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Morfology and hydrogeology of Vârtop-Coiba Mică-Coiba Mare-Izbucul Tăuz underground system (Bihor Mountains)

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Abstract. The upper basin of Gârda Valley (Gârdişoara and Gârda) in the center of Bihor Mountains represents one of the most interesting karst areas, not only in Romania but also throughout Europe. On an aerial length of almost 4.5 km and over 500 m of difference in altitude, it develops a complicated underground drainage, which also contains some of the deepest sumps in Romania. The system is joined by some of the largest caves in România, such as Hodobana cave, Coiba Mică-Coiba Mare system, Pârâul Orbului cave, Iezere cave, Oii cave, Sohodol II pit and not least the important Tăuz spring (Izbucul Tăuz), explored so far on 1000 m length. All this karst system is the result of successive captures of the Gârdişoara Valley and losses in the adjacent hydrographic systems.

Introduction

The studied area develops in a massive limestone (400-600 m thick) of Upper Jurassic age within the Biharia terrane. On the other hand, in the Vârtop plateau the karst relief is in contact with deposits of the Lower Jurassic (clays, sandstones and quartz micro-conglomerates) belonging to the Hettangian-Sinemurian. This lithological contact led to a disorganized surface of hydrographic network, each small watercourse is lost individually through ponor-caves or impenetrable swallets, the hydrographic organization taking place exclusively underground. The limestone deposits of Upper Jurassic age are affected by a fragile tectonics, of Saxon type, with many faults and major strikes (slip faults). It is noted a main fracture direction, NE-SW, and a secondary one, NW-SE. From the tectonic point of view, the whole area depends on the great fault of Galbena. The structural area is within a wide homocline. The limestone layers are inclined towards the SW, with falls of 30-40 degrees. The stratification discontinuities are either of the type of joints or of the type of diastema. These discontinuities played a major role, especially in the formation of the Coiba Mare cave. The hydrography of the area is focused on Gârdişoara and Gârda Valleys. Paleo-Gârda had a continuous course, but the karst capture from Coiba Mică cave, divided the entire valley into three sectors: the upper sector, Gârdişoara (between the Gura Apei spring and Coiba Mică cave), a short, medium sector, between Coiba Mică cave and Coiba Mare cave, with a character of sohodol (completely flooded by Gârdişoara only in large waters) and the lower-middle sector, of the Gârda Valley. The Vârtop plateau (developed at altitudes of 1200-1300 m) is a more complicated case, with countless small surfaces of water courses, which all have their source into the Călineasa plateau, creeks with lengths between 200 and 1000 m. The whole underground system has a final drainage point in Izbucul Tăuz spring, located at 850 m altitude, and having the highest discharge flow and depth in Bihor Mountains. But before the Izbucul Tăuz resurgence, Gârda Valley receives on the right the morphological confluence of the Sohodol Valley, a typical sohodol. An affluent of this sohodol is the Hodobana Creek, and in its left slope the largest maze in limestone of Europe, the Hodobana cave, is developed. Finally, in the upper sector of the Sohodol Valley, there is the Sohodol II pit, the karst plateau Iezere and Iezere cave at the watershed point.

Initially it was thought that the sole underground drainage is the one between Coiba Mare cave and Izbucul Tăuz resurgence, because in the 1950s the marking with fluorescein have shown this route. The explorations undertaken by the author, in collaboration with the Speleology Club „Z“ from Oradea, between 1973-2019, have demonstrated that we are dealing with a complex and impressive underground hydrographic network. Thus, a coloring done in 1980 in the Colibi cave (the highest one located in the Vârtop plateau) demonstrated a direct connection between the Colibi cave and the Pârâul Orbului cave, the colorant appearing in a tributary of this cave after only 3 hours. Another marking did in Pârâul Orbului cave showed fluorescein reappearing after five days in the tributary with sump (Black Sump) of the Secondary water course in Coiba Mare cave. With this spectacular coloring, a direct connection between the Vârtop plateau and the Izbucul Tăuz

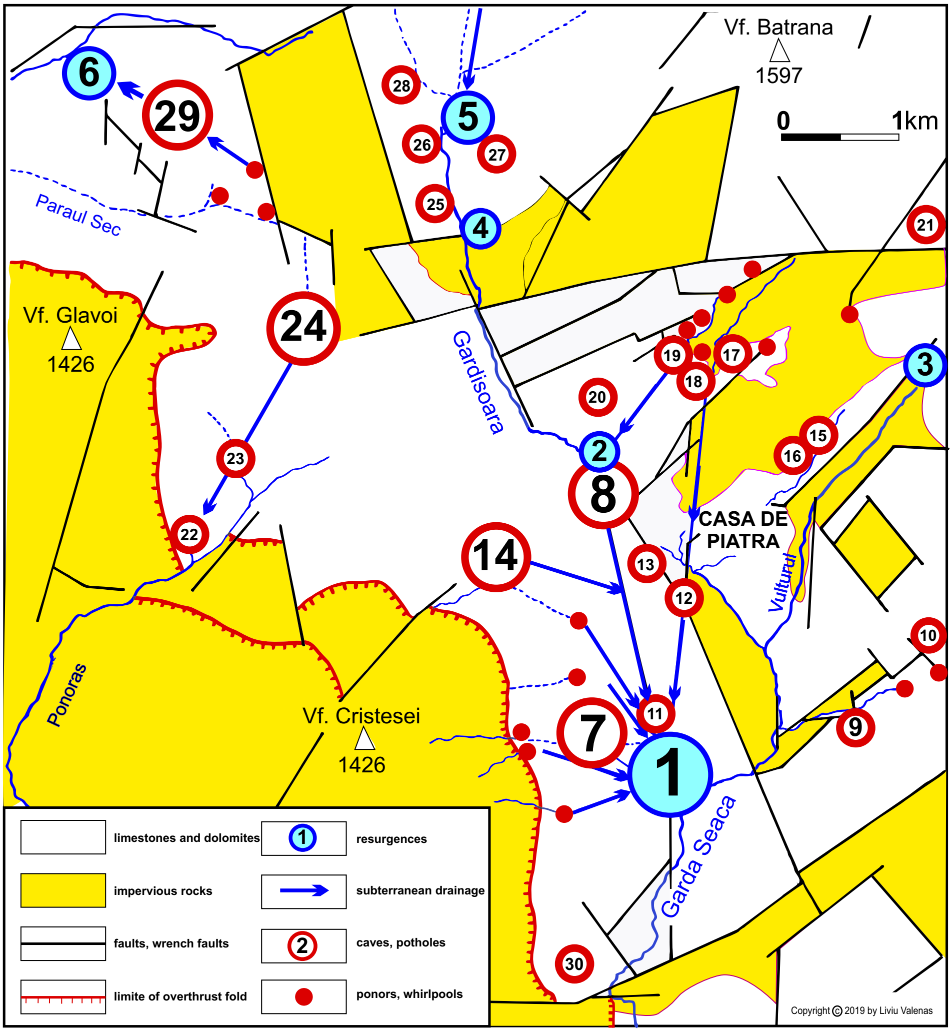

Figure 1. Geological and hydrogeological map of the area Casa de Piatră-Hodobana-Tăuz. (Cartography Liviu Vălenaș & Paul Damm). 1: Izbucul Tăuz, 2: Izbucul Coibița, 3: Izbucul Văii Vulturului, 4: Izbucul de la Coliba Ghiobului, 5: Izbucul Gura Apei, 6: Izvorul Rece, 7: Peștera din Pârâul Hodobanei, 8: Sistemul Coiba Mică-Coiba Mare, 9: Peștera cu Apă din Pârâul Brusturi, 10: Peștera-Aven din Pârâul Brusturi, 11: Peștera cu Două Intrări din Dealul Tăuz, 12: Peștera Mare din Băroaica, 13: Peștera Oii, 14: Avenul Sohodol II, 15: Avenul din Dunga Vulturului, 16: Peștera din Dunga Vulturului, 17: Peștera de la Colibi, 18: Peștera din Pârâul Orbului, 19: Peștera de după Deluț, 20: Peștera Ghețarul de la Vârtop, 21: Avenul I din Călineasa, 22: Peștera Moara Scochii, 23: Peștera Moara Dracului, 24: Peștera de la Iezere, 25: Peștera Șura, 26: Peștera cu Apă din Fața Bălăcenii, 27: Avenul I din Dâmbu Blidarului, 28: Peștera-Aven din Fața Bălăcenii, 29: Rețeaua Lumea Pierdută, 30: Peștera cu Patru Intrări din Pârâul Micușii.

spring was proved. The air-distance is 3.5 km, for a difference of altitude of 513 m, taking into account the deepest sump in the Izbucul Tăuz resurgence, its bottom being at an absolute altitude of 767 m. The relatively long time in which the dye appeared from Pârâul Orbului cave in to Coiba Mare cave makes us see a flow mostly under pressure. It is possible that at this secondary underground course (in relation to the first order drainage Coiba Mică cave - Izbucul Tăuz resurgence) other tributaries may also rally. However the underground courses in the Vârtop Plateau, i.e. those of the important De După Deluţ cave, De După Deluţ pit and De După Deluţ ponor, is finally organized into another underground drain, parallel to that between the Colibi cave and Coiba Mare cave, with final drain in the small spring of Coibiţa, located only 49 m in front of the large entrance from Coiba Mare cave. The discovery in 1979 of the great network of Hodobana cave once again demonstrated the complexity of the hydrogeological organization of the area. The three independent water courses in this underground network, including a 1020 m long underground river, have as their final drain the entire Izbucul Tăuz resurgence, and the Sohodol and Bolfu ponors, from the upper basin of the Sohodol Valley. The extremely small difference between the minus point of Hodobana cave and Izbucul Tăuz resurgence, of only 11 m, makes us to believe that we are still dealing with a flow under pressure. Paul Damm (Damm 2001) also saw in the Iezere cave, located 4.6 km air-distance from the Izbucul Tăuz resurgence, an insurgence of the Tăuz. Until proven otherwise (a coloring or marking) we are skeptical in this case. In contrast, the small water course of Sohodol II pit is, without discussion, a small underground tributary of the major drainage Coiba Mică - Coiba Mare system. For all these secondary drains (those from the Vârtop plateau, those from the Sohodol Valley basin and the Iezere cave), there are necessarily future markings.

Finally, lets deal with this major drain, Coiba Mică cave - Izbucul Tăuz resurgence. From the terminal sump (Lake of Death) from Coiba Mare cave to Izbucul Tăuz resurgence (sump no. 4), remains an air-distance of 1900 m and a difference of altitude of 80 m. Only this difference has made us to believe since 1978 to a partial flow in the vadose regime. This conclusion was also joined by Iancu Orăşeanu (Orăşeanu 1996), who, following new markings of this major underground course, highlighted a transit time of 7 days between Coiba Mică cave and Izbucul Tăuz resurgence, and during the 11 days of observation the flow had a single maximum, i.e. a piston type flow. According to Iancu Orăşeanu, the underground course has a free flow, without important tributaries, the delay of the tracer being due exclusively to the deep sump in Tăuz resurgence. In 2014 a team of Finnish divers, who attacked simultaneously, both the Tăuz Izbuc resurgence and the terminal sump in Coiba Mare cave, only partially confirmed this theory.

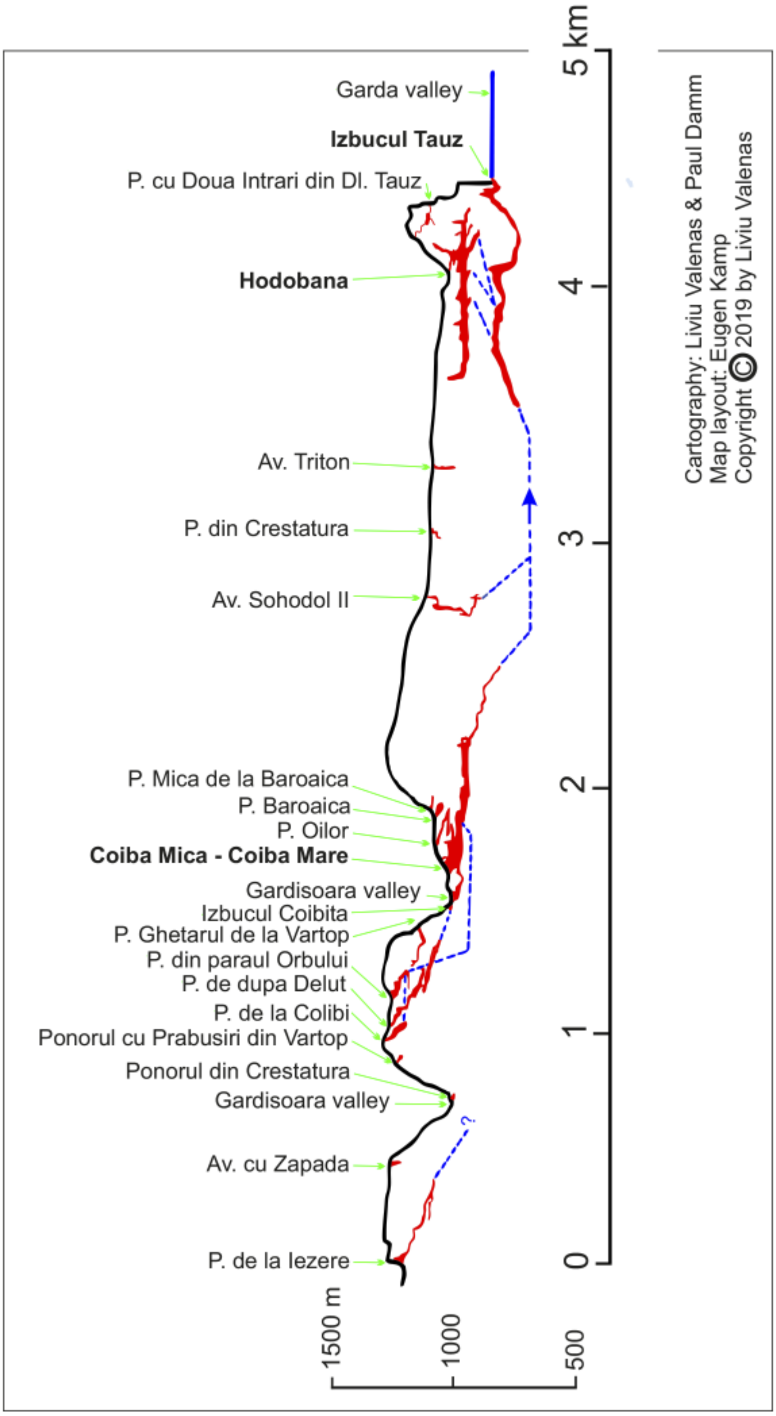

Figure 2. Longitudinal section of the Vârtop-Coiba Mică-Coiba Mare-Hodobana-Izbucul Tăuz area (Graphic by Liviu Vălenaș & Paul Damm).

Figure 3. Pârâul Orbului cave in Vârtop plateau (Photo by Liviu Vălenaș, 2019).

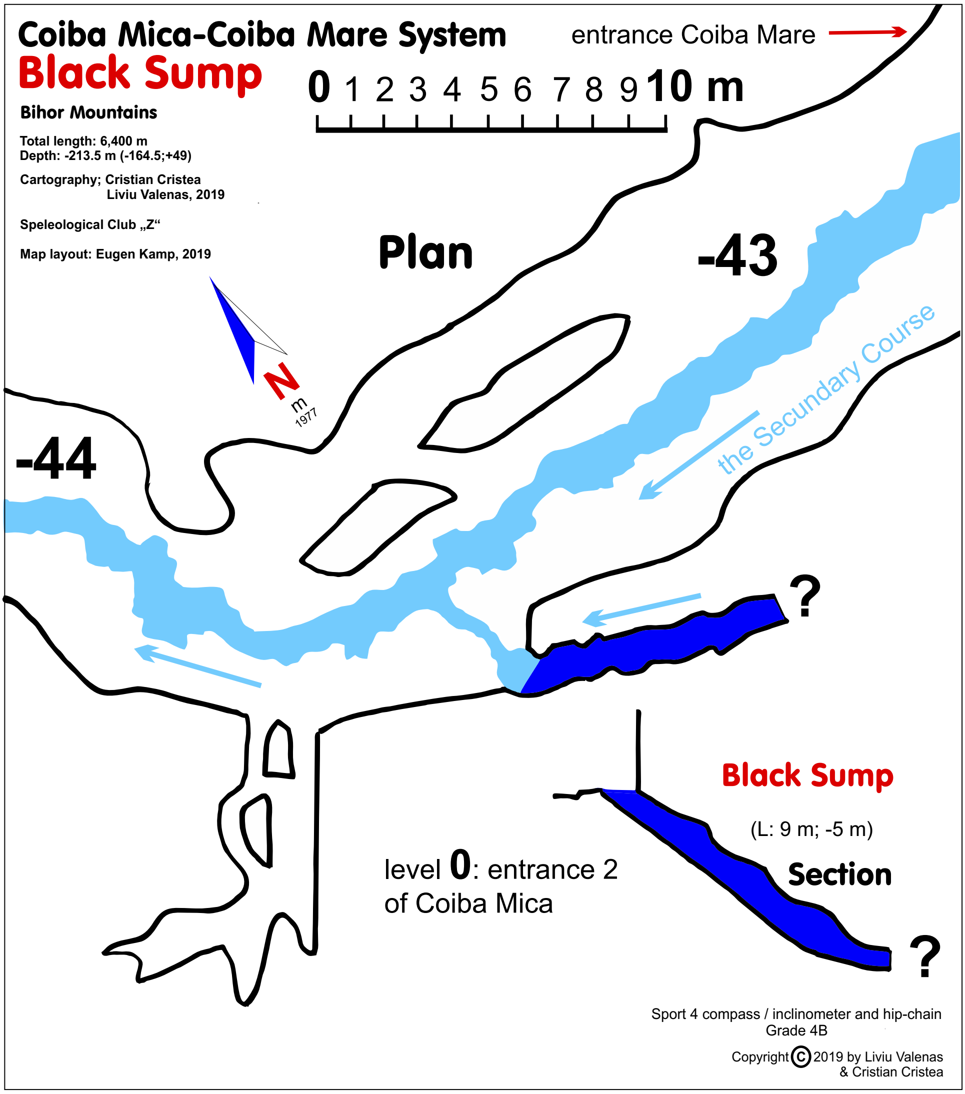

Figure 4. The Black Sump of Coiba Mare cave (Cartography by Cristian Cristea & Liviu Vălenaș, 2019).

Partly the underground course is vadose (in the explored area of Tăuz resurgence is also a waterfall of 4 m), but the explored gallery is divided by several deep sumps, the one in Coiba Mare cave is exceeding 100 m deep, so the delay of the tracer is due to several deep sumps. We observed no tributary on the vadose section of Izbucul Tăuz resurgence, but it is possible that the tributary from Hodobana, for example, appears submerged, directly in a sump (no. 2?).

Figure 5. Entrance to Coiba Mică cave completely flooded (Photo by Liviu Vălenaș, November 11, 2019).

The cave system Coiba Mică - Coiba Mare

The cave network Coiba Mică - Coiba Mare is an awesome Romanian cavern even if not the longest. The cave entrance portal is the largest, and its long stream has the biggest flow in Romania. A tremendous and complicated 4 km long phreatic-pipes maze at the entrance makes it unique in Europe. In 2014, scuba divers reached a depth of 92.5 m in final sump, a top national record of diving of that date (Pereţ & Drăgan 2016). The physical dimensions of the cave system are: total length: 6400 m; depth: 213.5 m (-164.5;+49); extension (not sump no 2): 585 m; total length/extension: 10.9.

History of explorations

The locals (Motz) have known the Coiba Mare cave's large entrance for hundreds of years. They named it Stone House (Casa de Piatră). Over time, the hamlet near cave received the name Stone House and the cave, the name of Coiba Mare to differentiate it from neighboring Coiba Mică cave.

In 1922, the biologists René Jeannel and Arnold (Arthur) Winkler visited the Coiba Mare cave (Jeannel & Racovita 1929). In 1953 and 1956, Marcian Bleahu, Iosif Viehmann and Dan Coman explored for the first time the cave

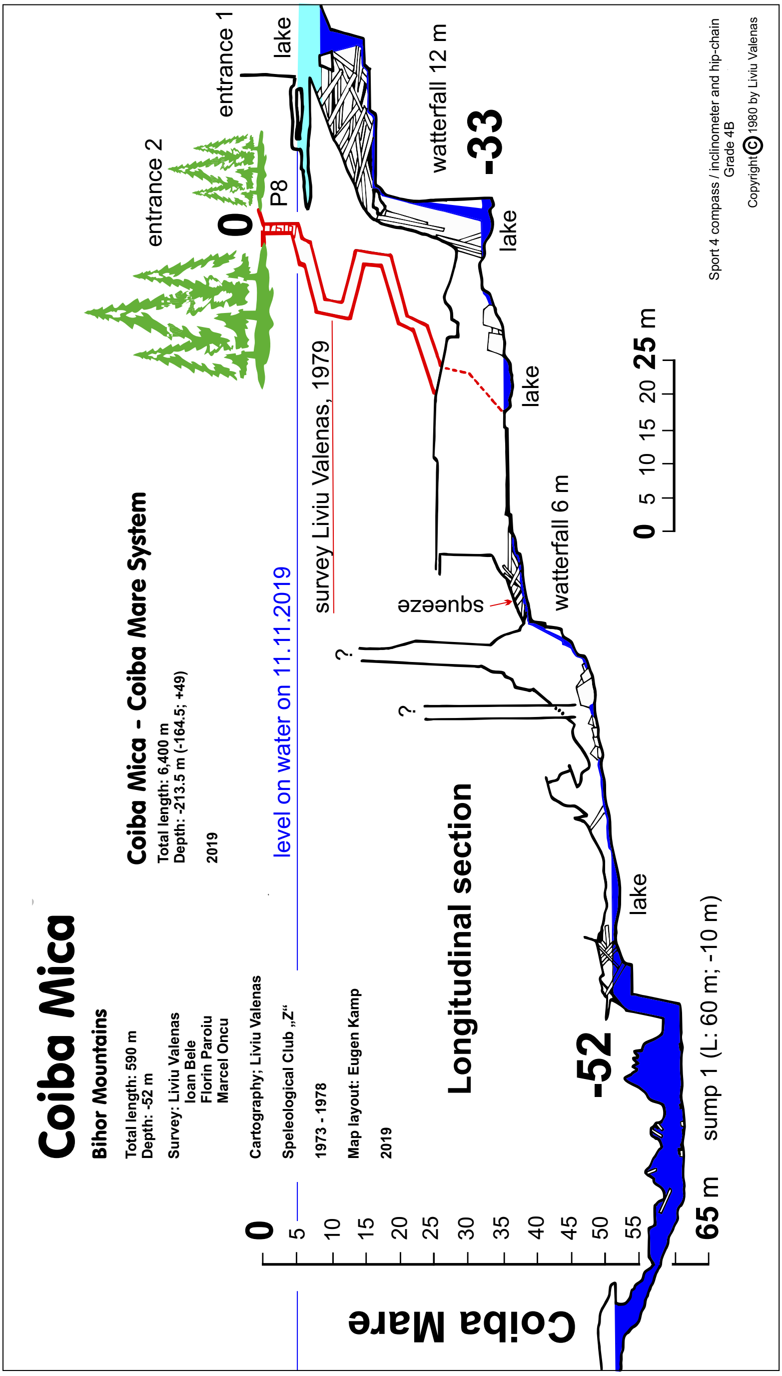

Figure 6. Longitudinal section through Coiba Mică cave (Cartography by Liviu Vălenaș, 2019).

