010). *Ruthenica filograna* has the highest number of collected individuals (930) and constancy (68%).

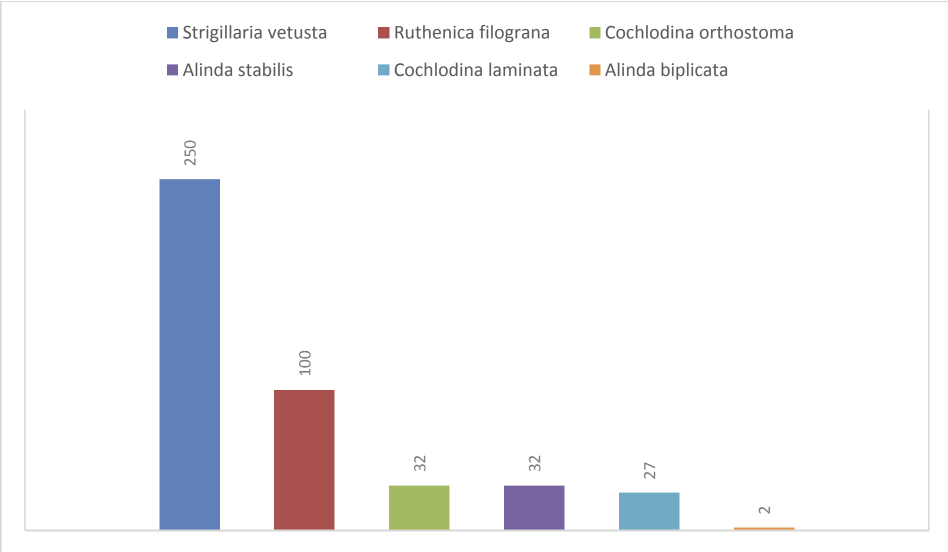

Figure 9. Number of individuals of clausiliid species in the Bihor Mountains (based on Lengyel & Páll-Gergely 2010).

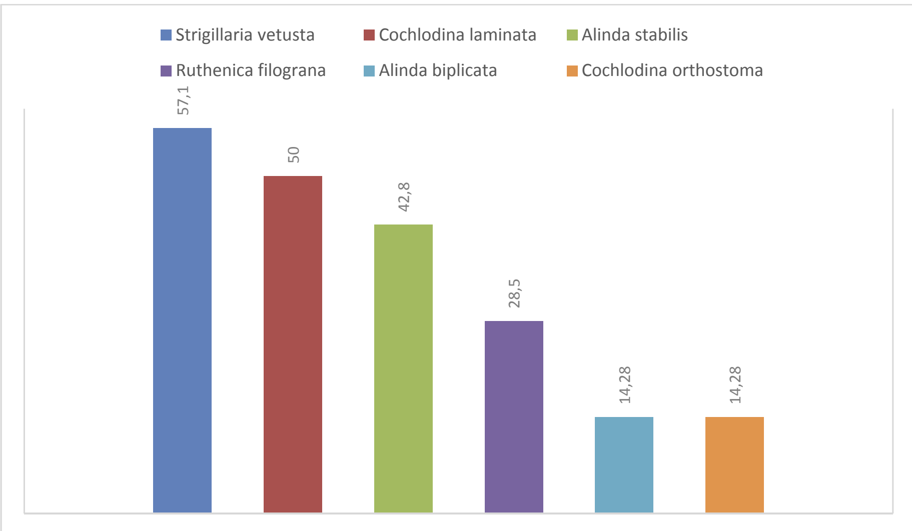

Figure10. Constancy of clausiliid species in the Bihor Mountains (based on Lengyel & Páll-Gergely 2010).

Strigillaria vetusta (Rossmässler, 1836).

A very variable species in terms of shell morphology (Lengyel & Páll-Gergely 2010). Similar to Ruthenica filograna, is was found frequently (number of collected individuals: 376, constancy: 76%, see Figs. 7 and 8).