Figure 7. The main entrance to Coiba Mare cave, the largest portal in Romania, 74 m wide and 47 m high (Photo by Dan Moldovan, 2018).

mainstream, limited by upstream and downstream terminal sumps. They surveyed 760 m and published the map in 1957, declaring the cave as “finished” and “of a local interest” (?!). As for Coiba Mică cave, Marcian Bleahu & co. defined it as “an impassable swallow hole” (?!). For the next two decades, the two caves fell in complete oblivion.

In February 1973 Liviu Vălenaş and Ioan Bele reached Coiba Mică cave and discovered not an “impenetrable swallow-hole”, but a true cavern. They explored and surveyed the cave on 270 m, but a sump stopped the downstream exploring. In 1975, the Speleological Club “Z” led by Liviu Vălenaş continued exploring and survey of the Coiba Mare cave. Between 1975 and 1976, the small team of speleologists: Liviu Vălenaş, Eleonora Vălenaş, Gheorghe Drimba and Emil Silvestru explored and surveyed the cave on 4724 m. The most significant result is a vast phreatic maze near the entrance, with a total length of 3874 m. The survey of the entrance portal proved it as the largest one in Romania: 74 m wide and 47 m tall. In 1977, a new team led by Liviu Vălenaş explored the cave with guest participation of Gábor Halasi†, Petru Brijan† and Ovidiu Cuc†. The length of the Coiba Mare cave reached 5400 m. In January 1978, the scuba diver Florin Păroiu (supported by Liviu Vălenaş, Nicolae Sasu, and Dorel Pop) passed the sump between Coiba Mare cave and Coiba Mică cave, realizing the junction between the two caves, the length of the new caves network reaching 5680 m.

Figure 8. Former open sump 1 of Coiba Mare cave, now the floods have completely swept the floor of the secondary course (Photo by Liviu Vălenaș, 2019).

Figure 9. The entrance to Coiba Mare cave flooded after a flood produced in winter (Photo by Ovidiu Guja, December 31, 2010).

Liviu Vălenaş published in 1978 the detailed map of the 5680 m (Vălenaș 1978). In 1979 Nicolae Sasu, together with a group of Polish speleologists, discovered a small pothole near Coiba Mică cave, making the junction with Coiba Mică cave. The total length of the cave system Coiba Mică - Coiba Mare is thus 6140 m. In 1979, the search for airy-parts in caves ended. Plunging in last Coiba Mare cave sump (Lake of Death) was sole choice to advance. In 1982, Liviu Vălenaş invited Lászlo Czakó, a Hungarian scuba diver to dive the lake. A giant plug of submerged timber logs forced the scuba diver to abandon at 16 m depth. Between 1973 and 1982, Speleological Club "Z" organized 14 exploration camps attended by 57 speleologists and scuba divers.

In 2014, a small group of Finnish scuba divers: Sami Paakkarinen and Patrick Gronquist, in collaboration with Adrian Pereţ, did a great performance in the downstream sump of Coiba Mare cave (Lake of Death). They dived 200 m up to the depth of 92.5 m, a top record of Romania (Pereț & Drăgan 2016). With this last action, the underground system reaches 6400 m total length and a deep of 213.5 m (-164.5; +49). In 2017, Speleological Club "Z" collaborated with the scuba diver Cristian Cristea. The last one dived for the first time the small sump

Figure 10. The Secondary Course in Coiba Mare cave (Photo by Ovidiu Guja and Iosif Gergely, 2014).

downstream of the open sump in Coiba Mare cave. He advanced 9 m to a depth of 5 m. Diving in this sump will resume soon.

Description

The caves network has two main entrances: Coiba Mică and Coiba Mare. Each has an active course joining underground one with other. The main water stream (underground Gârdişoara) enters through the Coiba Mică cave and runs the network on 725 m length. After 341 meters, the main course joins with the 317 m long secondary watercourse (from Coiba Mare cave). Tributaries of up to 85 m length add to cavern hydrography. In this active compound, must add the impressive 3,873.5 m long fossil maze, from the entrance in Coiba Mare cave. It is three quarters of the total length of the cave network Coiba Mică - Coiba Mare.

The entrance in Coiba Mică cave (1016 m altitude, elevation 0 m of the network: the pothole, 1028 m altitude) is at the of a 12 m high antithetic rock-step. After a 20/3 m entrance portal, the cavity presents a short descending path followed by a 12 m deep waterfall, the largest of the entire network. At the base of the waterfall, it opens in a 28/21/12 m hall, developed along the limestone layers. The active gallery presents a narrow passage of 1/1 m, and a 6 m waterfall dropping into an 18/13/15 m room full of boulders (Blocks Hall). The gallery continues more rectilinear, and after passing an open sump (ceiling at 0.5 m) at -35 m, it reaches the Sump 1 of the network, dived on January 1, 1978.

Downstream of Sump 1, the main watercourse passes through a 128 m gallery with a section of 5/4 m, having three notable lakes (one of these is 22 m long). After 341 m and at -40 m, the mainstream receives the waters of the 317 m long secondary watercourse, in the Confluence Hall (35/20/17 m). The secondary watercourse penetrates from the surface through the 74/47 m portal of Coiba Mare Cave (elevation -28 m, altitude 1000 m). At 8 m and 10 m east of the main entrance, opens two secondary fossil entrances, suspended in the wall of the large portal, with sizes of 7/2 m and 2.5/5 m. These two entrances open into a network of low galleries with phreatic morphology: the tube network. Through 14 phreatic tubes with lengths of 7-15 m (developed along rock layers), the 314 m long network communicates with the Great Hall and A.M. Winkler Hall.

After the great 74 m/47 m portal follows Great Hall (95/47 m), one of the largest halls in Romania. The Great Hall assures a connection to several small networks, belonging to the large maze from the entrance. At 60 meters from the entrance, on the left side of Great Hall, is the A.M. Winkler Hall (23/16/18 m), full of limestone blocks (-22 m). From this chamber extends to south the Bears

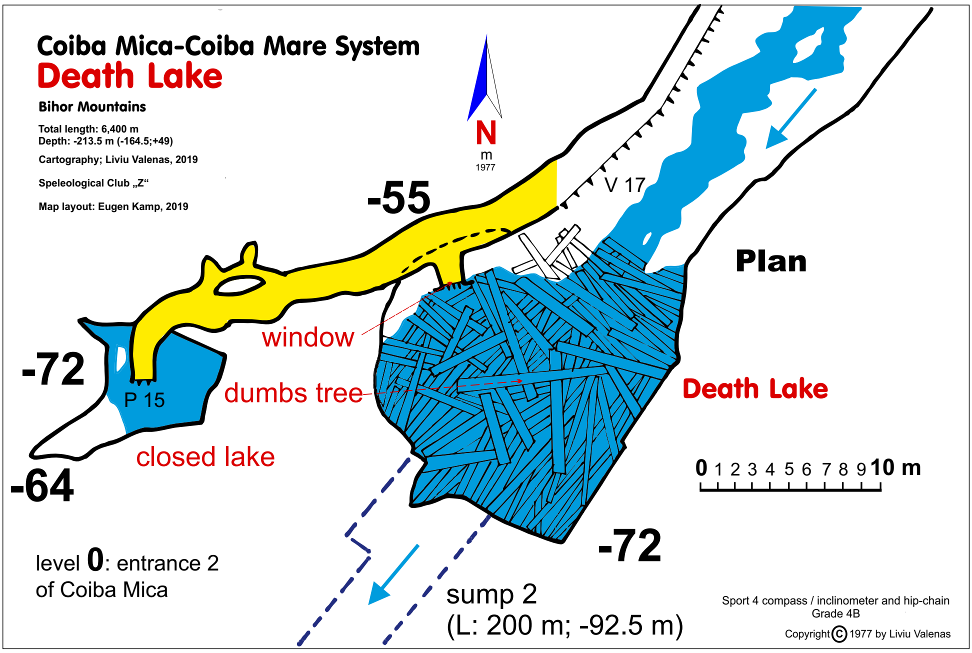

Figure 11. The terminal sump (Lake of Death) in Coiba Mare cave, cartography by Liviu Vălenaș, 2019.

Gallery one of the cavern's important galleries. The gallery has a length of 172 m and climbs on 41 m. Adding its upper and lateral floors the total length of this cave part reaches 670 m. We discovered the Bears Gallery in January 1976 after an unclogging. The Bears Gallery is one of the most magnificent cavities (with sections of 10/30 m), with a slope of 20-37 degrees covered by moonmilk. The horizontal terminal part bifurcates into two branches ended at 31 m and 24 m elevation. From -16 m elevation in the Bears Gallery, a 34 m long near-vertical chimney reaches the upper level of the Bears Gallery, representing a 314 m long maze floor. Through two other drops of 30 m, the upper level communicates again with the Bears Gallery. Between the 32 m level and elevation of 10 m, a 51 m long intermediate level exists that does not extends to the Bears Gallery.

Back to the 74/47 m portal, in its overhung ceiling, between the elevation -5 m and +9 m (+23 m and +37 m above Coiba Mare cave entrance), there are entrances to three galleries. Only the gallery at +9 m has important development. This gallery is a maze at the beginning (with many rock pillars), then presents two important drops of 20 m (obstructed) and 40 m who communicates to the Great Hall.

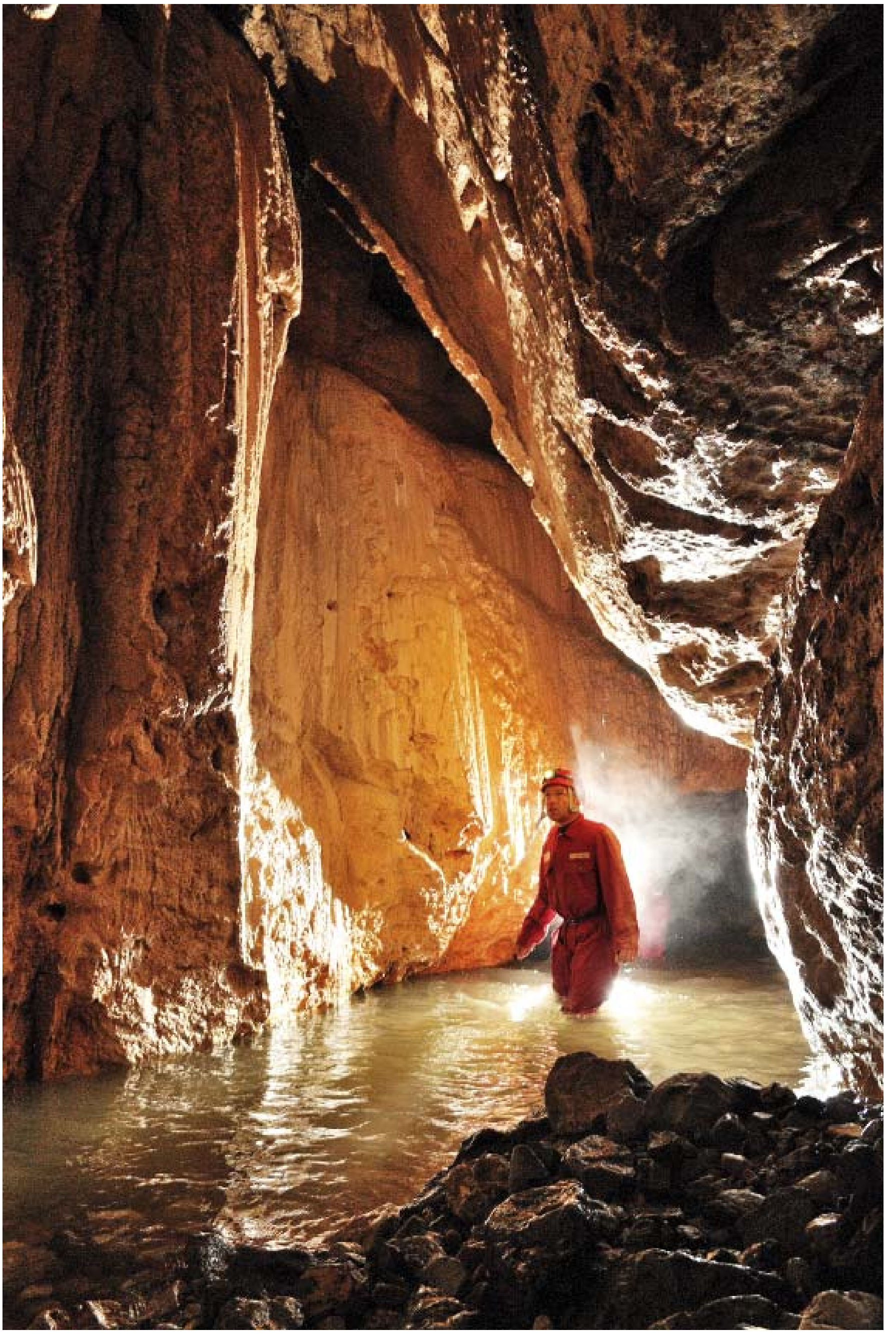

Figure 12. The main course in Coiba Mare cave (Photo by Ovidiu Guja & Iosif Gergely, 2014).

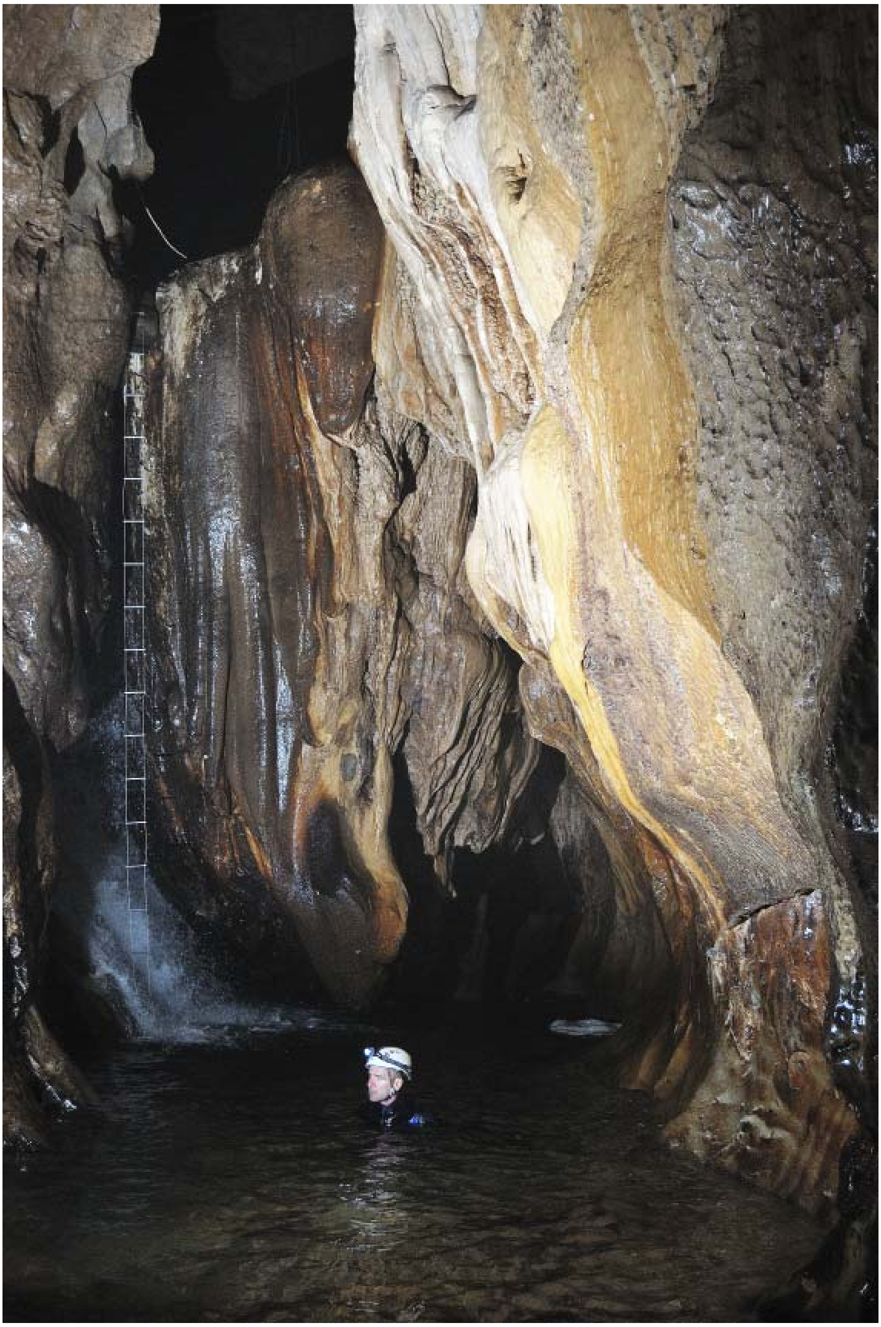

Figure 13. The 6 m high waterfall on the main course in Coiba Mare cave (Photo by Ovidiu Guja & Iosif Gergely, 2014).

In Great Hall's south-eastern wall, opens (on faces of rock layers) nine phreatic tubes. They belong to a 967 m long maze network (the Great Maze) on a 115 m horizontal distance. The tubes have a diameter of 1.5 m to 4 m and appear as a spider net. At every 5-10 m is a branching, and the next gallery exposes the same features. An impressive gallery of the Great Maze is a straight 27 m tube with a 1.4/2 m elliptical section. The Great Maze communicates with the active downstream from Great Hall, and also a descendant gallery intercepts a tiny, inactive sump linked to the inaccessible active network of the fossil maze.

In Great Hall's western part, following a wide 14-m-long gallery, it extends to the René Jeannel Hall, the next large hall (55/22/45 m) in Coiba Mică-Coiba Mare cave network. The most important gallery starting from this chamber is a 106 m long slide, a 30-60 degrees ascending slope, difficult to explore it due to moonmilk. At the Big Slide's upper end three rooms are developed, disposed at high levels. The highest point reached in the Coiba Mică-Coiba Mare cave network is White Hall at +49 m. The Big Slide rises to 85 m above René Jeannel Hall. At +4 m in Great Slide opens the 438 m long Small Maze, having the same morphology as that of Great Maze. We must mention two karstic items: a 70 m long active gallery passing above Grand Hall's watercourse and a 37 m deep pit communicating with Great Hall. Above this pit it is rising a 13 m tall chimney; a 50 m drop fragmented in two parts. The 37 m pit is linked to the 124 m long galleries of the Cheating Maze.

The secondary watercourse crosses Great Hall and reaches after 137 m in the active gallery the Open-Sump (a 2 m long ceiling lowered to 0.5 m). After Open-Sump the cavern's morphology changes. The maze portions are missing and the active galleries build the network. After their joins to the mainstream in the Confluence Hall, the united watercourses flow about 386 m, in an 15/20 m imposing gallery to the terminal sump (Death Lake) at -72 m. On this 386 m long segment of the cave, the active gallery receives only one notable 53 m long tributary, and it develops a top floor, represented by six galleries, the longest having 70 m. An escalade of 17 m upstream of Lake Death it is intercepted the last 23 m long fossil segment of the cave. From here, through another 15 m drop, we reach an another sump lake at −72 m, closed completely. The distance in plan, between this sump and the Lake of Death, is only 14 m. In 2014, scuba divers dived the terminal sump (Death Lake), Sump no 2, through a surprising 200 m long gallery with several 1/5 m sections and a negative slope, to the depth of -92.5 m and the gallery still continues (Pereţ & Drăgan 2016). In conclusion Coiba Mare cave has one of Europe's deepest sumps.

Figure 14. Phreatic morphology in the Great Maze of Coiba Mare cave (Photos by Liviu Vălenaș, 2019).

Figure 15. Phreatic morphology in the Great Maze of Coiba Mare cave (Photos by Liviu Vălenaș, 2019).

Figure 16. Phreatic morphology in the Great Maze of Coiba Mare cave (Photos by Liviu Vălenaș, 2019).

The Coiba Mică - Coiba Mare cave system is developed on a horizontal distance of 585 m (not sump no 2) and has a branching coefficient of 10.9, one of the highest figures for the endokarst of Romania. This high figure is for the Coiba Mare cave entrance's maze, which has 3,873.5 m and means 60.5% of the total cave network. This maze develops on a horizontal distance of 225 m, with a branching coefficient of 17.2. The remaining 31.8% (i.e. 1,806.5 m) of the cave network it is developed on a horizontal distance of 550 m, with a branching coefficient of 3.5. These figures prove that the Coiba Mică - Coiba Mare cave network comprises two distinct parts: a poor-branched active part, and a multiple-branched fossil labyrinthine part.

Geology and tectonics

The cave network Coiba Mică - Coiba Mare is developed in the fractured-limestone of Upper Jurassic age and in a frail tectonic of Saxon pattern. It is obvious on the cave's map that the galleries are developed along two-main-fractures: NE-SW and NW-SE, resembling a chess-board pattern. On the surface it may be recognized this tectonic pattern in the Gârdişoara - Gârda region.

Morphology and genesis

The Coiba Mică - Coiba Mare caves network is created from the water loss in distinct stages of Gârdişoara Valley. At beginning, losing water in the river-bed created the phreatic tubes maze in the Great Hall of Coiba Mare cave. Later, the two-stages sinking of the groundwater table shaped a two-level maze of galleries at 30 m high. The arrangement of phreatic tubes is in an angled plane and 50-m-deep wells make the access between the two epiphreatic levels. This model of tubes and wells from Coiba Mare cave is similar to the D.C. Ford's model for the Mendip region of England and named as phreatic-loop by D.C. Ford (Ford 1965, 1971). The valley has further deepened its bed and resulted in a fossil maze in which the re-shaping in vadose-regime stopped. The current entrance to Coiba Mare cave captured the valley through a vacuum capture- a theory imagined by M. Bleahu (1957). Then, the insurgence moved 370 m upward in the valley, i.e. the present entrance of the Coiba Mică cave. From that moment, the vadose regime re-shaped the cavern current active galleries. As regards the Great Hall (95/47 m) of Coiba Mare cave, a major north-south oriented fault disturbed the stability of the strata, resulting in their collapse and it created the hall. Then, dissolving emptied the hall of limestone blocks.

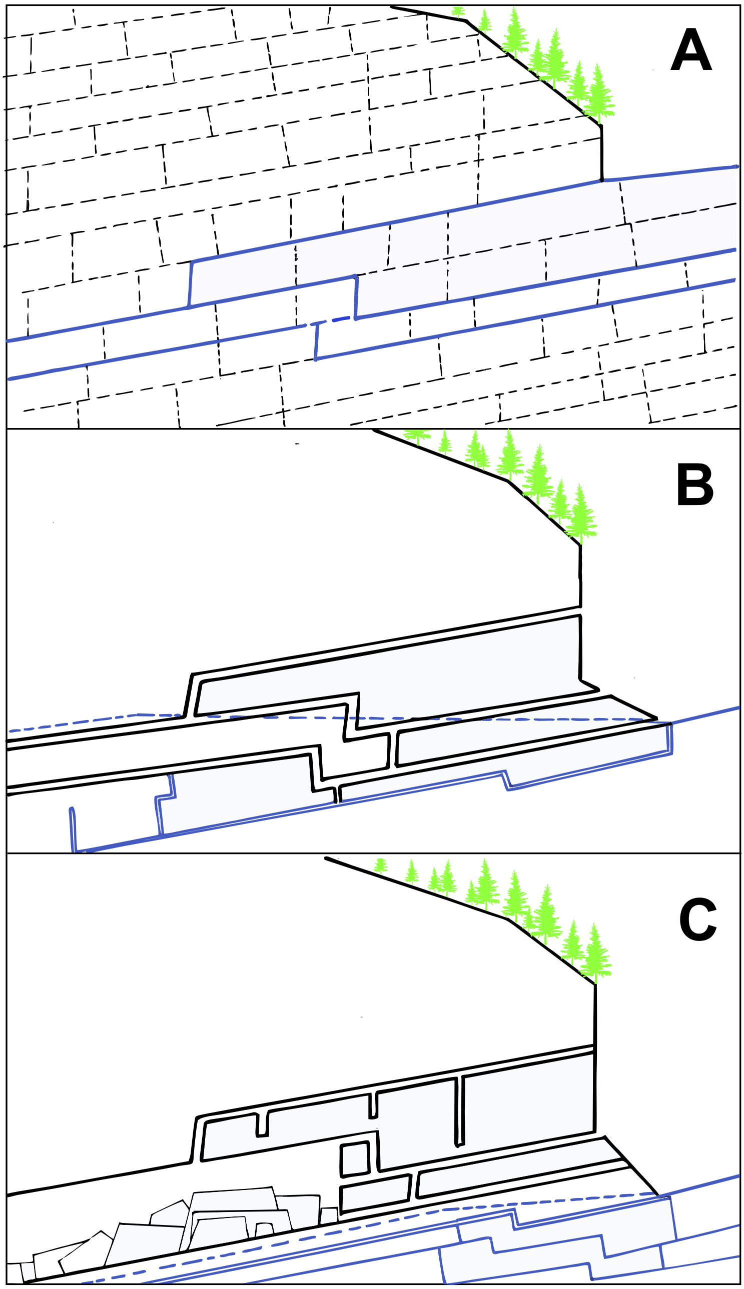

Figure 17. How formed the Great Maze and the Great Hall in Coiba Mare cave (Graphic by Liviu Vălenaș, 2019).

Figure 18. Izbucul Tăuz spring (Photo by Adrian Pereț, 2014).

Hydrogeology

The cave network of Coiba Mică - Coiba Mare has several active water courses. A 925 m long course drains Gârdişoara Valley through Coiba Mică cave and includes the sump where it dived 200 m. Then, a 317 m long secondary stream getting out from Coibiţa Spring and after only 49 m on the surface it penetrates into Coiba Mare cave through the large 74 m wide portal entrance. Coibiţa effluent drains the karst from the NW part of the Vârtop plateau. Both active courses, after their uniting in the Confluence Hall, receive eight other small tributaries with lengths up to 85 m, coming from infiltration water, and a high flow tributary that comes from the Black Sump. The last one drains the SE part of Vârtop plateau and caves from Colibi and Orbului Creek, according to a fluorescence marking performed in 1980. The drain of the entire caves network Coiba Mică - Coiba Mare is through the great Tăuz spring, at a horizontal distance of 2600 m (1900 m from sump no 4 of Tăuz) from the final sump in Coiba Mare cave. In 1978, L. Vălenaş (1978) imagined a theory for the last underground watercourse saying that the water flow alternates the vadose regime with that one under pressure, through very deep sumps. Finnish divers validated that theory in 2014.

As a curiosity, in Coiba Mare cave there are two active galleries that extend one above the other. A tiny stream of the Little Maze, going over the water course of Great Hall. Through the Tăuz spring, it drains water from the Colibi cave. So, the whole hydrogeological network has a horizontal length of 3500 m and an elevation of 430 m (513 m, considering the sump 2 of Tăuz).

Climatology

The temperature inside the caves varies between 4.1 and 5.0 ˚C (4.1 ˚C has been registered in René Jeannel Hall on November 15, 2019). Humidity is over 90% (92% - René Jeannel Hall, November 15, 2019) and the cavern is strong ventilated. In winter time, in Great Hall at the cave entrance and in the most of Great Maze, the air temperature is between -5.0 and -10 ˚C , which leads to spectacular ice formations (stalactites and curtains up to 12 m high).

Comments

The caves network Coiba Mică - Coiba Mare is a unique cavern system in Romania, because of the 3.8 km long maze of phreatic tubes. The epiphreatic flowing created this maze (Vălenaș 1978). In 2018, C. Ciubotărescu and B. Onac (Ponta & Onac 2018) thought to a deep-phreatic pattern for the maze genesis, but they visited only the periphery of the maze. Genesis for the rest of the caves network is a vacuum capture of water imagined by M. Bleahu in 1957 (Bleahu 1957). The karst beneath Gârdişoara Valley sucked firstly the water stream through the swallow-hole Coiba Mare, then through the now-clogged pit near Coiba Mică cave and finally through the swallow-hole Coiba Mică. Today, a 35 m and 12 m antithetic steps divide the Gârdişoara Valley. Climatic oscillations in the Pleistocene and Holocene changed the river valley. An interlude of catastrophic rainfall, determined a temporary clogging of the Coiba Mare cave entrance, and resumption of subaerial course by the Gârdişoara Valley. We acknowledge M. Bleahu's ideas on the periglacial act in the full cavern genesis (Bleahu 1964).

Sohodol II Pit, a classic of the alpine speleology

Sohodol II pit is one of the deepest pit cave of Romania. Its depth of 193 meters and its 20 vertical shafts, give to it the status of European alpine pit cave. The physical dimensions are: total length: 507 m; depth: -193 m; extension: 74 m.

History of exploration

In September 1979, R. Sima, R. Părăliște and Z. Tabără from Turda City's Caving Club „Casa de Piatră" discovered and explored Sohodol II Pit to a depth of 37 meters. R. Sima, L. Pop and D. Felea resumed the pit research in June 1980. They halted at -92 m by equipment problems at the deepest pitch, P38. Consequently, R. Sima signed an agreement of exploration with Speleological Club „Z". On September 2, 1980, Liviu Vălenaș, Radu Sima, Lucian Pop and Dan Felea reached -193 m, the bottom of the pit cave, and surveyed the cavity. All action lasted less than 12 hours.

Description of Sohodol II Pit

Sohodol valley hosts the Sohodol II pit at 1150 m above sea level on the left slopes, at 40 m height above the bottom of the valley. The pit is 2,5 km upstream of Sohodol valley confluence with Gârda Valley (Gârda Seacă). The Sohodol II pit entrance is on the mountain rim. The interfluve has on opposite slopes (between Gârdişoara and Gârda Valleys), exposing the entrances to cave Coiba Mică-Coiba Mare (6400 m total length), Oilor (545 m length) and Băroaica (70 m length). Set in limestone pavements, the entrance of 0,55 m/0.40 m in Sohodol II pit enables the access to one shaft of 25 m depth (P 25). This shaft is like a cone. Following an accumulation of timber forming an unstable plug, a sloping gallery of 10 m continues through a vertical pit of 3.8 m (P 4) to a chamber of 2 m/2 m/7 m. From this room (-33 m depth), the cavity continues through a near horizontal gallery to the next shaft (P 34). The gallery has narrow passages and corallites. The stones' collapse produced a chaotic landscape of false „loops". One of them is Dan Felea Chamber, 11 m/4 m/17 m.

At -40 m depth, is situated the opening of the second big overhanging pitch (P34) and at -54 m with a slight balancing of ropes, a platform may be reached. At -74m, the base of this shaft has a section of 7 m/4.5 m. After a short horizontal passage, a 45° galley with a 1m /4 m section continues immediately with two 8 m and 9 m overhanging vertical pits (P 8 and P 9) and has the access to a room of 8m/4m/14m, at -92 m depth. On the southern part of this hall is the opening of the biggest overhanging pitch of 37.7 m depth (P38). Like in P 34, a slight balancing at -110 m, allows reaching a good platform. The base of P 38 is wide of 7m/6 m (-130 m depth).

From this depth, the morphology of the pit cave is slightly changed, the shape of the cavity resembling a 'canyon' gallery. Although the vertical pits chains up to the final depth of -193m, they are of small size (generally between 2 and 4 m). Thus three negative steps (2.5 m, 3 m, 3 m) lead to a pit of 4.7 m (P5). At -150 m depth, following to three negative steps (between 1 m and 2.2 m), the orientation of the cavern is changing from N - S to SE - NW and stays up to -193 m depth. However, the morphology of the cavity remains the same. From -150 m depth, it

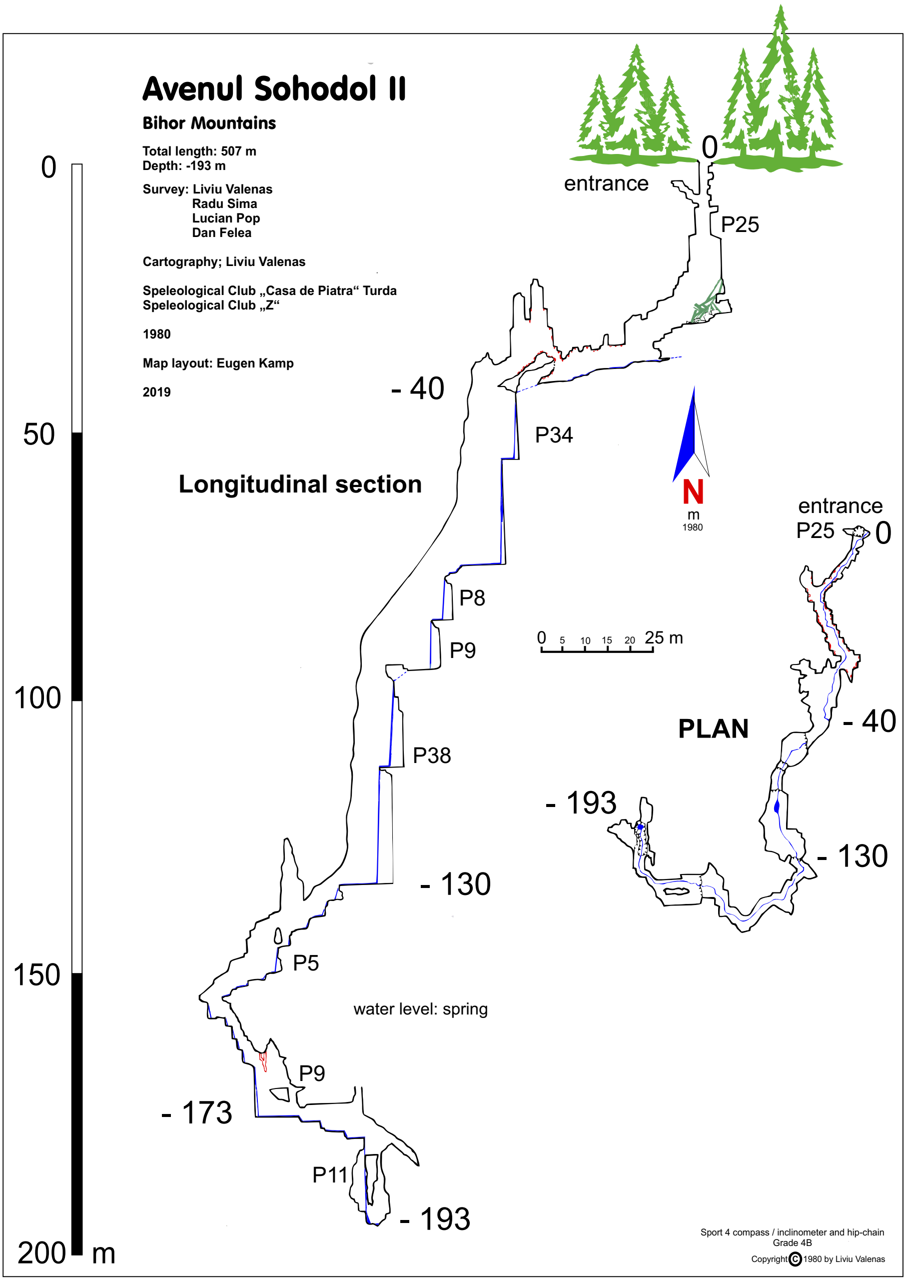

Figure 19. Sohodol II pit, longitudinal section and plan (Cartography by Liviu Vălenaș, 2019).

reaches -164 m depth through negative vertical steps, the biggest of which are 3.8 m, 3.0 m and 3.4 m, respectively. A slightly deeper pitch (P9) follows in a hall of 6m/3 m size at -173 m depth. This hall has the stone pillars resulted by contacting of parallel pits. From here, there are two ways ahead: a narrow canyon and a clay gallery in the top (with a section of 0.6/0.6 m) called the 'corkscrew'. Following four negative steps of 1 m, 0.2 m, 1.8 m and 1 m, a vertical pit of 3 m (P 3), extends in the Puțul Imposibil Hall (-180 m). After a 10.4 m shaft (P 11), followed immediately by another pit of 2.5 m depth (P 3), it reaches the bottom of the Sohodol II pit at -193 m depth. From this point there is not any hypothetical possibility of going deeper.

The development of Sohodol II pit is 507 m. 62.7% are vertical shafts, and 37.3% horizontal and angled galleries. Must underline the depth of 193 m is a chain of vertical pits only. It is an unusual case in the Bihor Mountains. Another note is about the short gap between vertical shafts(e.g. from - 40 m depth downwards the maximum break is 7 m). The pit cave has a unique verticalness and a total extension of 74 m. This morphometric depicts an alpine pit.

Geology and Tectonic

From the lithological point of view, the pit is developed in the Early Cretaceous limestone of Barremian or Aptian ages. The pit, however, extends probably into the Tithonic limestone at the bottom of the pit. The study of geologic sections might prove this theory. Sohodol II pit is developed along rock fractures, into a similar network of cracks like Coiba Mică-Coiba Mare cave system did.

Morphology and Genesis

The basic rock is visible everywhere inside the cavity. Dropping stones and clay deposits are not characteristic. From the -150 m downwards, it can see common speleothems. Typical pots often develop at the bottom of the vertical shafts. The morphology of the Sohodol II pit presents a transition from the phreatic pattern to the 'vadose flow' (mostly typical canyons and pots).

Hydrogeology

A permanent water spring from percolation, flowing from -33 m depth, defines the pit hydrology. The water supply mode is liable for steadily increasing of the flow rate up to -193 m depth. At the time of the last exploration (September 2, 1980), the flow was almost negligible. The water flow rate is possible to increase to one liter/sec or more in the spring or in the flood time. At -193 m, the water is collected in a small basin, without any obvious drainage. The drainage must exist, but it is weak.

Until now, we do not have consistent data on pit drainage. However, the location of the pit is in the proximity of the underground river of Coiba Mică-Coiba Mare system, and it makes us to believe that the pit continues, into the aquifer having the exit in the Tăuz resurgence. The air distance between the entrance in Sohodol II pit and Izbucul Tăuz resurgence is 2500 m and an altitude difference of 300 m (1150 m - 850 m above sea level).

The aerial distance is small between Sohodol II pit's bottom and the terminus sump of Coiba Mică-Coiba Mare cave system. The two ‚terminuses' are at the same altitude above sea level (957 m- bottom of Sohodol II pit and 956 m - the terminus sump in Coiba Mare cave). We supposed that Sohodol II pit is connected to the Izbucul Tăuz resurgence as the ‚base level' but this does not happen. In reality, Coiba Mică-Coiba Mare system drainage is the ‚base level'. There is no doubt that the geologic appearance of the terminus area in Sohodol II pit indicates the reaching point of the ‚base level'. Here is another search added to many others who question the concept of 'base level' in karst. In my opinion, this aspect of flowing finds its explanation in the parabolic curve under which the flow of water through limestone is generally carrying out. The ‚base level' for a drain of type 2 is the drain of type 1, to which water flows gravitationally. Sohodol II pit no doubt is a drain of type 2.

Climatology

The temperature inside the pit cave is a 4.4 - 5.0 degrees Celsius and humidity over 90%.

Comments

Sohodol II pit is developed first in the deep-phreatic regime, and then it is continued in a vadose flow along the main geological faults. From the morphologic point of view, the cavity is a typical alpine pit, excavated in the steady rock, without alluvial deposits.

Hodobana Cave, a unique maze in Europe

It is one of the largest (22,142 m total length) cave of Romania occurring in compact limestone of Jurassic age and resulted from the water-intake of Hodobana Creek on an aerial length of 812 m. The physical dimensions are: total length: 22,142 m; depth: 181 m (-121 m, +60 m); extension: 812 m; total length/extension: 27.3.

History of explorations

In April 1979, Florin Păroiu and Nicolae Sasu looked for access to the underground watercourse between final sump of Coiba Mare cave and Izbucul Tăuz spring. By chance, they found a tiny hole in one slope of Hodobana Creek, a tributary of Sohodol Valley. The entrance in the cave had only 1m/0.8 m and did not encourage the cavers, but a stream of air gave hope. After 13.5 m of a severe, upward crawl, they reached a tiny hall plenty of boulders. The air current blew weakly between floor stones. An easy removal of stones and a 2.5 m drop created access through rock boulders. They entered a 37 m long horizontal gallery (Subway Gallery) and then into a larger room - Florin Păroiu Hall. A confusing landscape, small drops, and squeezing paths led them to the edge of a large-size shaft - the Hope Shaft, 28 m deep where they stopped. Speleological Club "Z" organized a new campaign in August 1979. Nicolae Sasu, Florin Păroiu, Éva Györfi and Nicolae Paul descended the Hope Shaft. They crossed through a small phreatic gallery and through several tiny drops and reached the final sump at 150 m in depth (later mapped at -119 m). These first explorers of network appreciated cavity length at only 2 km.

In September 1979 Liviu Vălenaş decided to explore and survey the giant maze and took two revolutionary decisions using single-rope techniques and teams of two or three cavers. Together with Éva Györfi, he mapped the access up to final sump at -119 m depth. In October 1979, Liviu Vălenaş and Nicolae Sasu did a new campaign. After lowered to the 28 meter deep shaft in Gothic Hall, they walked upstream on the same course and mapped downward to the final sump. Climbed free a 4 m high waterfall, passed through a meandered route including Dante Hall and stopped above Mammoth Hall on the edge of a 20 m drop. An inclined plane avoided the drop and allowed free descend. The next four campaigns of mapping proved Hodobana cave being developed in the upstream watercourse with many floors. After the first 3-4 levels mapped, other floors have been discovered (24 floors in total including the intermediate levels). Exploration came to an end in October 1979 by lack of people. The solution was to join forces with other caving clubs or singles. Cavers from Romania and abroad came and helped Liviu Vălenaş to map the cavern. These caving clubs are "Emil Racoviţă" Bucharest, "Speodava" Ştei, "Flacăra" Iaşi, "Casa de Piatră" Turda, "Hades" Ploieşti and "Cristal" Timişoara from Romania and "ZHKTJ" Katowice from Poland. In December 1979, Liviu Vălenaş, Horia Mitrofan, Nicolae Stoica-Negulescu and Rodica Stoica-Negulescu explored Mammoth Hall and forced a squeeze to several fossil levels. Then, they discovered a 20-meter-wide shaft and descended it to a big underground river. A few days later, Liviu Vălenaş, Constantin Gagea, and two Polish cavers descended again to the big river hall. They explored the watercourse to an impenetrable sump. Then, explored a 1020 m-long, meandered, and tight gallery on upstream course to an ending hall. In Terminus Hall it is a final 30 m high waterfall, and that team did not climb it. The ground surface is near to it. In February 1980, Liviu Vălenaş and Dan Nanu explored the Eastern Side. It is a fossil network (Slave Canyon, Wind Gallery, Dan Nanu Gallery, a.o.), representing a distinct part of the cave. Here are the most stunning speleothems and the largest galleries in diameter. During the 1980 year, the superior floors of the Hodobana cave have been mapped. There are 6 to 8 main floors and three times more secondary floors. In October 1980, Hodobana cave measured 15,752 m in length. During 1981, Liviu Vălenaş and Caius Tenţ discovered the continuance of Great Tributary. They mapped near 2 km through a new stream and its upper floors. It was the last important discovery in Hodobana cave. In 1981, the cave recorded 22,042 m of development. The discovery of a small upper floor by Liviu Vălenaş & co. in 1987, added to the cave length a new length, unchanged until today, of 22,142 m. In the year 1983, Liviu Vălenaş, Caving Club “Speodava” Ştei (Petru Brijan and Ovidiu Cuc), and Cristian Lascu organized scuba diving into the final sump at -119 m. Cristian Lascu dived and explored the sump on 5 m distance and 2 m in deep. The sump was tight, the water muddy and without visibility. The safety made him renounce. There is no hope of passing through this point to the underground river between Coiba Mare cave and Izbucul Tăuz spring.

A Polish team together with Nicolae Sasu climbed a 60 m high slide from the Coralloids Gallery. They used bolted anchors and reached a bottom bag near the surface. It is the greatest cavity positive elevation reached by cavers. Hence, Hodobana Cave has a total elevation unevenness of 181 m (-121; + 60).

Later, Petru Brijan tried to climb the 30 m high waterfall from the Terminus Hall using a climbing platform and bolts. He and Liviu Vălenaş transported in harsh conditions, a massive steel platform! Petru Brijan abandoned after climbed 10 m. A few months later, two Polish cavers used same the platform and bolts but abandoned after 20 m.

In 1983, Liviu Vălenaş completed the large map of Hodobana cave, at a scale of 1:200. In February 1984, Museum of Oradea City held a public meeting showing the map. After 1987, no one ever reached the final point of the cave. European cavers agreed that orientation inside the cave is impossible.