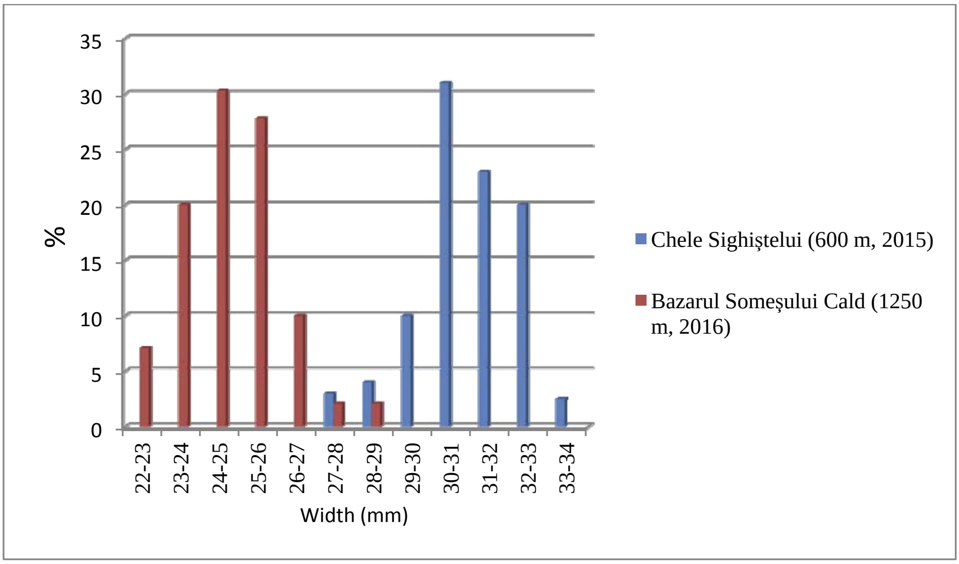

Figure 11. Frequency distribution histograms of width of *Drobacia banatica* in different biotopes (Sampling sites: 4 and 25).

Cochlicopidae

Cochlicopa lubrica (O. F. Müller, 1774)

Cochlicopa lubricella (Porro, 1838)

Ellobiidae

Carychium minimum O.F. Müller, 1774

Carychium tridentatum (Risso, 1826)

Enidae

Ena montana (Draparnaud, 1801)

This species was collected in the Gheţarul Scărişoara over 1000 m a.s.l.

Mastus bielzi (M. Kimakowicz, 1890)

Merdigera obscura (O. F. Müller, 1774)

Gastrodontidae

Zonitoides nitidus (O. F. Müller, 1774)

Helicidae

Caucasotachea vindobonensis (C. Pfeiffer, 1828)

Drobacia banatica (Rossmässler, 1838)

The largest specimen (width: 34.7 mm) was found in a rock-glacier (Nr.16. Chişcău, 09. 04. 2009.). In this sampling site the number of individuals was only five (arithmetic mean 34.2 mm)!

This is a very variable species, illustrated by specimens, which were collected at different elevations (Fig.11). *Drobacia banatica* is generalist and it has a large ecological plasticity and climatic variability. The number of individuals and constancy is illustrative of that (163 and 68%).

Arianta arbustorum (Linnaeus, 1758)
This species is found only in the alpine region of the Bihor Mountains (Cheile Someșului Cald – 1250 m, Vf. Boga –1340 m, Valea Brădetanului – 1200m).

Helix pomatia Linnaeus, 1758

Isognomostoma isognomostomos (Schröter, 1784)
A relatively rare species, its constancy reaches only 40%.

Faustina faustina (Rossmässler, 1835)

Hygromiidae

Euomphalia strigella (Draparnaud, 1801)

Kovacsia kovacsi (Varga & L. Pintér, 1972)
No living individuals were found, therefore the identification was based solely on shell morphology and on the ecology (rock-grassy, rock-shrub and open-wood).

Trochulus hispidus (Linnaeus, 1758)

Limacidae

Limax cinereoniger Wolf, 1803

Table 1/A: Sampling sites and number of species in Bihor Mts.

Species	Sampling sites												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Acanthinula aculeata													
Aegopinella epipedostoma				1		3						3	
Aegopinella pura	12		2					4	1				
Alinda biplicata													
Alinda stabilis						1	3	4				1	3
Alopia bielzi													
Arianta arbustorum				4				5					
Arion circumscriptus			1										
Aspasita triaria	7								4				
Carpathica calophana			2	1				1		1			
Carychium minimum													
Carychium tridentatum	2												
Caucasotachea vindobonensis													
Chondrina arcadica clienta			1						17				
Cochlicopa lubrica													
Cochlicopa lubricella		1											
Cochlodina laminata	1					5	3		4				
Cochlodina marisi													
Columella columella													
Drobacia banatica	16	1		35	2		3	11	7	1		6	
Ena montana	3												
Ena obscura													
Euomphalia strigella									2		1		
Faustina faustina	14		1						9			3	
Fruticicola fruticum													
Granaria frumentum									37				
Helix pomatia			1				1						
Isognomostoma isognomostomos	10		3			1	5	1				2	
Kovacsia kovacsi		2							35				
Laciniaria plicata									2				
Limax cinereoniger			1										