Description

In the middle of Gârda (Gârda Seacă) Valley, Hodobana cave opens into Hodobana Creek‘s right slope. Hodobana Creek is a tributary of Sohodol Valley in the river basin of the Gârda Seacă Valley. The first two valleys are karst-valleys,

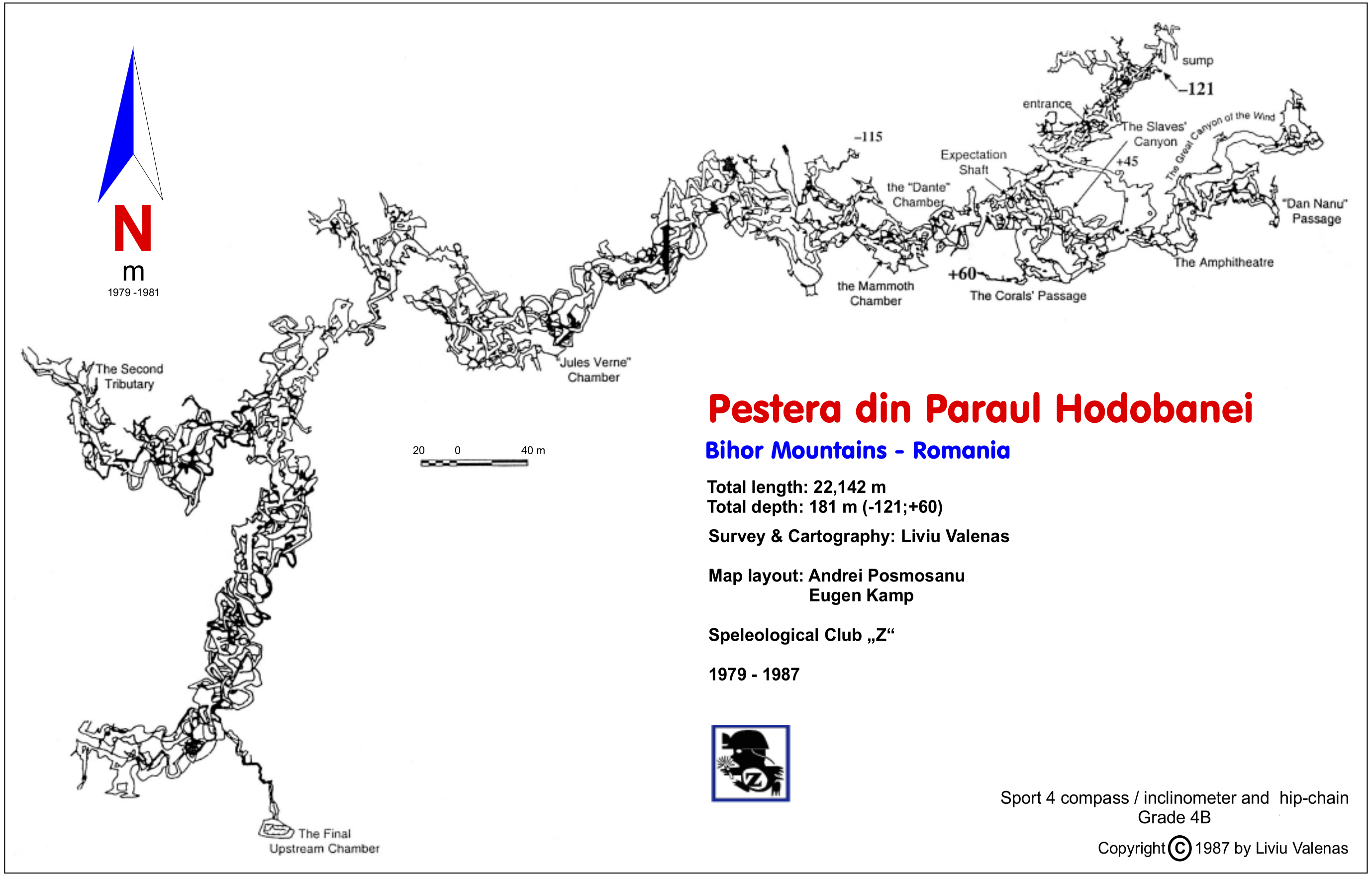

Figure 20. The plan of the cave from Hodobana Creek (Cartography by Liviu Vălenaș, 2019).

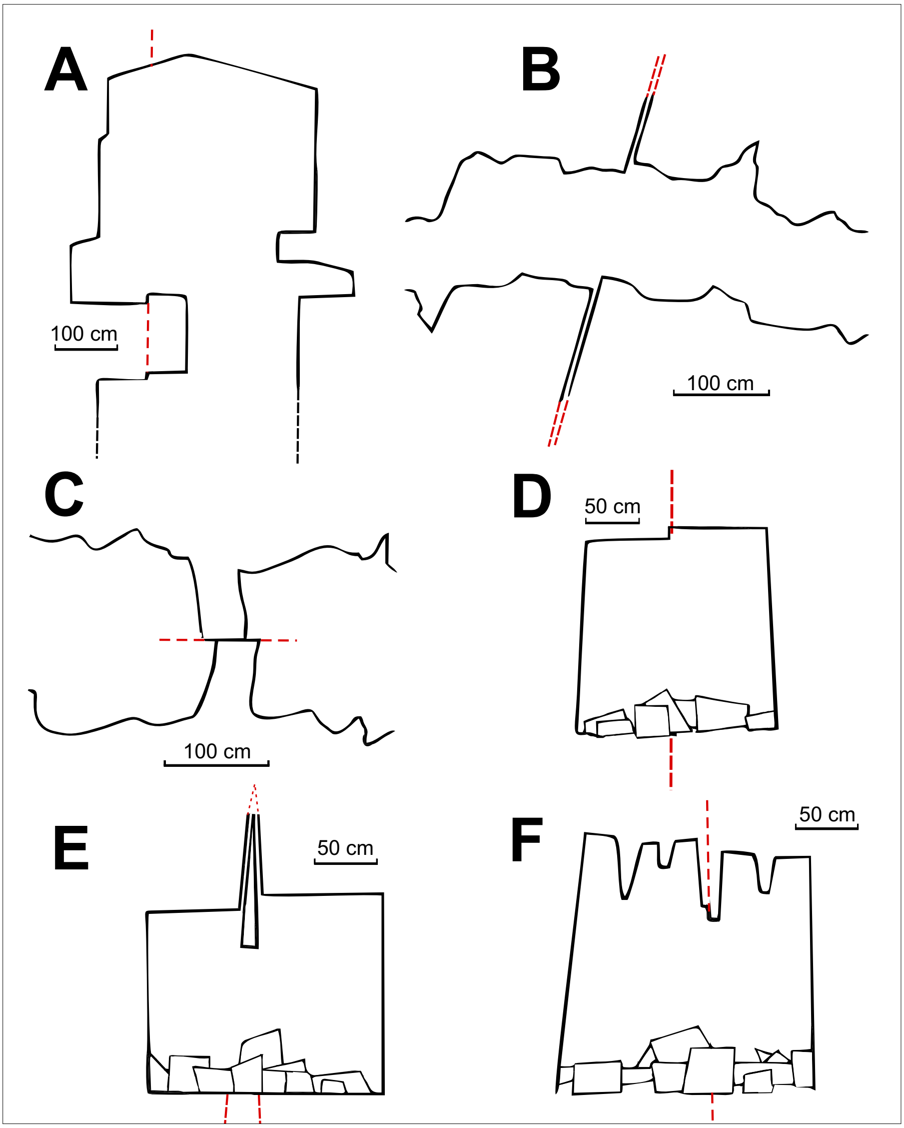

Figure 21. Active tectonics in the Peștera din Pârâul Hodobanei cave (Graphic by Liviu Vălenaș, 2019).

so-called "sohodol" - with no surface course and gorge up to 80 m high. The cave entrance has an elevation of 20 m above Hodobana Creek, and an altitude of 980 m above sea level. The cave is developed in E-SW direction. The water loss in Hodobana Creek, Hoanca Fileştilor Swallet and neighbouring sinks, created the three underground courses up to 1020 m length each.

The entrance into the underground network is small (1 m/0.80 m). After a 13.5 m long slightly ascending gallery, it continues in a small chamber of 5 m/2 m/1.5 m full of boulders. Through a 2.5 m-deep shaft, it reaches a small maze, followed by a 37 m-long and 1 m-high straight horizontal gallery, the Subway Gallery. This gallery is connected to a larger room, Florin Păroiu Hall and the continuance is confusing. It crawls along a new low passage, Hedgehogs Gallery, which opens in a broader space. In the left side, it ascends 50 m-high on Coralloids Gallery, the highest point of the network (+ 60 m). In the front-right, it is a slide descends to Hope (Speranţei) Shaft, 28 m-deep. Little to the right, it reaches the upper part of Slave Canyon, which allows shorting of the 28 m-deep shaft through a free descending. To the right, Slave Canyon, tight and challenging, extends into the Eastern Side. It is the fossil part of Hodobana Cave measuring 1.5 km of large galleries including Amphitheater Hall, Wind Gallery and Echo Gallery. The last one is a descending water slide with a unique acoustic in Romania. Eastern Side has the most stunning speleothems in Hodobana cave. Noteworthy a chimney is connected to the surface, the air stream and fir-tree roots prove this. From the bottom of P28, it descends to Gothic Hall. There on the right hand, a small-sized phreatic gallery hosts a stream that flows 6 m to a muddy sump. It is the deepest point of the network, -119 m (by diving, C. Lascu, -121m). The main continuation of the network starts with a free climbing over a 4 m high waterfall upward to Gothic Hall. In Hodobana cave 24 levels are developed on 6-8 core floors oriented on the west-southwest. It follows Dante Hall. A medium-sized rocky chamber. Through a negative angled phreatic tube with clay reaches the largest cavity of the network, the Mammoth Hall, full of boulders, 57 m long, 20 m wide and 42 m high. The top cave floor passes above this cavity and through a window can descend into the middle of the hall on a 40 m rope. It is the biggest cave vertical. A small stream disappears from this chamber into an impenetrable sump. The cave continues through the hall on the western side. It passes through a squeezing passage and then it continues as a step of 15 m high to a superior gallery with concretions. On the superior levels, it passes through “Storm”- an ascendant squeezing earth-floor passage where met the mightiest air blow and it reaches the top of Great River Hall, from where is a descent in two-steps of 20 m each direct in the hall. Downward, Great River ends in a rocky and impenetrable sump. The stream flow rate is 10l/s the biggest by far. The Great River flows along a meandered low level. The gallery has several cut meanders of 30-40 cm width and 1020 m length. After 200 m, a small 3 m high waterfall from the right side, announces the Great Tributary. The new gallery is 250 m long and multi-floored (over 2 km long). Great River continues its way and before its end is a junction, on the right side, with a

100 m long and low gallery. From here, the watercourse follows a narrow gallery ending in a 30 m high room with a waterfall coming from the ceiling. It is Terminus Hall at 2020 m from the cave entrance. Here, the ceiling has only few meters to surface. After Damm & Moréh (2011), the final waterfall originates from the nearby Hoanca Fileştilor Swallet.

Geology and tectonic

Hodobana cave develops in fractured-limestone of Upper Jurassic age. It is obvious in the cave's map that the galleries develop along two-main-fractures: NE-SW and NW-SE, somewhat in a "chessboard" pattern. At the surface it can recognize this tectonic pattern in the main faults and joints of the Gârdişoara-Gârda region.

Active tectonics

The cave from Hodobana Creek is adequate for the study of active tectonic in endokarst. We can define many forms, separated by morphology and forming mechanism. Below are these cases:

1. Galleries fractured on vertical

There are "micro-faults" (Fig. 21D), forming a tract of 5-10 cm, visible along the top of various galleries (cannot see it on the floors because of rubble or alluvial components). The morphology of ceilings shows separation occurred after the excavation and shaping of the galleries (on both sides of the micro-fault line are the same corrosion forms and speleothems).

2. Galleries fractured on horizontal (strike-slip faults)

This case (Fig. 21B) is more widespread in Hodobana cave than the last one. It is exposed in the gallery as a fracture that moved on the horizontal in opposite directions, often at a 60-80° angle, having a bigger displacement (10-30 cm) than the vertical faults case. The fault line spread from one wall to another and is a large crack unshaped later by corrosion and decompressed to 1-2 cm (often with friction mirrors).

3. Rock benches or terraces fractured on vertical

These refer to vertical oscillations of the gallery wall (Fig. 21A), divided on vertical by "micro-faults". The most prominent pattern is a rock-bench suspended at 18 meters above the Great River bed having the front taller with 5 cm than the inner part near the wall. This is not a local or gravitational event, but related to active tectonics.

4. Segmented pillars or corrosion blades

Micro-faults have sectioned on vertical these morphological forms (Figs. 21C, F) created in a phreatic regime, while the “micro-strike-slip faults” shaped them on horizontal.

5. Blades of rock distended

They (Fig. 21E) are frequent in the cave of Hodobana and are an odd form. It is a thin limestone blade (5-10 cm wide), lowered by gravity through friction between reactivated strikes between two “micro-faults”. Distended blades displaced on horizontal are rare.

6. Friction mirrors

Friction mirrors appear either from the reactivation of the original mirrors (and then polished) or are later mirrors produced by moving of “micro-strike-slip faults”. It is a normal form in Hodobana cave.

7. The crush of ceilings

This case has nothing to do with active tectonics, but within Hodobana cave is a specific feature generated by “micro-defects” and “micro-strike defects” that have destroyed the balance of limestone beds. The irreparable effect is a huge collapse of the rocks that lead to the closure of the galleries and the chambers.

A further detailed study can develop the forms described. We must notice the similarity with forms from the Occidental Tatra Mountains, Poland (Grodzicki 1970).

Morphology and genesis

Hodobana cave resulted from a progressive underground Hodobana Creek loss. The cave has been developed on the right slope, parallel to the actual valley, and it is near to the surface. Its genesis relates to Hodobana river bed water infiltration and to meteoric water loss in the large sinkholes and Hoanca Fileştilor swallow-hole from valley‘s origin watershed (Damm & Moréh 2011). The cave it is formed into a bati-phreatic regime, being immersed. The upper fossil-floor exhibits many elliptical sections and a great break of limestone because of intense tectonic. As a curiosity, this bati-phreatic gallery has no speleothems. The cave network at the beginning had one kilometer in extension. The eastern Side of Hodobana cave is a paleo-watercourse to a paleo-resurgence in Sohodol Valley. Between the Hall of Collapsed Stones and the surface is a distance of 100 or 150 meters but the paleo-resurgence did not find yet. In geological time, total loss of Gârda river moved downstream to Izbucul Tăuz spring (850 m altitude). The relevant

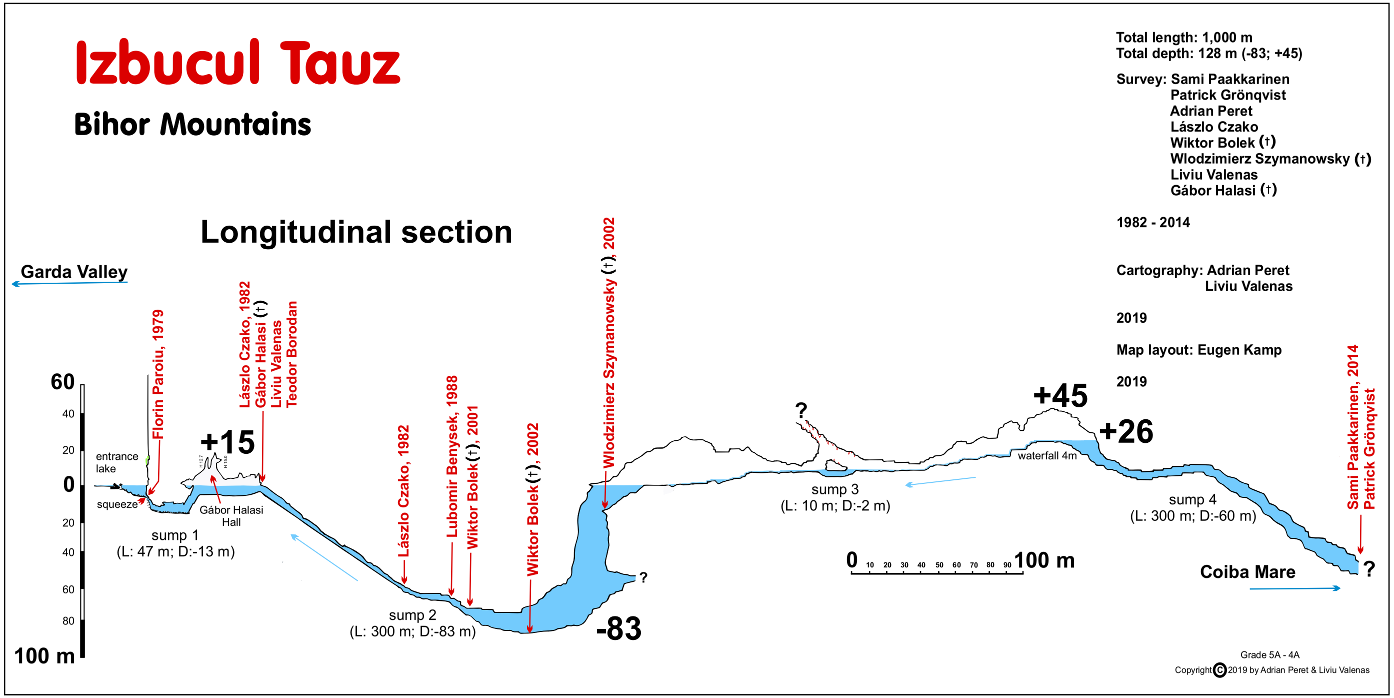

Figure 22. Longitudinal section through the Izbucul Tăuz spring (cartography by Adrian Pereț & Liviu Vălenaș, 2019).

underground course has moved beneath the Sohodol Valley and had an enormous impact on Hodobana cave. The paleo-watercourse of 2000 m long, has been separated into three major sectors and captured by the Izbucul Tăuz spring. The cavity passed to a vadous regime because Tăuz spring is at 140 m elevation below the Hodobana paleo-resurgence from the Sohodol Valley. Effect of the vadous regime is a remarkable multi-floored network, unique in Europe. Many of the floors are of the same gallery with narrow erosion levels filled with alluviums, collapses and speleothems.

Hydrogeology

Coloring of the watercourse was not yet done for Hodobana cave. But, without doubt, the three main underground watercourses drain through Izbucul Tăuz spring because the cave and the resurgence are in the same geologic unit, Tăuz Hill. Tăuz spring has a flow between 0.530 and 10 m^3/s at floods. Beyond small final sumps of the three main watercourses, the flow is changing to a phreatic regime until joining to the big groundwater stream between Coiba Mică cave and Izbucul Tăuz spring. A coloring or marking of water could prove it. For illustration, between the final sump from -119 m and Tăuz resurgence (850 m altitude) are only eleven meters elevation unevenness on an aerial distance of 800 meters and it sustains our hypothesis for a phreatic drainage regime. In 2014, two Finnish cave-divers, Sami Paakkarinen and Patrik Grönquist succeeded to dive at 83 m depth in the Tăuz spring sump no 2 and found a vadose stream, climbed a waterfall of 4 m and explored several hundreds of meters to the sump no 4.

Climate

The temperature of the air is 4-5 degrees Celsius. The cave is highly aerated, with many vented spaces. Humidity: over 90%.

Mineralogy

Hodobana cave is one of the richest caves in stalagmites and calcite crystals. They develop in the upper fossil-floors and in Eastern Side. Besides calcite, no further minerals have been identified. Galleries with watercourses and large halls affected by stones collapsing have no significant formations.

Evolution of the Gârdişoara Valley

Gârdişoara Valley (Gârda) is an epigenetic valley that deepened in the Bihor unite until the interception of the Upper Jurassic massive limestone stack. This valley had an underground watercourse for a long time through these limestones, digging a canyon, of which today there is only the right slope conserved. The first loss in the underground was represented by the Băroaica cave, then the insurgence was moved a little further upstream, in the Oilor cave, both caves being suspended today, at 60 m relative altitude above the valley. These are fossil caves, with no active flow. It is possible that these two cavities have communicated each other in the past, as the Coiba Mică cave communicates with the Coiba Mare cave. We believe that the so-called „vacuum intake" as imagined by M. Bleahu (1957) was the main intake mechanism of the Gârdişoara River to underground. The proof that these two caves have the old insurgences of the Gârdişoara Valley, are the presence of quartzite pebbles, discovered by the present author in 1974 in these cavities, pebbles that could only come from the unkarstifiable-rocks-belt, which is 2 km upstream. Somewhat surprisingly, the Gârdișoara Valley left at one point these two caves, again for a long time, deepening with almost 60 m in the limestone bed. Probably a very humid climate allowed the transport of a huge amount of alluvium in these caves until their entrances were clogged. Later, by the erosion of the right slope of the Gârdişoara Valley, these entrances were re-opened again.

But the Gârdişoara River activated a new water loss, about 700 m in upstream, the current entrance to Coiba Mare cave. Here, however, the process was much more complicated, with three important phases. First, using exclusively the stratification faces of the limestone bed, a groundwater aquifer created, the proof is the huge maze of groundwater pipes (unique in Romania) from the entrance to Coiba Mare cave. The Gârdişoara Valley went underground again, into a second step, the water flow being exclusively under pressure. A new climate change caused the water course by 30 m underground, resulting in a second level of phreatic tubes. In these two phases we are convinced that Tăuz resurgence didn't existed, but another resurgence, closer, fossil today, which we could not yet discover, probably being totally clogged.

The third phase was the abandonment by the Gârdişoara River of the maze of groundwater pipes flowing in a vadose regime through Coiba Mare cave. Through the same vacuum caption, Gârdişoara River activated a new insurgence, at 370 m upstream, Coiba Mică cave. Instead Coiba Mare cave was still used, but only the median sector. At present Gârdişoara River is activating a new insurgence up, known as Ponorul din Crestătură, located upstream at 700 m from Coiba Mică cave. However, because the limestone bed continues 1.5 km downstream of the Izbuc Tăuz, it is possible that a new resurgence may be activated in the geological future further downstream. The underground system of the Gârdișoara Valley has a clear tendency of spatial expansion, both upstream and downstream.

Conclusions

The studied area is a spectacular example of karst multiple intake areas, the most important being the Gârdişoara Valley. The main cause of these recharge areas are without doubt the successive climatic changes, which have taken place from the lower Pleistocene to the present. From this point of view we can only rally to the conclusions reached by M. Bleahu (1964) regarding the role of the periglacial in the karstification processes in Bihor Mountains. A recent example reinforces this hypothesis. Coiba Mare cave had, for at least 100 years, at 95 meters from the entrance, a so-called opened sump 1, a part where the ceiling was lowered only 50 cm from the active course. In the last years, after the year 2000, the periodic floods (a consequence of global climate change) have simply cleaned the underground trough of the Secondary Course in Coiba Mare cave, today the ceiling is found not at 50 cm high, but at 3 m!; the opened sump 1 simply disappearing. Regarding the initial formation of the Coiba Mare cave, we see an almost perfect similarity with the theories of Ford (1965, 1968, 1971). The initial phase of a karst aquifer, after the latter is the formation of anastomoses on stratification faces. The water is forced, under pressure, to flow according to the inclination of the layers, until the hydrodynamic laws require the water, pushed by force, to ascend. In Coiba Mare cave these are easy to see, at present there are wells that connect with the different levels of groundwater tubes. Generally, many of these wells, which the Romanian speleologists wrongly believe that they were created into a vadose regime, are in fact the remains of a bathymetric regime, being formed not from top to bottom, but from bottom to top. Finally, for all underground networks, active or fossil, in the Vârtop-Casa de Piatră-Hodobana area, we do not see older erosional structures than the early Pleistocene.

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NYMPHAEA Folia naturae Bihariae	XLVI-XLVII	49 - 54	Oradea, 2020

Morphology of Hoanca Urzicarului Pit, Bihor Mountains

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Abstract. Hoanca Urzicarului pit is located in the central part of Bihor Mountains, in a massive Jurassic limestone in Galbena Valley. With a depth of 290 m, it is not only one of the deepest cave in Romania, but its 85 m drop is also one of the longest, continuous vertical pit in the country.

Introduction

Hoanca Urzicarului pit is located at the southeastern edge of the Galbena Basin, in the central part of Bihor Mountains, which host some of the largest caves in Romania. Hoanca Urzicarului is a typical alpine pit, with a succession of large shafts. Lack of visibility in the sump halted the exploration at -288 m, preventing a possible connection with Păulesei resurgence, 3 km away. The cavity contains a wide range of calcite speleothems and crystals.

History of exploration

The cave was discovered in 1977 by Speleological Club „Speodava“ Ștei - Dorel Sâsână, Petre Brijan and Ovidiu Cuc (Brijan 1978). Initially the cave was named the Independence pit (Avenul Independenței), but Liviu Vălenaş renamed it three years later as Hoanca Urzicarului pit, according to the geographical situation. By 1977, the cavers from Speodava mapped the pit to a depth of -317 m, the cavity becoming the second deepest in the country after Tăuşoarelor cave in the Rodnei Mountains. In 1980, Liviu Vălenaş, Petru Brijan, Nicolae Sasu, Nicolae Stoica-Negulescu and Horia Mitrofan produced a more accurate survey of the cave, which reduces the depth to -286 m. In the same year two other branches were discovered, one with a small stream explored by Liviu Vălenaş and Nicolae Sasu, who crossed two very narrow spots and were stopped by an inaccessible passage at -267 m. The second fossil branch ending at -254 m was explored later by L. Vălenaş and P. Brijan. In 1981 Liviu Vălenaş with a team of Polish cavers discovered at the upstream end of the Crystals Gallery (-200 m) a large hall (Sala Urodzinowa). In late 1980, the cave was 1125 m long, and by the end of 1981 it reached 1300 m in length. In 1997 a Swiss diver-caver dove the terminal sump at -286, but almost immediately, at -2 m abandoned the exploration as the underwater passage became too narrow and the water had no visibility. Presently, the total vertical range of the pit is 290 m (-288; +2).

Cave description

The pit is located at an elevation of 1170 m a.s.l., in the left side of Luncșoara Valley in Bihor Mountains, a few meters away from the basin divide, which delineates the Crișul Negru (Băița) Basin. The entrance begin with a subhorizontal passage, which after five meters ends on the edge of a 85 m vertical drop, one of the deepest in the country. In many of the tight spots down the pit, numerous tree logs and limestone boulders are present, thus, descending must be perform with great caution.

At the base of the 85 m pit, upstream is an ascending gallery (the Marten Gallery/Galeria Jderilor), along which a small stream flows all the way down to the sump at -286 m. The main passage descends at 50º, the floor being punched by a few vertical shafts, the deepest being 28 m, and ends in the Goliath Hall (Sala Goliat). At the end of the Goliath Hall, for the first time is intercepted a relatively horizontal section, where three branches began: a descending one (the Rimstone Gallery/Galeria Gururilor) ends at -254 m, a horizontal passage (Crystals Gallery/ Galeria Cristalelor), which downstream ends with an extremely narrow path that becomes impenetrable at -267 m. Upstream, the Crystals Gallery continues with a high chimney and a large hall, Sala Urodzinowa.

The main passage continues downstream along a 50-60º slope, interrupted by two drops of 7 and 10 m, respectively. Along this passage, a small stream flows

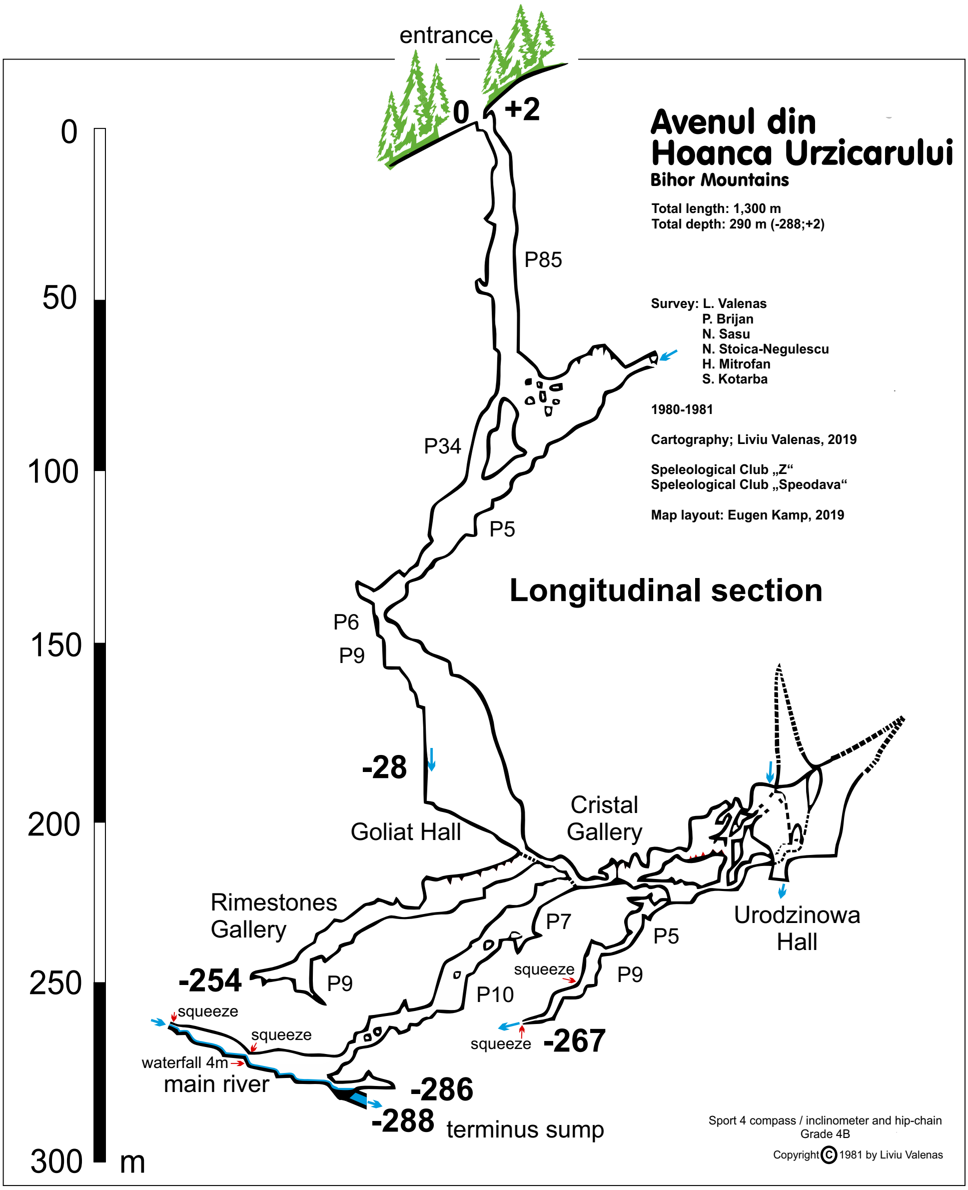

Figure 1. Longitudinal section of Hoanca Urzicarului pit. Cartography by Liviu Vălenaș, 2019.

having its origin in the Main Gallery and has a confluence at -286 m with a slightly larger streamlet (several L/s) coming from a 2 m high waterfall. The downstream section of the cave ends in a muddy sump, declared in 1997 by a Swiss diver as lacking of visibility. Upstream, after enlarging and passing a tight spot, the narrow passage ends after 50 m in yet another very tight passage (-262 m), from which the side tributary emerges. The cave is 1300 m long, with a 290 m (-288; +2) vertical range.

Cave speleogenesis

The cave is excavated in a massive Jurassic limestones, its genesis being controlled by a system of faults and joints. Initially the pit was formed in a phreatic regime from the bottom upward, as shown by the entrance section, followed by a second, vadose phase. The fact that the three branches (two active and one fossil) ends independently one from another at depths ranging between -254 and -286 m indicates that in the initial phase the cave stream recharged a resurgence located somewhere along Luncșoara Valley, a short distance from the cave. Later, the entire Luncșoara stream sunk underground, continuing its flow under the Dry Valley and recharging a new resurgence, the Izbucul Păuleasa spring located in Galbena Valley. No dyes studies were conducted in the cave so far. Between the end of the pit at -288 m, and the Păuleasa spring is a remaining vertical range of 200 m, it is clear that the flow will be in vadose regime. So far, the main collector heading to Păuleasa spring has not been intercepted by any of the cavities known in this region, thus, it remains an important aim for the next generation of cavers. The origin of the two small streams flowing through the main gallery and the Crystal Gallery is a percolation water. The relatively larger stream intercepted at -262 m, which disappears in the sump at -286, most likely originates in the sinkholes of the northern part of Vârtop plateau (1160-1200 m).

Cave climatology

The temperature in the pit ranges between 4.7 and 5.0º C, whereas the humidity is 90%.

Mineralogy

Hoanca Urzicarului pit contains numerous speleothems, including calcite crystals, developed mainly in the Crystals Gallery.

Conclusions

1. The Hoanca Urzicarului pit originally evolved in phreatic conditions, when the water enlarged the major fault lines and joints, then its passages were remodeled in a vadose environment.
2. The main stream of the cave is recharged by the sinkholes of Vârtop plateau, whereas the two smaller flows by percolation water. Initially the pit had the paleo-resurgence at 860-880 m elevation, a paleo-resurgence in Luncșoara Valley, whose waters subsequently sunk underground heading to a new resurgence, Păulesei spring located at 550 m elevation and 3.5 km away from the cave.

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Morphology and hydrogeology of Gruiețului cave (Pădurea Craiului Mountains)

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Abstract. Gruiețului cave from the Pădurea Craiului Mountains with a total length of 630 m is the resurgence of the great cave Hârtopul Bonchii (development: 6,668 m). Gruiețului cave is focused on an underground river of 235.6 m length, above which, in the final sector, a superior ascending level develops. The cave contains the most various concretions being from this point of view one of the most beautiful ones in the Pădurea Craiului Mountains. At present, the Speleological Club "Z" works together with the Town Hall of Roșia commune, Bihor county, on a preliminary project of touristic arrangements of the cave. But an arrangement which must respect the natural subterranean landscape.

Introduction

Gruiețului cave is situated on the left side of the Ștezelor valley, Roșia area (Fig. 1), central zone of Pădurea Craiului Mountains, at an absolute height of 395 m and at a relative height of 30 m. The stream coming out of the cave forms several small waterfalls on travertine deposits before flowing into the Ștezelor valley.

History of explorations

In the upper level, the author identified in 2019 a signature dating from 1936. Gruiețului cave was signaled by P. A. Chapuis and R. Jeannel in 1951 under the wrong toponym of the Fleazelor Valley cave, then T. Orghidan and collaborators in 1965, under the name of Șteazelor Valley cave or Poniței cave (Fig. 2). Iosif Viehmann, Gheorghe Racoviță and Teodor Rusu surveyed the active level in the same year 1965, but their map was never published. The terminal sump have been successively dived first by the late Petru Brijan (1984) and then by the French diver, Stéphane Lips, 2007. But after 10 meters they abandoned because of the very oozy water. In 1986, Emil Silvestru and Viorel Lascu made up a more precise map for 414 m. In 2014, a common team of the speleological clubs "Z" (Liviu Vălenaș) and "Speodava" Ștei (Robert Kovács and Lavinia Cozma) restarted the exploration of the cave, discovering the Kovács/Merinu Gallery. In 2019, a team of the Speleological Club "Z" (Liviu Vălenaș and Alexandrina Trif) and "Cristal" Oradea (Péter Merinu) made an almost complete exploration and they achieved a precise survey for 630 m of total length and + 50.2 m of vertical range. The map was officially presented at the Speleological European Forum in Sofia, Bulgaria in September 24-29, 2019 (Fig. 3).

Lithology, morphology, genesis and hydrogeology

The cave develops in strongly diaclazed and faulted Jurassic limestones. Excepting the first 10 m, the principal gallery, crossed by an underground river, is quasi horizontal up to the terminal sump. But before the sump, an upper level develops, which is totally different morphologically from the rest of the cave. It is continuously ascending, reaching in all a level difference of 43.6 m. It is also the best concretioned sector of the cave. The cavity, as a resurgence of Hârtopul Bonchii cave, was initially formed in epiphreatic regime, the upper level included. This was the first drain of Hârtopul Bonchii cave, then the whole cave was vadose remodelled. On the upper level, five old more important caves are preserved with dry waterfalls. The subterranean course flowing through the cave never dries, it has a flow of few litres per second but at flooding times it can exceed 100 l/s (Figs. 4, 5).

Description

From a relative great portal 15.6 m wide and 6.6 m high, after a short ascending sector where the stream forms small waterfalls, it penetrates the Entrance Hall, largely lit, with the dimensions of 30×18×16.5 m. The hall houses a bats colony. After a short narrowing the gallery is linked to the Great Hall (58×17×17 m) which

Figure 1. Roșia area. 1: Gruiețului cave; 2: Hârtopul Bonchii cave; 3: Izbucul Roșia spring (Cartography: Mircea Grindean).

on the left side has an impressive stalagmite flowing (Fig. 6.). The gallery gradually starts to get smaller as sections on the right side (in the forwarding towards the

Figure 2. The entrance of Gruiețului cave and the Entrance Hall (Photo Liviu Vălenaș, 2014)

sump), where are four more important laterals, out of which one is concretioned 68.5 m long (Figs. 7 - 8). The way gets low onward with the ceiling up to 0.6 - 0.5 m high. From a small hall with a circular formation resembling a pumpkin (Fig. 9), after 23.6 m it is linked down to the terminal sump (10 m length and 6 m depth, Stéphane Lips, 2007). Its diving temptations have successively failed because of the extremely oozy water. From the "pumpkin" on the left, an ascending slide starts, 23 m long, in a great slope leading to a very beautiful suspended lake with crystal clear water (Fig. 10). After it, the gallery gets lowered and after a vertical of 4 m, it opens in a hall of 18×7.5×11.4 m (Fig. 11). The climbing of a huge stalagmite waterfall flow 7 m high (Fig. 12) led to the discovery of a low concretioned gallery in 2014 with a total length of 42 m, which was not completely explored. It is the only question mark (except the terminal sump) which still remains for this cave morphology. From the last hall, after two ascending verticals of 2 and 1.5 m respectively, a gallery opens into the Terminal Hall (34×15×14 m) (Fig. 13). On the left, a narrower ascending gallery bifurcates into two branches ending through closed chimneys, the one of 8.5 m high reaches the maximum level of the cave of +50.2 m.

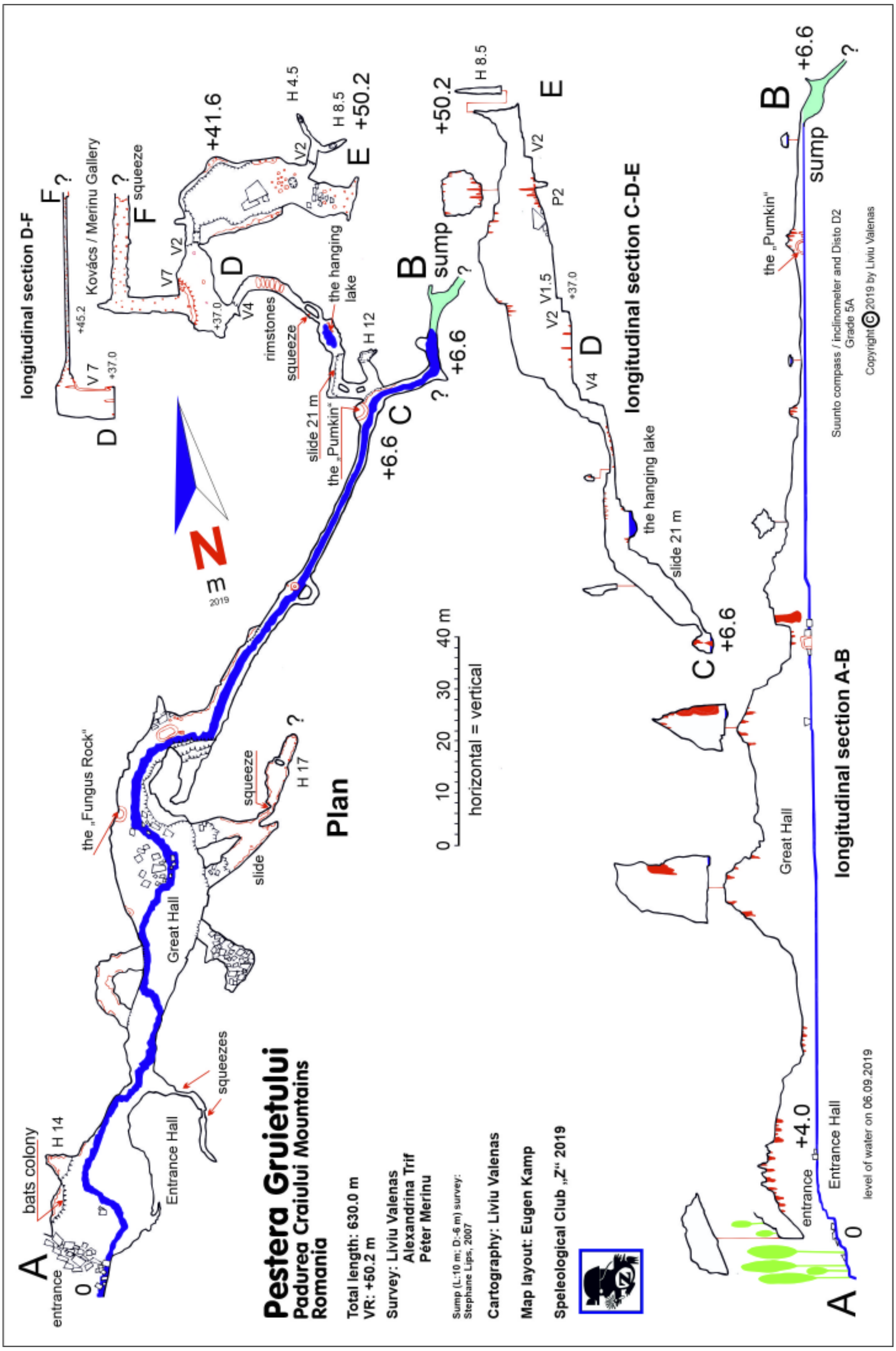

Figure 3. Peștera Gruietului cave, survey: Liviu Vălenaș, Alexandrina Trif and Péter Merinu, cartography: Liviu Vălenaș, map layout: Eugen Kamp, 2019.

Figure 4. The active of the cave between the Entrance Hall and the Great Hall (Photo Liviu Vălenaș, 2014).

Figure 5. The underground course in the Great Hall (Photo Liviu Vălenaș, 2014)

Figure 6 (up left). Stalagmite formation in the Great Hall (Photo Liviu Vălenaș, 2014).
Figure 7 (up right). Stalactite formations in the active course (Photo Liviu Vălenaș, 2019).
Figure 8 (bottom). The active course in the terminal sector (Photo Liviu Vălenaș, 2014).

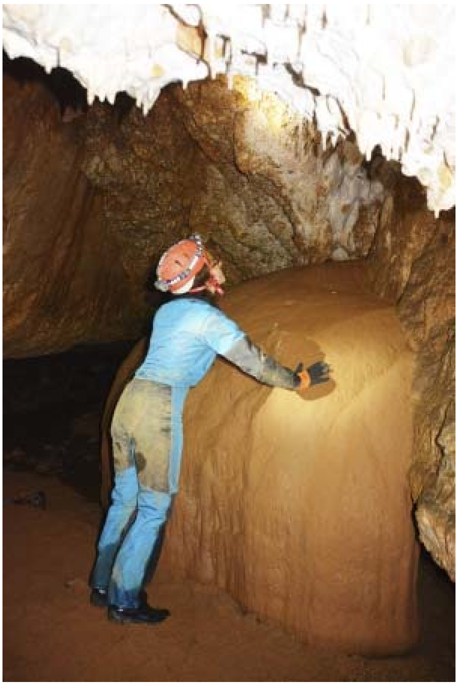

Figure 9 (up left). The “pumpkin “in the active terminal sector (Photo Liviu Vălenaș, 2019).
Figure 10 (up right). The suspended lake in the slide (Photo Liviu Vălenaș, 2014).
Figure 11 (bottom). The hall of 18 × 7.5 × 11,4 m in the upper level (Photo Liviu Vălenaș, 2014).

Figure 12. The stalagmite waterfall and the beginning of Kovács/Merinu Gallery from the upper level (Photo Liviu Vălenaș, 2014).

Figure 13. Stalagmite formations and calcite crystallizations in the Terminal Hall from the upper level (Photo by Liviu Vălenaș, 2014).

Comments

Mineralogy
Gruiețului cave contains the whole range of classical concretions and on the ceiling and on the walls of the upper level, calcite crystallizations develop.

Biospeology
The cave houses a bats colony which in 2014 stayed in the Great Hall and in 2019 in the Entrance Hall.

Possibilities of advance
The best possibility of advance in the future is on Kovács/Merinu Gallery in the upper level, a very low gallery which was not forced to the end in 2019 either but it continues towards Hârtopul Bonchii cave.

Details concerning Gruiețului cave survey
In 2014, the Speleological " Z" Club started reexploring and resurveying Gruiețului cave, Roșia, in the Pădurea Craiului Mountains. The new map are: 630 m development, + 50.3 m vertical range (VR), 230.7 m extension. If through developing Gruiețului cave it is only a medium cave in the endocarst in the Pădurea Craiului Mountains, in exchange, through the positive vertical range, it is one of the most important remontant caves in these mountains. The total length of 630 m is displayed in the following way: the active gallery (entrance - terminal sump) 235.6 m, laterals and loops on the active gallery 170.1 m, upper level 123.1m, laterals and loops on the upper level 101.2 m. The new survey was made with the technical means of the year 2019 (disto Leica etc.). But a new technique was also used, the one used by the Speleological Club "Z" ever since 2015 in Laos, achieving tens of photos and video films on the whole length of the cave. This allowed the achievement of a map and the sections with several details.

Observations concerning the old surveys
The first map was made (but only for the active gallery, without the laterals) by I. Viehmann, G. Racoviță and T. Rusu in 1965. The map was never published, that is why we do not have any comment. In 1986 Emil Silvestru and Viorel Lascu made a new map, this time the upper level was partially surveyed. The given development was 414 m and the vertical range +20.35 m. The drawing is relatively simple, the laterals on the left of the subterranean river schematically sketched and incomplete and the upper level wrongly oriented in the final sector. But the major mis-

takes are those concerning the level calculations. The 1986 team considered the 0 level the Entrance hall, which was wrong. The 0 level is under the portal, the lowest point. From here, the active, which makes small waterfalls and rapids, arises up to the entrance hall of 4 m vertical range. But the most serious error is the calculation of the vertical range of the upper level. The level of +20.35 m is absurd. Only the access slide (with a slope between 30 and 85 degrees) is 23 m long, reaches a vertical range of 14.75 m. In continuation the way is constantly ascending, sloping, having also four ascendant verticals of 4 m, 2 m, 1.5 m and 2 m respectively, and at the end a chimney in "the bottom of the sack" 8.5 m high (which was not climbed by those nominated earlier and neither did they climb the 7 m vertical leading to Kovács/Merinu gallery). The extension given by E. Silvestru and V. Lascu was 235 m, a small difference compared to the present mapping (230.7 m extension) is caused by the wrong orientation of the terminal hall in the upper level, an error belonging to E. Silvestru and V. Lascu.