Lymnaeidae

Galba truncatula (O. F. Müller, 1774)

Peregriana labiata (Rossmässler, 1835)

Table 1/B: Sampling sites and number of species in Bihor Mts.

Species	Sampling sites												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Mastus bielzi												2	
Morlina glabra													
Orcula jetschini			4										
Oxychilus depressus													
Oxychilus draparnaudi													
Oxychilus montivagus									6		1		
Pyramidula pusilla													
Platyla banatica	1		2										
Platyla microspira	4								7				
Platyla polita													
Punctum pygmaeum	5								1				
Pupilla muscorum													
Ruthenica filograna	10	18	48				11	7	138		4	6	6
Sphyradium doliolum													
Strigillaria vetusta	9	2	6	1	2	21	10		73		1	4	
Trochulus bielzi	5		3		1	8	5	1				10	
Truncatellina cylindrica									13				
Vallonia costata		2											
Vallonia pulchella									4				
Vitrea contracta									3				
Vitrea botteri													
Vitrea crystallina													1
Vitrea diaphana		1			1			13	4				1
Vitrea jetschini								1					
Vitrea subrimata			1										
Vitrea szekeresi	5	1	1					3					
Vitrina pellucida	6		14	1	2		6	5	10			1	
Zonitoides nitidus													
Number of species	**16**	**8**	**16**	**6**	**5**	**6**	**9**	**12**	**20**	**2**	**4**	**10**	**4**
Number of individuals	**110**	**28**	**91**	**43**	**8**	**39**	**47**	**56**	**377**	**2**	**7**	**38**	**11**
Ancylus fluviatilis													
Bythiospeum sp.													
Galba truncatula													
Peregriana labiata													
Pisidium sp.	–												

Table 2/A: Sampling sites and number of species in Bihor Mts. (C = constancy %, ∑ = number of individuals)

Species	Sampling sites													
	14	15	16	17	18	19	20	21	22	23	24	25	∑	C
Acanthinula aculeata	2								2	2	2		8	16
Aegopinella epipedostoma					5		1					1	14	24
Aegopinella pura	3			3	29				7		5		66	36
Alinda biplicata				3		1	1						5	12
Alinda stabilis					2				1				15	28
Alopia bielzi			34										34	4
Arianta arbustorum													9	8
Arion circumscriptus													1	4
Aspasita triaria									5				16	12
Carpathica calophana													5	16
Carychium minimum	8						3						11	8
Carychium tridentatum	6			2		10			361				381	20
Caucasotachea vindobonensis	1									2			3	8
Chondrina arcadica clienta	34		24	3						85	39		203	28
Cochlicopa lubrica									12				12	4
Cochlicopa lubricella	3								2				6	12
Cochlodina laminata	9						2			4			28	28
Cochlodina marisi												1	1	4
Columella columella					9								9	4
Drobacia banatica		5	2	5	24	1	10		1			33	163	68
Ena montana													3	4
Ena obscura	3									1			4	8
Euomphalia strigella	1												4	12
Faustina faustina							2			4	6	3	42	32
Fruticicola fruticum							1						1	4
Granaria frumentum			2	1						91	49		180	20
Helix pomatia			1	1		1	1					1	7	28
Isognomostoma isognomostomos				5	1							1	29	36
Kovacsia kovacsi	32								5	51	30		155	24
Laciniaria plicata	3			2									7	12
Limax cinereoniger													1	4

Moitessieriidae

Bythiospeum sp.
„All these species were collected from fresh-water sources and mountain rivers in Western Carpathian Mountains and Banat." (Grossu 1993. p. 297).