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The fossil record of Palaeogene crocodilians in Romania: preliminary data

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Abstract. Crocodilian remains are rather rare in the Palaeogene formations from Romania. The fossil record from a series of late Eocene (Priabonian) and early Oligocene (Rupelian) localities spread in the Gilău and Meseș sedimentary areas (northwest Transylvanian basin) indicates the presence of the genus *Diplocynodon* and Crocodylia indet. as part of the European endemic crocodilian fauna, that apparently survived the great faunal turnover across the Eocene/Oligocene boundary. The most informative specimens are known from the former Cluj-Mănăștur quarry (Priabonian) and Suceag 1 (Rupelian). Some isolated teeth, too few and devoid of enough diagnostic value for clear systematic assignations, are known from Jibou, Treznea and Turnu Roșu (former Porcești, southern border of the Transylvanian basin). However, further investigations are necessary to establish the closer taxonomic status of the available remains.

Key words: Crocodylia, *Diplocynodon*, Eocene, Oligocene, Romania.

Introduction

The late Eocene - early Oligocene time span means a period of huge importance for biota because it corresponds to a worldwide faunal turnover called the Grand Coupure (in English, Great Brake), that involved mammals and ectothermic vertebrates (Rage & Roček 2003). During the late Eocene, Europe still was an archipelago. Portions of this continent were immerged into extensive epicontinental seas, however the continental landmasses were interconnected at various times (Rage & Roček 2003). However, a trend of eustatic fall of about 50 m was estimated for the late Eocene - early Oligocene interval (Pekar et al. 2002). The Carpathian area has been reshaped in this period due to continuous northern moving of several continental blocks including the ALCAPA block (Austroalpine units in the Eastern Alps and Inner Western Carpathians), as well as the Tisia and the Dacia blocks (Schmid et al. 2008). Their collisions with the North European plate were oblique, causing an accretion wedge of Outer Carpathians (Golonka et al. 2003). The tectonic related volcanism, the uplifting mountain chains could have implications of the CO_2 level and on the atmospheric motion as well as on the water regime and implicitly, on the regional climate and biota. After the 'post-Laramic' overthrust nappe replacement in the Apuseni Mountains and South Carpathians three major sedimentary mega-sequences may be distinguished in the north-western area of the Transylvanian sedimentary basin: 1) uppermost Cretaceous – early Miocene (Egerian), 2) early Miocene (Eggenburgian) – middle Miocene (Ottnangian) and 3) middle - late Miocene. We will focus only on the first sedimentary mega-sequence that recorded in Eocene and Oligocene an alternating series of marine and continental deposits in Gilău and Meseș sedimentary areas.

During the latest Eocene a large carbonate platform, rich in calcareous algae, ostracods and mollusc shells, has been developed in the Gilău sedimentary area known as Cluj Limestone Formation (Mészáros 2000). Sometimes this carbonate platform emerged and has been exposed to atmospheric erosion (Codrea et al., 1997). In the former Cluj-Mănăștur limestone quarry, nowadays abandoned, at least three layers of coarse-grained limestone may be distinguished (Fig. 2). Koch (1894) named these layers as 'upper coarse limestone', exploited in historical times as building stones for various public buildings. These limestones yielded sometimes isolated bones or larger skeletal parts of various vertebrate representatives, mainly sea cows (Koch, 1894).

Around the Eocene/Oligocene transition, in NW of Transylvania an uplift related to the pre-Pyrenean and Pyreanian tectonic movements (*sensu* Émile Haug, in Dudich & Mészáros, 1963, Mészáros & Dudich 1989, Mészáros & Moisescu, 1991) lead to the deposition of continental strata consisting of fluvial red beds (Valea Nadășului and Moigrad formations). In Rupelian, an environmental turnover from fluvial to more flooded, fluvial-lacustrine, estuarine and marshy environments lead to the deposition of the overlying Dâncu Formation (Rusu 1972). The Dâncu Formation thickens from east to west; in the Cluj-Napoca city area it has a thickness of few centimetres (in the borehole on the location named Liliacul; VAC personal observation) to a few metres, whereas at Aghireș it reaches thicknesses of up to 14–17 metres (Moisescu 1975). Its lithology consists of alternating clay, marl and sand with several lumachelle and coal interbeddings. It has been suggested that the climatic deterioration during the Eocene/Oligocene transition (around 33.9 Ma) may have affected most of the ectothermic vertebrates, including snakes and crocodilians with considerable decline in their diversity (see e.g. Morlo et al. 2004, Martin 2010, Delfino et al. 2019).

The fossil record of crocodilians from the Palaeogene of Romania is rather scarce and mainly consists of isolated teeth (Pávay 1871, Koch 1884, Fărcaș 2011) and more rarely of skull remains, vertebrae and parts of the appendicular skeleton (Koch 1893, Fărcaș 2011). Nevertheless, in the latest years some progress has been made by documenting new fossil localities with crocodilian remains from a number of Palaeogene localities (see below). In the present paper we: 1) review the fossil localities yielding crocodilian remains from the Paleogene of Romania, 2) evaluate their taxonomic status based on diagnostic material and 3) the paleobiogeographic links of the identified taxa.

Abbreviations used: **MAP**, mean annual precipitation; **MAT**, mean annual temperature.

The fossil record

Upper Eocene (Priabonian) localities

Treznea 1. The fossil locality belongs to the Upper Eocene Turbuța Formation (Meseș sedimentary area, early Priabonian) and is situated in Șanțului Valley near the locality of Treznea (Sălaj County). The taphonomic context indicates a freshwater palaeoenvironment of marshy-lacustrine type with occurrence of charophytes and a series of palynomorphs representing gymnosperms (Cupressaceae and Taxodiaceae) and angiosperms (Fagaceae, Juglandaceae, Arecaceae and Nyssaceae) that corresponds to a paleoclimatic curve with the MAT of around 20 °C and the MAP of about 1200 mm (Petrescu & Balintoni 2004). The faunal association after Fărcaș (2011) yielded among others lepisosteid fish, freshwater

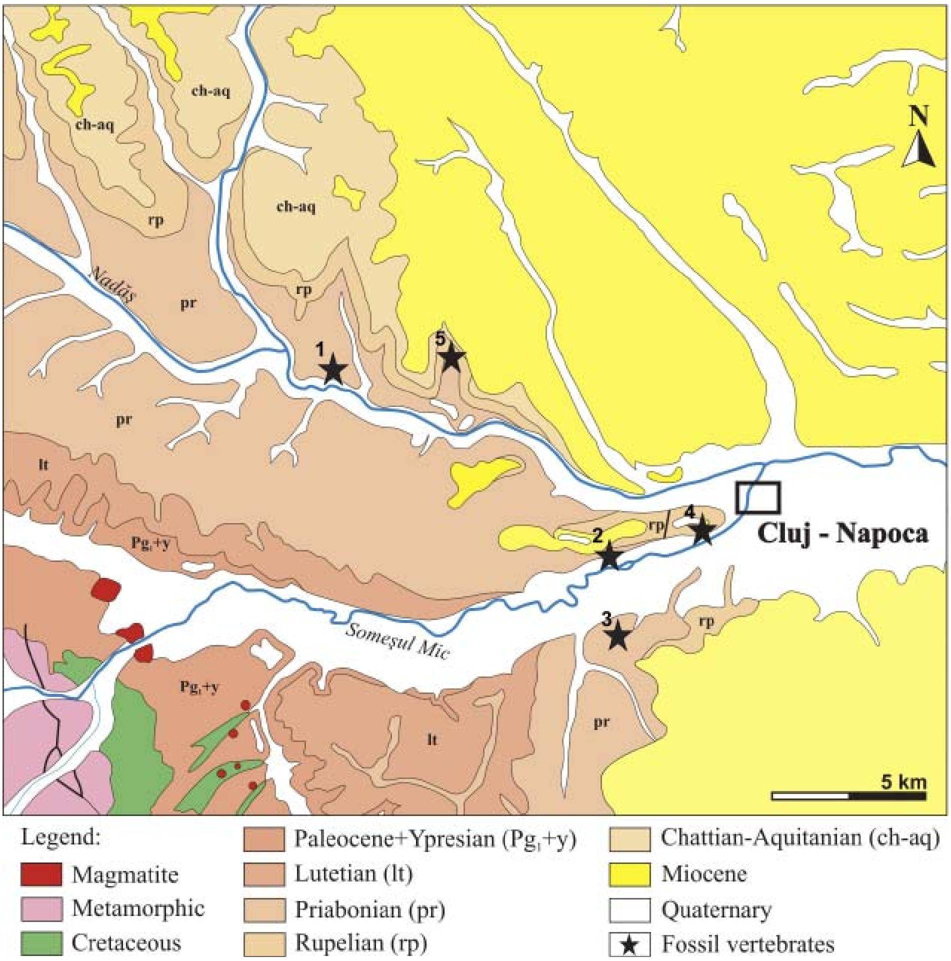

Figure 1. Geological map mentioning the Palaeogene localities with crocodilians from Cluj-Napoca area, Romania. 1, Rădaia; 2, Cluj-Napoca (Someș dam); 3, Cluj-Mănăștur; 4, Cluj-Napoca (Cetățuia); 5, Suceag.

turtles (Emydidae: ?*Mauremys*), alligatoroid crocodilians and marsupial mammals (*Peratherium lavergnense*).

The fossil material of alligatorid crocodilians consists of isolated teeth of various sizes. The teeth are variable in shape with at least two morphotypes: 1) lanceolate shaped teeth with labiolingual compression, provided with mesial and distal carinae and bearing faint apicobasal striations developed on both the lingual and labial sides (Fărcaș 2011: plate 21: 9-12); 2) low crowned teeth representing probably the posterior series with their crowns compressed labiolingually and pro-

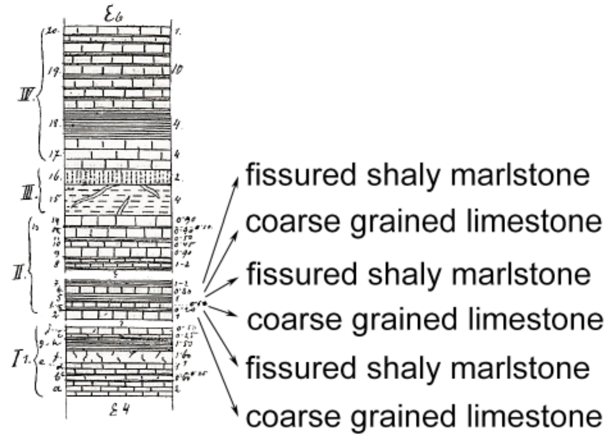

Figure 2. Synthetic litostratigraphic Koch's (1894) log of the coarse limestone beds around Cluj, with details highlighted on the Cluj-Mănăștur former limestone quarry.

vided with mesial and distal carinae. The apicobasal striations are well-developed on both the lingual and labial sides (Fărcaș 2011: plate 21: 7, 8; plate 22: 10).

*Rădaia.*The fossil locality belongs to the Upper Eocene Valea Nadășului Formation (early Priabonian) and is situated in the Nadășului Valley within the village of Rădaia (Gilău sedimentary area, Cluj County). Rădaia is the type locality of famous mammals: the rhinocerotoid *Prohyracodon orientale* Koch, 1897 and of the brontothere *Brachydiastematherium transilvanicum* Böck & Matyasowski, 1876. Beside mammals the fossil locality has yielded also few carapace fragments of *Trionyx* sp. (Fărcaș 2011) and fragmentary remains of crocodilians (Koch 1894). After Koch (1894) two isolated teeth of crocodilians have been recovered from Rădaia. Their height is 6 mm and their width at the base is about 3-4 mm (Koch 1894).

Cluj-Napoca (Someș dam). The fossil locality belongs to the Cluj Limestone Formation (Turea Group, Gilău sedimentary area, Priabonian). After Koch (1894), two isolated teeth of crocodilians have been recovered from "Someș beds" by Pávay (1871) along with a series of fragmentary sea cows remains. In fact, all these remains have been firstly assigned by Pávay (1871) to crocodilians (i.e. *Toliapicus* sp.). The tooth height is about 18 - 20 mm and their width at the base is about 7 mm (Koch 1894).

Cluj-Mănăștur. The fossil locality belongs to the Upper Eocene Jebuc and Cluj Limestone formations (Turea Group, Gilău sedimentary area, Priabonian). After Koch (1894) the main layers from the Cluj-Mănăștur limestone quarry are as follows: 1) coarse grained limestone bank (one metre depth, used as building stones or carved stones) with abundant ostracods, moulds of gastropods (mainly *Anomia tenuistriata*) and rare vertebrate remains (e.g. ”*Delphinus* sp.”); 2) fissured shale marlstone (0.2 meters depth) with ostracods and *Anomia*; 3) coarse grained limestone (0.5 meters depth) with ostracods and extremely small gastropods used as building stones or carved stones; 4) fissured shale marlstone (one meter depth) with ostracods and *Anomia tenuistriata*; 5) coarse grained limestone (0.8 meters depth) with ostracods and extremely small gastropods and rare *Anomia*; it represents the uppermost limestone horizon from the Cluj-Mănăștur limestone quarry; 6) fissured shale marlstone (one meter depth) with numerous chalk-like white limestone concretions; it represent the uppermost sedimentary layer from the quarry.

After Koch (1894), a partial skull of a small crocodilian consisting of “a maxilla and several inner bones of the skull” has been recovered by quarry workers. It somewhat resembled *Crocodylus communis* (i.e. *C. nyloticus*) but it is not identical with that because the fossil specimen possessed higher number of teeth (21-22) vs. *Crocodylus* having a lower number of teeth (Koch 1894).

Lower Oligocene (Rupelian) localities

Cluj-Napoca (Cetățuia) and Suceag 1. Both localities belong to the Dâncu Formation consisting of alternating clay, marl and sand with several lumachelle and coal interbeddings that indicate environmental changes from fluvial to more flooded, fluvio-lacustrine and marshy environments (Rusu 1972, Venczel & Codrea 2018). The Dâncu Formation thickens from east to west, having in Cetățuia Hill at Cluj-Napoca, a thickness of several tens of centimetres to a few metres, whereas at Aghireș, it reaches thicknesses of up to 14–17 m (Moisescu 1975). The formation contains one of the most diverse Rupelian continental faunal assemblages in Transylvania, especially yielding molluscs and vertebrates (fishes, frogs, squamates, turtles, crocodilians, birds, and mammals) consistent with an age of MP 23–24 (Reichenbacher & Codrea 1999; Codrea & Fărcaș 2002; Fărcaș & Codrea 2008). Fărcaș (2011) assigned the material to *Diplocynodon* sp. consisting of a fragmentary hemimandible, cervical, thoracal and caudal vertebrae, fragmentary ribs, humerus, pelvis, femur, tibia, metatarsal bones, phalanges and osteoderms.

Systematic part

EUSUCHIA Huxley, 1875
CROCODYLIA Gmelin, 1789
ALLIGATOROIDEA Gray, 1844
Diplocynodon Pomel, 1847
Diplocynodon sp.

Material: Cluj-Mănăștur: UBB V 1453, partial skull; Suceag: UBB V 450 uncatalogued, fragmentary left hemimandible.

Description. The UBB V 1453 sample exposes a partial skull in ventral view (Fig. 3). The following cranial bones have been identified in the sample: the premaxillae (the lateral margin of the right premaxilla is damaged), the maxillae (the posterior part of the right maxilla is broken off, probably when the skull has been recognized and collected by quarry workers), anterior parts of the paired palatines, a partial left quadrate, part of the right pterygoid with impressions of choanae and the posterior part of the left ectopterygoid. The rostrum is elongated and relatively narrow. The suture between the premaxilla and the maxilla is perpendicular to the sagittal plane and, lateral to the premaxillary-maxillary suture, a well-defined notch is developed.

The premaxilla is provided with five tooth alveoli of which the second and the fourth alveoli are larger than the others three ones. A large occlusal pit for the reception of the first dentary tooth is developed medial to the space between the first and second premaxillary tooth alveoli. The incisive foramen, enclosed completely by the premaxillae is large and almost circular, extending anteroposteriorly between the levels of the second and fourth tooth alveoli. The posterolateral margin of the premaxilla is not perpendicular to the sagittal plane at the level of the premaxillary-maxillary notch suggesting that it is not developed from the occlusal pit of the third and fourth dentary teeth.

The maxillary tooth row probably is composed of 16-17 alveoli; however, some uncertainty persists in this estimation because in both sides the posterior parts of the maxillae are damaged. The largest maxillary alveoli are represented by those of the nearly confluent fourth and fifth maxillary teeth and as a consequence the lateral margin of the maxilla depicts a lateral convexity between the first-sixth tooth alveoli, whereas those between the fifth-eighth are shallowly concave laterally; posterior to the eighth tooth position, the alveoli depict a nearly straight line. The occlusal pits are present posterior to the fifth maxillary tooth and positioned in line or slightly medial to the maxillary tooth row. A contact surface between the pos-

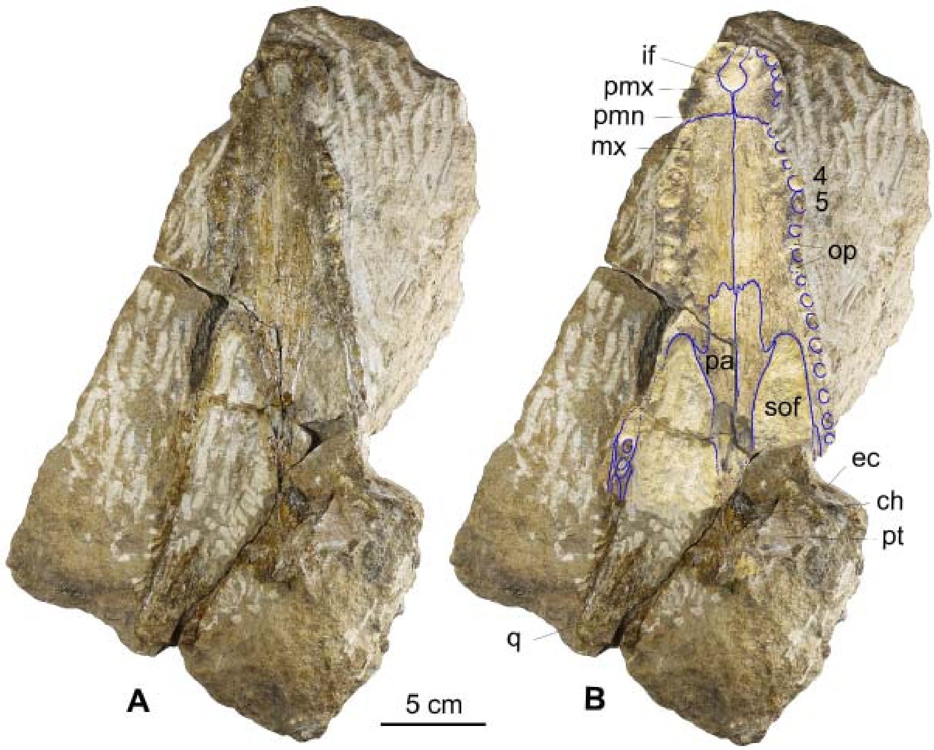

Figure 3. Partial skull of *Diplocynodon* sp. from the Cluj-Mănăștur former limestone quarry recovered in 1890. A. The original sample exposing the *Diplocynodon* sp. specimen in ventral view. B. Skeletal parts highlighted. Abbreviations: 4, 5 – fourth and fifth tooth maxillary tooth alveoli; ch – choana; ec – ectopterygoid; if – incisive foramen; mx – maxilla; op – occlusal pits; pa – palatine; pmn – premaxillary-maxillary notch; pmx – premaxilla; pt – pterygoid; q – quadrate; sof – suborbital foramen.

terior two or three maxillary alveoli and the anterior extension of the ectopterygoid is visible in both sides. However, this contact does not reach the medial margins of the tooth alveoli. No intact tooth crowns are available, but parts of the tooth crowns are conserved in few alveoli. The main feature of the crown remnants is that they have been provided with mesiodistal carinae and are devoid of any serration. The posterior alveoli are distinctly smaller and tend to have mediolateral compression.

The palatines shallowly widen anteriorly, whereas posteriorly these remain apparently parallel. The palatine-maxillary suture starts at the anteromedian corner of the suborbital fenestra and it reaches anteriorly the level of the eighth maxillary tooth position. The posterior part of the palatines is broken off exposing the complete choanal septum.

On the left cranial side, part of the pterygoid and ectopterygoid are exposed; the choanae are preserved only as imprints within the embedding sediments (seemingly the relatively thin pterygoid wings were broken off during the collecting procedures). The posterolateral parts of these bones are damaged. However, the pterygoid-ectopterygoid flexure is present.

The quadrate is exposed on the right ventral part of the sample. It preserves a relatively small sized quadrate condyle.

The UBB V 450 right hemimandible is fragmentary (Fig. 4: B-E), both the anteriormost (anterior margin with the first and second tooth positions) and posteriormost parts (posterior to the 14^{th} tooth position) are broken off. The symphyseal region is relatively short reaching the level of the third tooth position. In lateral view, the dentary is shallowly concave between the fourth and 11^{th} tooth positions. The largest alveoli are the third and fourth alveoli, which are confluent. The 11^{th} and 12^{th} alveoli are placed at some distance from each other and are comparable in size to those of third and fourth. In dorsal view, the dentary is gently curved with a lateral convexity at the level of third-fifth alveoli, whereas between the fifth-11^{th} alveoli there is shallow labial concavity.

Comments. The main feature of the partial skull is the possession of a pair of large and almost equal sized maxillary tooth alveoli (the fourth and fifth), which are nearly confluent similarly to the other members of the genus *Diplocynodon.* This character differs from *Asiatosuchus*-like taxa, which are provided with a single enlarged fifth maxillary tooth (Delfino et al. 2019). Another important feature is the presence of a premaxillary-maxillary notch which seemingly is not formed ontogenetically by the eroded margins of a premaxillary-maxillary occlusal pit (in the latter case the lateral margins should have been more abruptly angled). The anterior process of the ectopterygoid is short and approaches to the posterior two or three tooth alveoli, however it does not reach directly these alveoli. The ectopterygoid-pterygoid flexure is present and therefore it is retained during the ontogeny (Martin et al. 2014).

Crocodylia indet.

Material: Rădaia: partial left jugal; Treznea 1, Cluj-Napoca (Someș dam): isolated teeth.

Description. The bone, originating from historical collecting in Antal Koch's epoch is fragmentary, elongated and flattened labiolingually (Fig. 4: A). It is wider anteriorly and the orbital margin in this region is gently convex and rounded dorsally. The

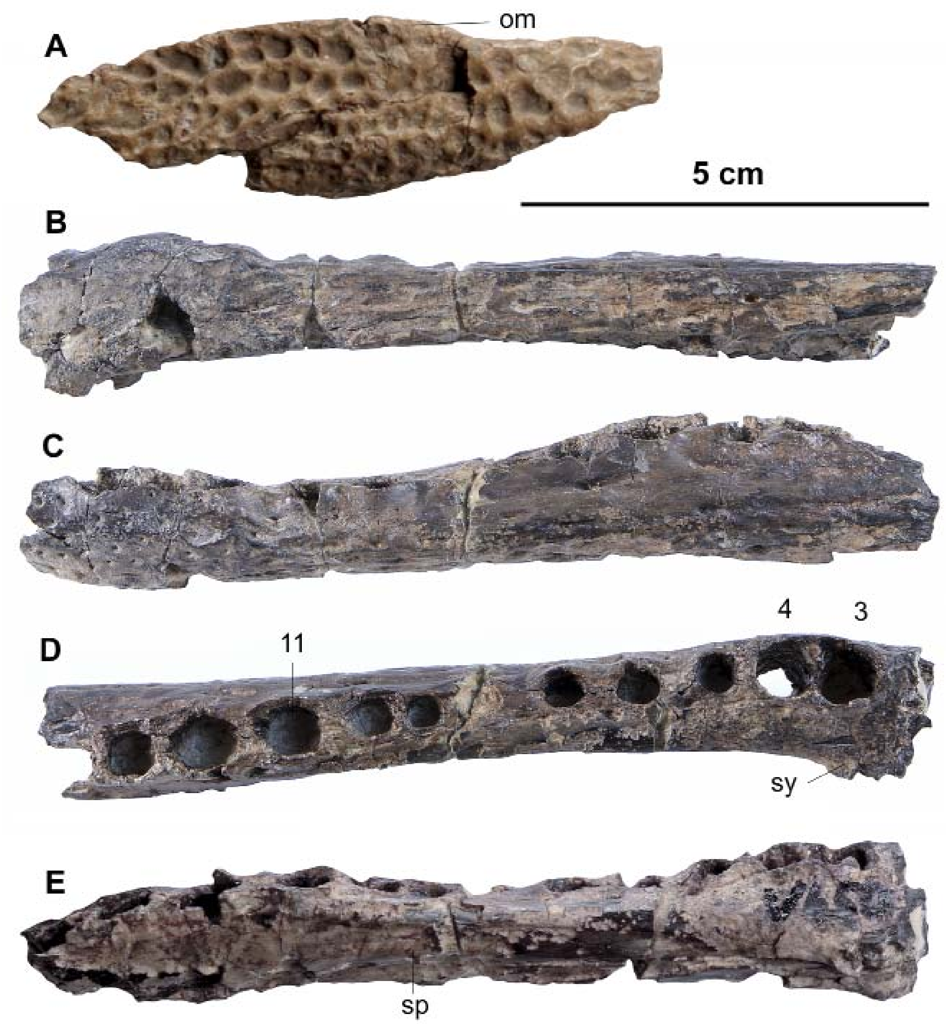

Figure 4. Some various isolated cranial remains of Palaeogene crocodylians from Romania. A. Fragmentary left jugal from the late Eocene (Priabonian) of Rădaia. B – E. Fragmentary left hemimandible from the early Oligocene (Rupelian) from Suceag 1. Abbreviations: 3, 4, 11 – third, fourth, eleventh dentary tooth alveoli; om – orbital margin; sp – splenial; sy – symphysis.

medial side of the anteriormost part displays an imprint that may come in contact with the maxilla; the posterior part is distinctly narrower, it probably contacted the quadratojugal. The postorbital process is not preserved.

Several isolated teeth are of various size (Koch, 1894; Codrea & Fărcaș 2002, Fărcaș 2011) and may represent the premaxillary, maxillary and dentary

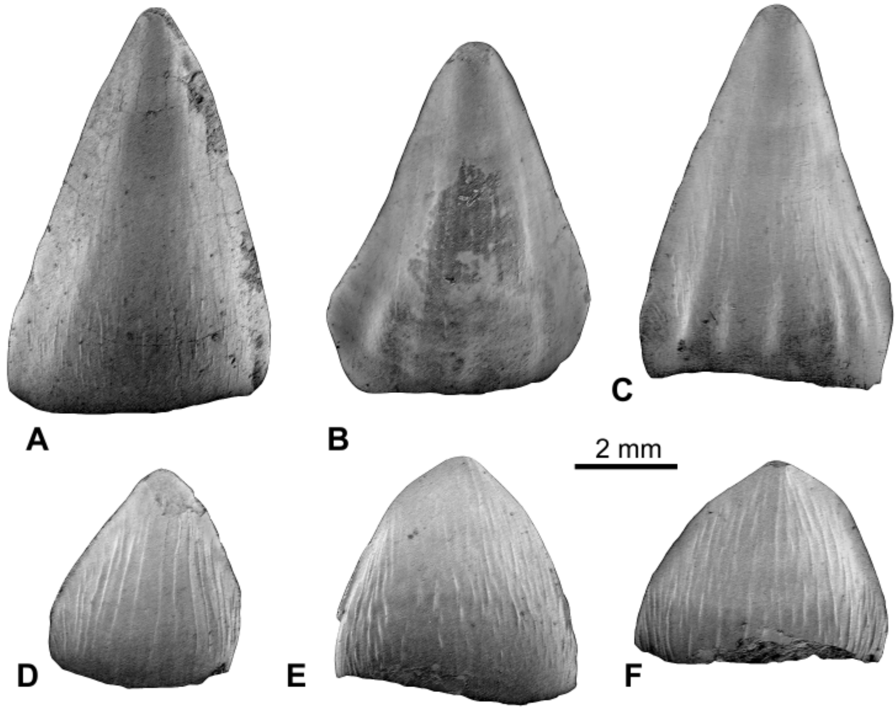

Figure 5. Isolated crocodylian teeth from Treznea. A-C. Isolated caniniform crocodylian teeth. D-E. Isolated conical crocodylian teeth.

teeth. The shape of tooth crowns representing probably the anterior series are caniniform (Fig. 5A-C). These are provided with mesiodistal carinae, but without serrations. A few gentle ridges are discernible near the base of the crown in one of the specimens (Fig.5C). Part of the teeth are conical and may represent posterior tooth series on the maxillae or mandible (Fig. 5D-E). These are provided with mesiodistal carinae and are devoid of serrations. A series of irregular carinae extend apicobasally on both the lingual and labial side of the tooth crown.

Comments. The morphology of the jugal specimen resembles that of the genus *Diplocynodon*, however, the medial side does not preserve the postorbital process and the detail with the ectopterygoid contact is also unknown. The morphology and the size of the available teeth display the generalized crocodilian pattern. These structures may represent also the genus *Diplocynodon*, however, this assumption cannot be fully demonstrated based on the above remains.

Concluding remarks

The oldest Cenozoic crocodilians in Romania originate from Jibou-Rona (Jibou Formation, Meseș sedimentary area), localities considered as late Paleocene (Thanetian) – ? early Eocene (?Sparnacian) (Gheerbrant et al., 1999; Codrea & Săsăran, 2002; Codrea et al., 2003; Petrescu et Codrea, 2003, 2004; Gaudant et al., 2004). Codrea & Fărcaș (2002) mentioned ”cf. *Doratodon* sp., and Crocodylidae s.l. indet.”, but the majority of authors refers only to indeterminate crocodilians. Until their discovery the progress about related systematic is extremely scarce, due to the poor sample of teeth and post-cranial bones. However, we can notice their small size not exceeding 1-1,5 meter in length. In these localities we notice fluvial-lacustrine environments were these fossil vertebrates had been preserved (Codrea & Săsăran, 2002, Petrescu & Codrea, 2003).

The available specimens document the presence of crocodilians in the late Eocene and early Oligocene localities from the Gilău and Meseș sedimentary areas. The fossil remains are relatively rare and up to present only the genus *Diplocynodon* has been identified, as part of the European endemic alligatoroid crocodilian fauna. The fossil record indicates that the above genus may have survived the major faunal turnover at the Eocene/Oligocene boundary (“Grand Coupure” = Great Break). Further research is necessary to establish the closer taxonomic status of these remains.

Apart from these fossils from the north-western Transylvanian basin, we have to mention also some isolated teeth originating from the southernmost border of the same basin. They are known from old collections from 19th century, stored in the collections of the Brukenthal Museum in Sibiu, Natural Sciences branch. They neither preserve too many diagnostic characters, nor clear stratigraphy. One may presume, however, that they are originating from Valea Nișului Formation (Priabonian), from Turnu Roșu (former Porcești) Palaeogene locality (Mészáros, 1996). But, since in this area older deposits are also exposed (i.e. Cuisian and Lutetian), there is an incertitude about their sharp stratigraphic level of origin. We may suspect that these crocodilian teeth were considered by ancient local palaeontologists (see Anonymous, 1850) to belong to Triassic reptiles (*Nothosaurus*), although such deposits are completely missing in Sibiu region. Therefore, we mention them herein just to complete the view on the paleogeography of the Palaeogene from the Transylvanian basin, but also to underline the potential of the deposits exposed on the southern border of the basin for such fossils.

Last but not least, we may expect crocodile Palaeogene remains also from the south-western corner or the Transylvanian basin, in the sedimentary area called Metaliferi (Codrea and Dica, 2005). The most detailed study of these deposits (Băluță, 1973, 1987), does not make any mention about crocodiles, neither in the Eocene, nor in the Oligocene rocks of the Ighiu Formation (Codrea and Dica, 2005). But, a closer look to these deposits could yield such fossils in future.

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Rediscovery of the cnidarian *Craspedacusta sowerbii* Lankester, 1880 (Hydrozoa, Limnomedusae, Olindidae) in Romania

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Abstract. After its first and only documented occurrence in Romania in 1936, the presence of the invasive freshwater cnidarian *Craspedacusta sowerbii* was reported again in July 2019 in a lake in Bihor county, northwestern Romania.

Introduction

The freshwater jellyfish *Craspedacusta sowerbii* Lankester, 1880 (sometimes spelled *C. sowerbyi*) is the only freshwater cnidarian that has both polyp and medusa form, and is frequent in oxbows and gravel pits with clear water and gravel bed. The polyps are a few millimeters long and live in pairs on water plants or on the bottom and under favorable conditions produce the 1-2 mm wide medusa, which reaches 2 cm by the end of summer (Kriska 2014). The species was described from London and is one of the nine species of this East-Asian genus and the only freshwater medusa with cosmopolitan distribution (on all continents except Antarctica), occurring in temperate, subtropical and tropical ponds, lakes, reservoirs, and rivers, and apparently preferring eutrophic ponds over oligotrophic large lakes (Jankowski 2001). Currently it is the most abundant and widespread freshwater cnidarian, and two of the resting stages of its reproductive cycle (podocysts and spherical frustules) are drought resistant (Dumont 1994). *C. sowerbii* is probably indigenous to the Yangtze River in China and the hydromedusae appear in shallow pools, isolated gravel pits, sand pits or quarries, and also in slow rivers (Didžiulis & Roman 2013). It is a thermophilous, eurybiontic hydrozoan with two adult forms, a fixed polyp and a free swimming, more visible medusa (the sexual form) which appears in bloom sporadically during the warm season (when water temperature rises to at least 25 °C), feeding on zooplankton, as well as on eggs and tiny larvae of fishes (Silva & Roche 2007, Didžiulis & Roman 2013). The lifespan is 34-51 days (Gang et al. 2006, cited in Didžiulis & Roman 2013), and adults are resistant on hypoxia (Wang et al. 2006).

Originally it started dispersing worldwide in the 1880s, mainly though unintentional introductions by humans of its drought-resistant diapausing stages. Its dispersion was possibly started in late 19th century by the increased commercial contacts with China and then continued unintentionally by the American troops stationed in Japan and in other Asian countries after World War II, as well as by the aquarium trade, plus through aerial dispersion by birds (Dumont 1994). The first record of introductions was from water-lily tanks in Regent's Park, London, in 1880, followed by polyps found in Philadelphia, USA, in 1885 (and then medusae in 1897). In 1901 it was found in France and in 1905 in Germany at Munich, then in Sweden it was first recorded in 1969 (Didžiulis & Roman 2013). It was first found in the Czech Republic in 1934 (Jaslovská & Stloukal 2004, cited in Jakovčev-Todorović et al. 2010) and in Ukraine in the 1950s in the cooling reservoir of the Chernobyl nuclear power plant, by means of negligent or irresponsible ornamental trade originating from South America (Protasov et al. 1981, cited in Alexandrov et al. 2007). It was known in the Rhine valley, Germany, since 1970, probably spread by aquarists, navigation and/or birds (Rey et al. 2000). It was recorded as an invasive species also in Hungary in 1957-1959 (Buchert 1960, cited in Abonyi et al. 2008), in Serbia since 1958 (Jakovčev-Todorović et al. 2010, Rat et al. 2016), in Slovakia in 1961 (Vranovský 2003), in Switzerland since 1962 (Lods-Crozet et al. 2013), in Italy since 1990 (Gherardi et al. 2013), in Bulgaria since 1991 (Trichkova et al. 2017), in Croatia since 1992 (Jaslovská & Stloukal 2004, cited in Jakovčev-Todorović et al. 2010), in Austria since 1998 (Grohs 1998, Kutzenberger 1998, cited in Gusenleitner & Aescht 2003), and in Lithuania since 2002 (Arbačiauskas & Lesutienė 2005), as well as in Greece (Karaouzas et al. 2015). The northernmost documented occurrence is from Finland (Väinölä 2002). Currently it is rather frequent in most European countries, except Albania, Belarus and some countries of former Yugoslavia (Didžiulis & Roman 2013).

In Romania it was first documented in 1936 (Șerbănescu & Panțu 1936) and there were no other published occurrences since then. The aim of the present paper was to record the rediscovery of the invasive species *C. sowerbii* in Romania.

Material and methods

On July 2. 2019, the author's colleague Cosmin Durgheu reported the presence of a group of "freshwater jellyfish" mostly in the pelagical region and close to the surface of the lake near the village Șauaieu, belonging to the commune Nojorid (Bihor county, northwestern Romania). The lake near Șauaieu is produced by an artificial dam and is surrounded by deciduous forests and by pastures.

Because of the small size and translucent habitus of the animals, no photos were taken at that time. Because of other circumstances, the present author was able to verify the site only on Oct. 2, 2019, together with Mr. Durgheu and photographer Ovidiu Pascu, sieving the water in several areas of the lake. In 2020 only several medusae were observed in August, during a rather cooler summer than in the previous year.

Results

The coordinates of the sighting are 46.944788 N, 21.921241 E. While verifying the site on Oct. 2, 2019, despite the weather still being rather warm, the water in the lake was already cooler and no freshwater jellyfish were found. Still, Mr. Durgheu, being an artist with a keen eye for details, provided a detailed verbal description of them. According to that, the observed hydrozoans (hydromedusae) were disc-shaped, about 20 mm in size, delicate and translucent, and with a whorl of many long and thin tentacles around the margin (Fig. 1). The mouth opening was central and a stomach structure (the manubrium) protruded down from the center of the bell. The animals had four noticeable, opaque white structures (the gonads) attached to four radial canals which are connected to a ring canal near the bell margin. The prominent size of the four perradial tentacles is a constant feature in *C. sowerbii* (Kramp 1951, cited in Jankowski 2001).

Thus, based on those descriptions, the habitat and the distribution data known for the species, the identification of the observed animals as medusae of *Craspedacusta sowerbii* Lankester, 1880 seems certain enough (Lankester 1880, Jankowski 2001), unless further verification would possibly identify another closely related species with invasive behavior.

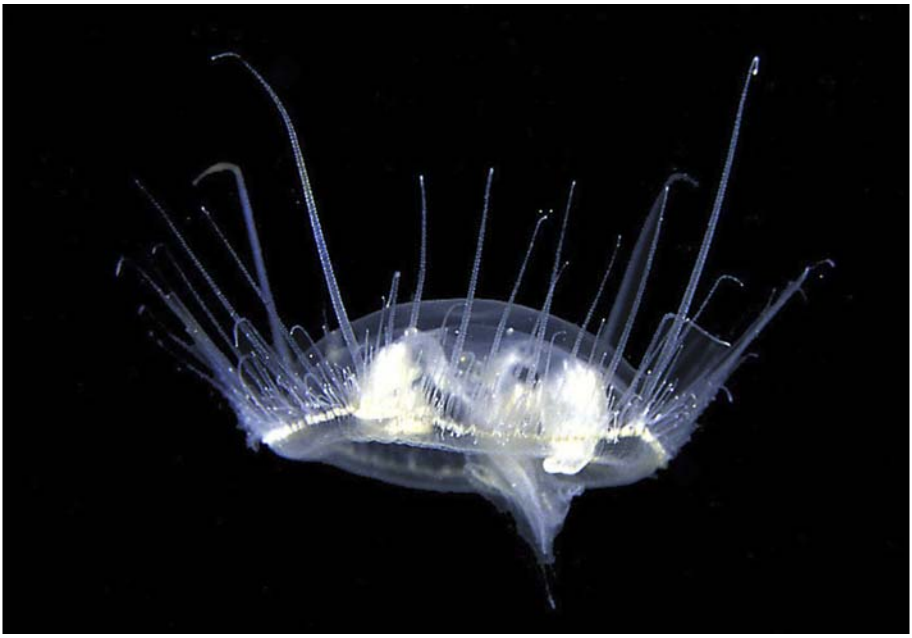

Figure 1. *Craspedacusta sowerbii* Lankester, 1880, medusa stage, habitus (photo after Christophe Dehondt).

Discussion

While this invasive species is widespread in Europe and cosmopolitan for decades, the recording of its presence in Romania was just a matter of time. *C. sowerbii* arrived in Romania before 1936, as briefly signaled in an ephemeral publication (Șerbănescu & Panțu 1936). Since then its presence there passed unnoticed because of its small size and inconspicuous nature, thus there are no other publications about it in Romania before the present documented rediscovery. The locals in Șauaieu report about sporadically noticing groups of "freshwater jellyfishes" in the lake near their village for several years when weather and water conditions were favorable (warmer), so an established population may exist in that lake.

C. sowerbii has circumglobal distribution, occurring in warm and temperate freshwater bodies (van der Land 2008; Schuchert 2019). The most probable vectors are shipping, waterfowl and unintentional or illegal introduction with fishes, crayfish or aquatic plants. As all Cnidaria, this hydromedusa is an opportunistic predator of zooplankton, benthic invertebrates, and fish eggs and larvae. It is harmless to humans and fish apparently do not consume it, but it is preyed on by *Or-*

conectes crayfish (DeVries 1992). Its impact on the plankton community, although currently insignificant, may increase with high medusae densities (Arbačiauskas & Lesutienė 2005), and blooms of polyps and medusae may have a cascading effect on primary producers and small herbivorous crustaceans, such as *Bosmina longirostris* and juvenile cyclopoid copepods during summer and in small lakes (Jankowski & Ratte 2001, Jankowski et al. 2005, Smith & Alexander 2008).

There are four hypotheses of invasion paths:

1. the natural distribution area was Eurasia;
2. polyps and medusae were transported with ornamental aquatic plants and fishes from the Yangtze River system (Slobodkin and Bossert 1991, Angradi 1998);
3. the dispersion was natural since the existence of Gondwana (Zienkiewicz 1940, cited in Didžiulis & Roman 2013); or:
4. it is a ponto-caspian species (Jankowski 2001).

Another possible way of invasion is by commensalism with the invasive zebra mussel *Dreissena polymorpha*. Polyps of *C. sowerbii* were found attached on its shells and they are sessile organisms without tentacles and with an apical mouth surrounded by nematocysts, so the strong water current generated by the bivalve's incurrent and excurrent siphons explains the preference of the polyps for that area of the shell (Stanković & Ternjej 2010). Another hypothesis about the success of *C. sowerbii* as invasive species could be related to the eutrophication of stagnant waters ("brownification", or higher content of dissolved organic matter and higher dissolved organic carbon concentration), which protects *C. sowerbii* individuals from the harmful effect of UV radiation (Caputo et al. 2018).

In recent years, interest appeared in keeping it in aquaria as an ornamental species, but this poses great potential invasive risk because of negligence in the aquarium trade industry (Skolka & Preda 2010). Supposedly as a result of climate change, recently it has reached northern regions, such as the Moscow River, which passes through the Russian capital (Bavaru & Bercu 2017). Other local invasions in Sweden and Lithuania in 2002 suggest recent climate warming as possible cause for its dispersal. Optimal water temperatures for medusa development are 19-30 °C. The inconspicuous polyp stage, more tolerant to lower temperatures and dying at temperatures above 30 °C (Acker & Muscat 1976), is possibly far more common than the planktonic medusa stage (Dumont 1994, Angradi 1998), in addition to the fact that it does not always produce medusae (Fritz et al. 2007). Therefore, the distribution of *C. sowerbii* may be much wider than currently recorded. One of the main factors for production of medusae is increased water temperature (over 25 °C), and mass production occurs only sporadically and thus it needs no control (Didžiulis & Roman 2013).

Interestingly, a single sexed population of medusae is usually observed, thus making sexual reproduction infrequent and casting doubts on the importance of medusae for population sustainability, as opposed to budding polyps (Pennak 1989, Arbačiauskas & Lesutienė 2005). The fact that within most countries only single-sexed medusae populations are present suggests that there were only a limited number of introduction events to single countries, but different habitats were colonized afterwards due to high mobility within regions, a hypothesis still to be verified by molecular analyses on populations (Fritz et al. 2007).

The biology of *C. sowerbii* is well known, but its distribution data are unpredictable and possibly underestimated. Therefore, registering its occurrences by asking people to inform local authorities in case they see the medusae in a particular place, e. g. through an online survey as applied in Germany and Poland (Didžiulis & Roman 2013), may provide material for further studies.

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Body size and sexual dimorphism in *Geolycosa vultuosa* (C. L. Koch, 1838) (Araneae: Lycosidae)

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Abstract. We performed body measurements and analysed sexual size dimorphism of the burrowing wolf spider *Geolycosa vultuosa*. The body length of females was significantly greater than that of males, which was due to the larger opisthosoma. Males, on the other hand, had significantly longer legs, which probably facilitate their movement in search for mating partners. There is a female-biased SSD in the case of prosoma and opisthosoma length and width, and total body length and a male-biased SSD in the other computed indices. However, the SSD in *G. vultuosa* is not as pronounced as in some other spider species. The length of prosoma seems to be the best proxy of total body size as suggested by the pairwise correlations.

Key words. *Geolycosa vultuosa*, burrow, size dimorphism, prosoma length, leg length.

Introduction

Body size of spiders is highly variable among species, sometimes even within the same species (Gasnier et al. 2002). It is affected by the available food resources during development (Uetz et al. 2002), by altitude (Ameline et al. 2018, Hein et al. 2019), latitude (Puzin et al. 2014), urbanization (Dahirel et al 2019), density of spiders (Drapela et al. 2011), complexity of vegetation in the habitat (Stańska et al. 2018), and in turn, it can influence many life behaviours like individual fitness, fecundity, mating, reproductive investment, web building, diameter of the burrow entrance (Miller & Miller 1984, Carrel 2003, Bowden & Buddle 2012, Ameline et al. 2018, Dahirel et al. 2019, Hein et al. 2019). Sexual size dimorphism is common among spiders, with females being generally larger than males, as they invest more energy in reproduction (Moya-Larano et al. 2002, Framenau 2005, Logunov 2011, Stańska et al. 2018). A few studies reported situations with males being bigger than females (Gasnier et al. 2002), these including also species of spiders where males have high reproductive investment (Aisenberg et al. 2007).

With 2431 described species, Lycosidae is the sixth largest spider family in the world (World Spider Catalog 2020). The genus *Geolycosa* Montgomery, 1904 comprises large-sized spiders which live in burrows dug into the ground (Miller & Miller 1984, Fuhn & Niculescu-Burlacu 1971, Carrel 2003). From this genus, in Romania only the species *Geolycosa vultuosa* (C. L. Koch, 1838) is present, its global range including Slovakia, Hungary, south-eastern and eastern Europe, Turkey, Caucasus and Iran (World Spider Catalog 2020). It occurs in open dry habitats (Szinetár 2006), on sand dunes, in sand pits, xerophilous and mesic grasslands, fallows (Sas-Kovács & Sas-Kovács 2014a, Sas-Kovács & Sas-Kovács 2014b). Adults can be found between May (June) and September (October) (Fuhn & Niculescu-Burlacu 1971, Szinetár 2006), the mating taking place most likely in September (Szinetár 2006) or even later if fall is warm.