Table 2/B: Sampling sites and taxa in Bihor Mts. (C = constancy %, ∑= number of individuals)

Species	**Sampling sites**													
	14	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**∑**	**C**
Mastus bielzi						7							**9**	**8**
Morlina glabra										3	3	1	**7**	**12**
Orcula jetschini				4					1				**9**	**12**
Oxychilus depressus									2				**2**	**4**
Oxychilus draparnaudi				1									**1**	**4**
Oxychilus montivagus	10		2	1			3						**23**	**20**
Pyramidula pusilla	17		2				5			49	1		**74**	**20**
Platyla banatica				2					5				**10**	**16**
Platyla microspira					4				9	6	4		**34**	**24**
Platyla polita					1								**1**	**4**
Punctum pygmaeum	1				1	2			24				**34**	**24**
Pupilla muscorum	1								16				**17**	**8**
Ruthenica filograna	53		16		58	39	11			195	302	8	**930**	**68**
Sphyradium doliolum	8					3	1			3	2		**17**	**20**
Strigillaria vetusta	55		33	44	2	13	2			74	19	5	**376**	**76**
Trochulus bielzi				4	3		1						**41**	**40**
Truncatellina cylindrica	6								7	1	1		**28**	**20**
Vallonia costata	2		1						11	4			**20**	**20**
Vallonia pulchella	35								12				**51**	**12**
Vitrea contracta	1												**4**	**8**
Vitrea botteri				1									**1**	**4**
Vitrea crystallina							1						**2**	**8**
Vitrea diaphana	8				16						17		**61**	**32**
Vitrea jetschini				4									**5**	**8**
Vitrea subrimata	1												**2**	**8**
Vitrea szekeresi				3									**13**	**20**
Vitrina pellucida	7		2	5	53	2			1	5	13		**133**	**64**
Zonitoides nitidus									1				**1**	**4**
Number of species	**26**	**1**	**11**	**19**	**14**	**10**	**15**	**–**	**19**	**17**	**15**	**9**		
Number of individuals	**310**	**5**	**119**	**94**	**208**	**79**	**45**	–	**485**	**580**	**492**	**54**		
Ancylus fluviatilis								9	6				15	
Bythiospeum sp.									1				1	
Galba truncatula									5				5	
Peregriana labiata								14					14	
Pisidium sp.	1												1	

We collected one sample only from scum of the Sighiştel brook. According to Sîrbu 2006, the following species can found in the Pişolca and Coliboaia caves of Sighiştel Valley: *B. transsylvanicum* Rotarides, 1943, *B. carpathicum* Soós, 1940 and *P. leruthi* (C. Boettger, 1940).

Orculidae

Orcula jetschini (M. Kimakowicz, 1883)

Sphyradium doliolum (Bruguière, 1792)

Oxychilidae

Aegopinella epipedostoma (Fagot, 1879)
Welter-Schultes (2012) does not report this species from Romania, but Lengyel & Páll-Gergely (2010) listed it from the Bihor Mountains and published a drawing of its reproductive anatomy.
Aegopinella pura (Alder, 1830).

Carpathica calophana (Westerlund, 1881)

Morlina glabra (Rossmässler, 1838)

Oxychilus depressus (Sterki, 1880)

Oxychilus montivagus (M. Kimakowicz, 1890)

Planorbidae

Ancylus fluviatilis O.F. Müller, 1774

Punctidae

Punctum pygmaeum (Draparnaud, 1801)

Pupillidae

Pupilla muscorum (Linnaeus, 1758)

Pyramidulidae

Pyramidula rupestris (Draparnaud, 1801)

Spelaeodiscidae

Aspasita triaria (Rossmässler, 1839)
Collected only in Cheile Sighiştelui and Gheţarul Scărişoara.

Truncatellinidae

Truncatellina cylindrica (Férussac, 1807)

Valloniidae

Acanthinula aculeata (O. F. Müller, 1774)

Vallonia costata (O. F. Müller, 1774)

Vallonia pulchella (O. F. Müller, 1774)

Vertiginidae

Columella columella (G von Martens, 1830)
„Widespread in all the Carpathians, especially in the alpine zones, but also frequent in alluvia and löes” (Grossu 1993). This species became extinct in Pleistocene in Hungary (Fűköh et al. 1995).

Vitrinidae

Vitrina pellucida (O. F. Müller, 1774)

Zonitidae

Vitrea diaphana (S. Studer, 1820)

Vitrea contracta (Westerlund, 1871

Vitrea crystallina (O. F. Müller, 1774)

Vitrea jetschini (M. Kimakowicz, 1890)

Vitrea subrimata (Reinhardt, 1871)

Vitrea szekeresi Deli & Subai 2011
The distribution of this species reaches its northern limit in the Bihor Mountains (Deli & Subai 2011).

CLASS BIVALVIA

SUBCLASS HETERODONTA
Sphaeriidae

Pisidium sp.
Only a single valve was collected from the flotsam of the Sighiştel brook.

Acknowledgements

This contribution is dedicated to the memory of Prof. Ioan Bușiția (1874–1953) from the high school of Beiuș, who dedicated all his active life to nature protection from the Apuseni Mountains. Prof. Bușiția noted on September 9 1931, in his touring guide-book of Apuseni Mountains [written by Czárán Gyula (1847-1906)]:

"and I wish from all my heart that the love for Nature brings many Hungarian tourists to us, so that we may delight in the beauty of our glades in brotherhood and good understanding, and practice tourism for the pleasure of our hearts and bodies".

"şi îmi doresc din toată inima, ca iubirea Naturii să aducă mulţi turişti maghiari între noi, ca să putem să ne încântăm frumuseţea poienilor noastre în fraternitate şi în bună înţelegere, să practicăm turismul pentru plăcerea inimilor şi a trupurilor noastre."

"s óhajtom teljes szívemből, hogy a Természet iránti szeretet sok magyar turistát hozzon közibünk akikkel együtt gyönyörködhessünk havasaink szépségében, testvéri szeretettel, jó egyetértésben gyakoroljuk a turistaságot, szívünk gyönyörködtetésére s testeink edzésére."

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Rezumatul (*Abstract*) informativ în limba engleză (plus în limba în care s-a redactat articolul) va fi sub forma unui singur paragraf, fără să depăşească 3 % din lungimea totală. Acesta va cuprinde cele mai importante idei ale articolului, precum şi concluziile (vor fi evitate prescurtările şi citarea unor lucrări).

Textul integral al manuscrisului se va redacta la două rânduri (cu caractere Arial 10 pct.), aliniate la stânga, în formatul A4, lăsând pentru marginea dreaptă şi stângă cel puţin 3 cm; toate paginile vor fi numerotate.

Lucrările citate vor fi trecute în ordine alfabetică (vor fi cuprinse numai lucrările citate in text). Se va folosi modelul următor:

Frost, DR. & Hillis, D. M. 1990. - Species in concept and practice: herpetological applications. *Herpetologica* **46**: 87-104.

Lindemann, R. & Yochelson, E. L. 1994. - Redescription of *Stylolina* (Incertae sedis). In: Landing, E. (Ed.): *Studies in Stratigraphy and paleontology*. NewYork State Museum, Bulletin 481: 149-160, New York.

Taylor, T.N. 1981. - *Palaeobotany: An introduction to fossil plant biology*. (McGraw-Hill Book Co.) New York, 589 p.

Danciu, M. 1974. - Studii geobotanice în sudul Muntelui Baraolt, Teză de doctorat, Universitatea din Bucureşti, Bucureşti, 175 p.

Tabelele vor fi anexate separat (*portrait* sau *landscape*, salvate în fişiere separate: ex. Table 1, 2, etc., preferabil Excel sau PDF), fiecare pe câte o foaie separată, nepaginată şi vor fi prevăzute cu câte un cap de tabel. Acesta va conţine numărul şi titlul tabelului (dimensiunea maximă: 125x175 mm sau 175x125 mm).

Figurile se vor executa în tuş negru pe calc sau vor fi tipărite pe hârtie albă, de calitate foarte bună, fiecare pe foaie separată în format B 5 şi numerotate consecutiv (Fig. 1, Fig. 2, etc.). Caracterele folosite după micşorarea figurii nu trebuie să fie mai mici de 2 mm. Vor fi acceptate figuri (diagrame, desene, fotografii) în formatul electronic (preferabil TIFF, EPS) cu dimensiunea maximă de 125x175 mm, cu o rezoluţie minimă de 600 dpi pentru desene (*line drawings*) şi 300 dpi pentru fotografii. Figurile generate de computer vor fi salvate în fişiere separate (Figure 1, 2, etc.). Locul preferat al figurilor se va marca în manuscris pe partea dreaptă a paginii respective.

Pentru fiecare articol publicat, autorii beneficiază de 15 extrase şi de un volum al anuarului Nymphaea.