The aim of this study was to enlarge knowledge on *G. vultuosa* by collecting morphometric data and analyzing sexual size dimorphism. To our knowledge, little work has been performed on this species in this direction (Fuhn & Niculescu-Burlacu 1971).

Material and methods

The study was conducted in autumn of 2014 in an intensively grazed sandy grassland near Scărișoara Nouă locality, in Carei Plain, north-western Romania (47°38'27"N, 22°14'05"E, 142 m a.s.l.) (Figs 1, 2). In Carei Plain its distribution is

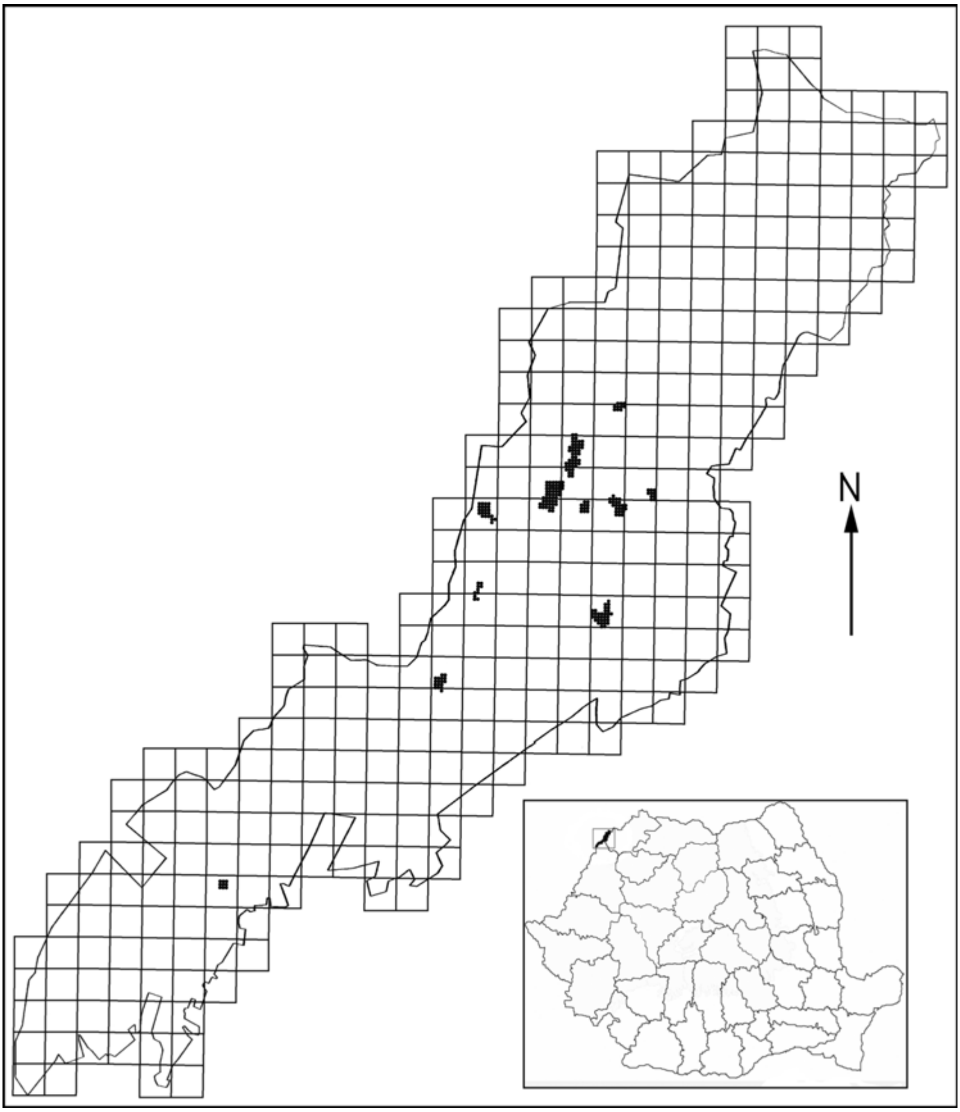

Figure 1. Distribution of *Geolycosa vultuosa* in the Carei Plain protected area (map from Sas-Kovács et al. 2014a).

well documented (Sas-Kovács & Sas-Kovács 2014a, Sas-Kovács & Sas-Kovács 2014b). The species can be easily identified in the field according to the features presented in Fuhn & Niculescu-Burlacu (1971) and Szinetár (2006).

A total number of 54 individuals of *Geolycosa vultuosa* were captured, of them 7 being females and 47 males. Males were easily collected as they were

Figure 2. View of the habitat of the studied *Geolycosa vultuosa* population.

wandering freely in the habitat, while females were generally captured at the entrance of their burrow. Spiders were placed one by one in glass Petri dishes that had graph paper glued on the bottom, and then were photographed with the help of a digital camera (Canon EOS 600D). Weight measurements were done with a digital scale. Weight measurement in females was possible only for two individuals, these having 480 mg and 500 mg, respectively, so this parameter will be discussed in more detail only for males. With the exception of seven individuals in very poor condition, the rest of the spiders were released into the habitat of origin after data collection.

Length and width of the prosoma, opisthosoma and sternum, and length of the legs were measured for the studied males and females (Figs 3-5). Measurements were obtained using AxioVs40 v.4.8.2.0. In order to estimate the area of a spider we calculated its "rough area" (RA), which is the area of a circle with the radius being the average value of the leg lengths. We have also calculated the leg/prosoma ratio, by dividing the average value of leg length with prosoma length (LPRl) and width (LPRw). To quantify the degree of sexual size dimorphism (SSD) we divided the average value of an index of the males with the average value of the females. All these indices were calculated following Gasnier and his collaborators (2002). The opisthosoma area (OA) was calculated after the formula OA=π*opisthosoma length/2*opisthosoma width/2, following Moya-Larano and his collaborators (2003). Length measurements are given in millimetres.

A non-parametric ANOVA (Mann-Whitney U test), was used to compare the differences of sizes between males and females. Spearman's rank correlation was used to test the strength of the linear relationship between various paired data. All these tests were performed with STATISTICA v.8.0. (StatSoft. Inc.).

Results

We observed significant differences in several measured and computed indices. Total body length of females varied between 15.57 and 22.05 mm, and that of males between 14.65 and 18.65 mm. The body length of females was significantly greater than that of males ($U_{7,47}=51$, $p<0.01$). However, we did not found significant differences between sexes concerning the length and width of the prosoma. But both the opisthosoma length and width were larger in females ($U_{7,47}=42$, $p<0.01$ and $U_{7,47}=4.5$, $p<0.0001$). The opisthosoma area was also greater in females ($U_{7,47}=22$, $p<0.0001$). Males, on the other hand, had significantly longer legs (leg I, $U_{7,16}=19$, $p<0.05$; leg II, $U_{7,16}=13$, $p<0.01$; leg III, $U_{7,16}=13$, $p<0.01$; leg IV, $U_{7,16}=26$, $p<0.05$) (Fig. 6) and a greater RA ($U_{7,16}=15$, $p<0.01$). The other computed

Figure 3. Females of *Geolycosa vultuosa* in the field.

Figure 4. Male of *Geolycosa vultuosa* in the field.

indices also showed significant size differences in favour of males (LPRl, $U_{7,16}$=4, p<0.001;LPRw, $U_{7,16}$=7, p<0.01).

There is a female-biased SSD in the case of prosoma and opisthosoma length and width, and total body length (SSD-prosoma length=0,91; SSD-prosoma width=0.95; SSD-opisthosoma length=0.80; SSD-opisthosoma width=0.72; SSD-total body length=0.85), and a male-biased SSD in the other indices (SSD-leg I length=1.15; SSD-leg II length=1.18; SSD-leg III length=1.17; SSD-leg IV length=1.11; SSD-RA=1.32; SSD-LPRl=1.24; SSD-LPRw=1.20).

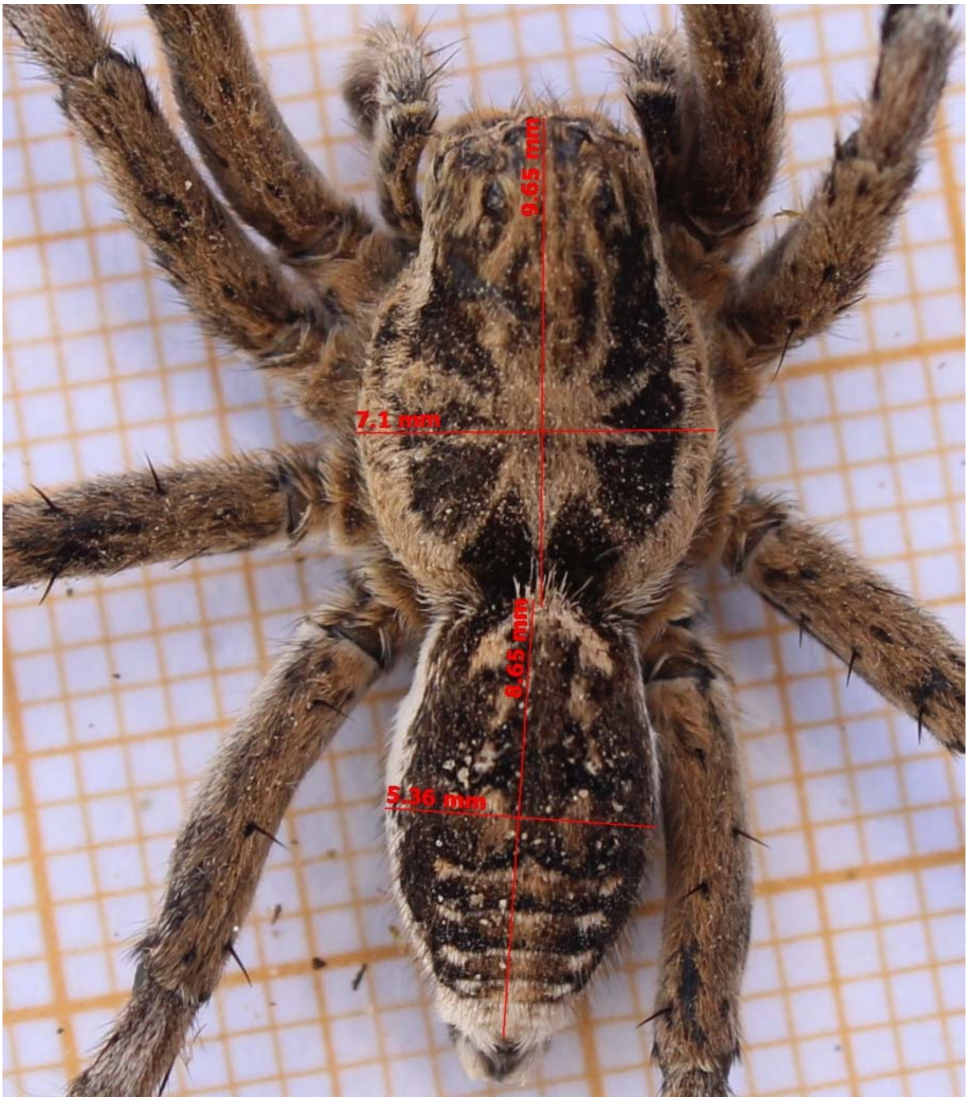

Figure 5. Performing measurements on a male of *Geolycosa vultuosa.*

Weight of male spiders of *G. vultuosa* varied between 210 and 670 mg, with an average of 670 mg. Pair combinations revealed statistically significant correlations ($p<0.05$) and positive in all cases in males. The strongest correlations (with the Spearman's R value being over 0.8) were obtained for the following pair of variables: prosoma length and prosoma width, prosoma length and body length, and opisthosoma length and body length. In the case of females, statistically signif-

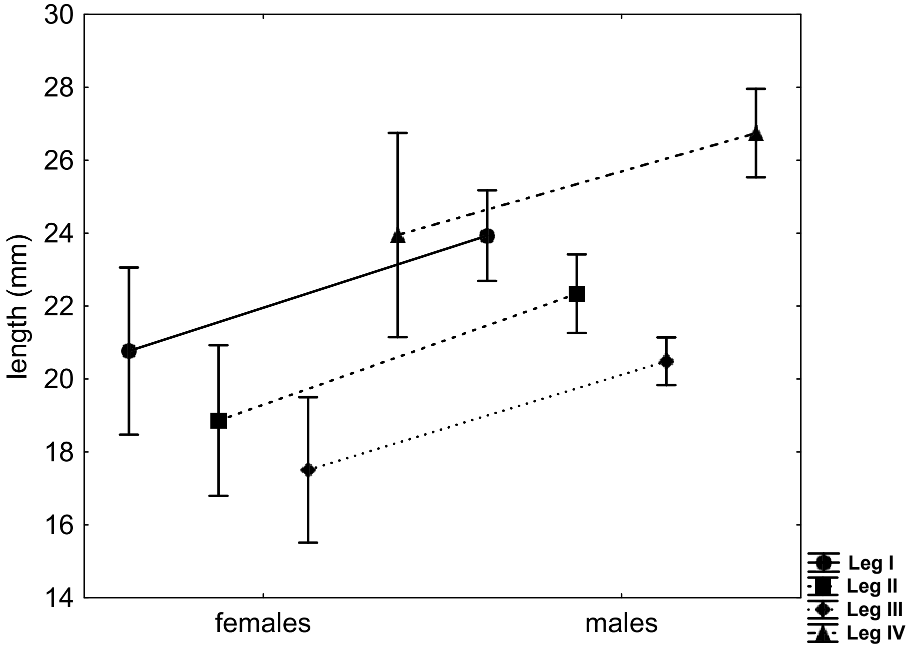

Figure 6. Means ± 0.95 confidence interval for leg lengths

icant ($p<0.05$) and positive correlations were obtained only for the prosoma length with its width, with opisthosoma width and body length (Spearman's R value over 0.9 for all pair of variables). Morphometric data are summarized in the Table 1.

Discussion

We did not found significant prosoma size differences between sexes, though this is a common feature among spiders, with both the width and/or length of prosoma being generally larger in females (Framenau 2005, Gasnier et al. 2002, Stańska et al. 2018), and occasionally in males (Gasnier et al. 2002, Aisenberg et al. 2007). In our case, the greater body length of females is due to the larger size of the opisthosoma, with an area of 51.36±11.67, compared to 29.83±5.54 in males. The study took place in fall when females prepare for hibernation and egg development, and accumulate energy reserves, and while the size of prosoma remains unchanged after the final moult, the opisthosoma can expand depending on the amount of food consumed (Foellmer & Fairbairn 2005). Larger females are able to produce larger egg clutches (Drapela et al. 2011, Bowden & Buddle 2012), but not necessarily larger eggs (Ameline et al. 2018).

Table 1. Morphometric data for the individuals of *Geolycosa vultuosa* (measurements in mm, SD=standard deviation, Min=minimum, Max=maximum, n=number of measured individuals)

	Males			Females		
	Mean±SD (n)	Min	Max	Mean±SD (n)	Min	Max
Body length	16.67±1.10 (47)	14.65	18.86	19.45±2.34 (7)	15.57	22.05
Prosoma length	8.98±0.48 (47)	7.94	9.74	9.86±1.40 (7)	8.58	11.86
Prosoma width	6.54±0.32 (47)	5.71	7.17	6.88±1.13 (7)	5.26	8.42
Opisthosoma length	7.69±0.72 (47)	6.48	9.12	9.59±1.37 (7)	6.94	10.88
Opisthosoma width	4.90±0.49 (47)	3.94	6.43	6.73±0.68 (7)	5.52	7.29
Sternum length	4.12±0.32 (7)	3.57	4.6	4.06±0.49 (6)	3.31	4.57
Sternum width	3.18±0.37 (7)	2.69	3.57	3.43±0.40 (6)	3.02	3.98
Weight (mg)	473.40±97.31 (44)	210	670	-	-	-
Femur I	7.02±0.32 (7)	6.48	7.59	6.42±0.55 (6)	5.88	7.17
Patella I	2.70±0.19 (7)	2.42	2.94	2.82±0.45 (6)	2.29	3.52
Tibia I	5.80±0.40 (7)	5.41	6.65	4.78±0.42 (6)	4.15	5.21
Metatarsus I	6.29±0.32 (7)	6.00	6.78	4.52±0.43 (6)	4.03	5.10
Tarsus I	3.43±0.24 (7)	3.16	3.87	2.87±0.19 (6)	2.69	3.10
Leg I length	23.93±2.33 (16)	19.04	27.84	20.76±2.47 (7)	16.76	23.94
Femur II	6.50±0.29 (7)	6.24	7.11	5.80±0.66 (6)	5.11	6.54
Patella II	2.44±0.16 (7)	2.17	2.67	2.44±0.40 (6)	2.01	3.00
Tibia II	5.10±0.24 (7)	4.75	5.52	4.11±0.32 (6)	3.58	4.46
Metatarsus II	5.82±0.45 (7)	5.41	6.62	4.21±0.55 (6)	3.45	4.95
Tarsus II	3.35±0.19 (7)	3.12	3.71	2.72±0.28 (6)	2.42	3.18
Leg II length	22.33±2.02 (16)	17.34	24.75	18.86±2.23 (7)	16.21	21.99
Femur III	5.80±0.28 (7)	5.32	6.23	5.36±0.54 (6)	4.64	6.05
Patella III	2.20±0.18 (7)	2.03	2.58	2.34±0.32 (6)	1.85	2.67
Tibia III	3.87±0.21 (7)	3.67	4.27	3.35±0.25 (6)	2.90	3.62
Metatarsus III	5.50±0.35 (7)	5.17	6.15	4.26±0.51 (6)	3.67	5.12
Tarsus III	3.27±0.23 (7)	2.87	3.58	2.75±0.23 (6)	2.47	3.04
Leg III length	20.48±1.22 (16)	18.35	22.70	17.50±2.15 (7)	14.07	20.51
Femur IV	7.28±0.32 (7)	6.68	7.70	6.90±0.74 (6)	5.82	7.89
Patella IV	2.50±0.10 (7)	2.36	2.66	2.69±0.31 (6)	2.37	3.18
Tibia IV	5.64±0.25 (7)	5.32	6.07	5.18±0.47 (6)	4.59	5.76
Metatarsus IV	7.55±0.40 7()	7.11	8.36	6.51±0.81 (6)	5.66	7.77
Tarsus IV	3.97±0.24 (7)	3.68	4.28	3.38±0.27 (6)	3.02	3.75
Leg IV length	26.74±2.27 (16)	20.86	29.08	23.94±3.02 (7)	19.47	28.10

Males, on the other hand, were more concerned with mating, the copulation in this species taking place in autumn (Fuhn & Niculescu-Burlacu 1971).They have longer legs which facilitate movement in search of sexual partners (Gasnier et al. 2002, Foellmer & Fairbairn 2005, Framenau 2005, Sas-Kovács et al. 2015), and may also play role in avoiding predators (Moya-Larano et al. 2002). Females remain in burrows all the time, occasionally coming to the surface to seize a possible prey or to widen their burrow, being active in the vicinity of the burrow entrance (Chikhale et. al. 2013). Mating take place at the entrance of the burrow because below, its diameter is just enough to allow the passage of a single individuals (Miller & Miller 1987). Females are most likely to encounter males with high mobility, which are usually also the fittest (Ahtiainen et al. 2004). Nevertheless, males lose energy reserves during roving for suitable mates, but this, as it was shown for the orb-weaving spider *Argiope aurantia*, is not size dependent, with larger males not being necessarily in advantage (Foellmer & Fairbairn 2005).

Framenau (2005) studying two species of wolf spiders with different life history found, similar to us, that males had considerably longer legs than females, but this was true only in the case of *Venatrix lapidosa*, whose females also excavate burrows, and not in *Artoria* in which both the males and females are vagrant. *G. vultuosa* is also a burrowing wolf spider, but longer legs in males had also been reported in *Alopecosa psammophila* (Sas-Kovács et al. 2015), a wolf spider species in which burrow construction behaviour has not yet been revealed. Thus, this gender specific difference does not seem to be limited to Lycosidae species with sedentary females.

Our results on body size and length of the prosoma of the *G. vultuosa* individuals mirror findings of other studies on this species (e.g. Fuhn & Niculescu-Burlacu 1971), indicating that this characteristic is well conserved in many circumstances. However, not all *Geolycosa* species are this big, for example *G. xera archboldi* and *G. hubbelli* have a mean prosoma width of only 3.55 mm, and 4.47 mm, respectively (Carrel 2003). Although there is sexual size dimorphism in *G. vultuosa*, this is not as pronounced as in some other spider species. For example, considering the RA index (rough area), we obtained that males are 1.32 larger than females, while Gasnier and his collaborators (2002) received for SSD-RA values between 1.32 and 2.78, for various Ctenidae species. Nevertheless, the greatest differences in this size index were obtained for those species in which there was a significant gender difference in prosoma length too. Few lycosid species exhibit extreme sexual size dimorphism with males reaching a maximum 50% of females' size (see in: Logunov 2011). It should also be noted, that these dimorphisms, i.e. in RA, longer legs, become evident only after the spider reaches sexual maturity (Gasnier et al. 2002, Framenau 2005).

Weight gain and size of spiders can be influenced by a multitude of factors, such as prey availability (Bowden & Buddle 2012, Dahirel et al. 2011), or in the case of burrowing spiders the size and the average distance of the nearest neighbour, the average value of the neighbours within a radius of one meter (Marshalll 1999). However, Marshall (1999) conducting research on a population of *G. xera archboldi* in central Florida found that mass gain was influenced only by the size of the nearest neighbour, though in a negative manner. Interestingly, in our study, weight was only moderately correlated with the other measured parameters. It was the worst performing variable in this sense. All the others yielded strong or very strong correlations in the pairwise combinations. This has importance for situations when there is not enough time and/or resources for complex measurements and a single parameter that reflects the total body condition, is required. Several studies use prosoma width in this regard (Framenau 2005, Bowden & Buddle 2012, Ameline et al. 2018, Dahirel et al. 2019, Hein et al. 2019, Beckers et al. 2020), since while the width of prosoma is a parameter with a relatively fixed value in the case of an adult spider, the total weight or body length varies with the ingestion of food or water (Uetz et al. 2002). In our study, the length of prosoma seems to be rather a good proxy of body size (Figs 7, 8), which in turn, can offer indications on the development conditions of its owner (Ameline et al. 2018), and can be efficiently used even for discrimination between subspecies (Puzin et al. 2014). Use of the prosoma length as a proxy of body size has been suggested before for spiders with elongated carapace (Gasnier et al. 2002).

Because of the moderately large sample size, and a little underrepresented female number, our result is robust, but still may represent a good starting point for future researches comparing the biometric features of different *G. vultuosa* populations according to habitat conditions. The Carei Plain is an ideal land in this sense, as here the species populations are relatively stable and even expanding due to the generation of new habitats through the excessive grazing practiced in the area (Sas-Kovács & Sas-Kovács 2014a).

Conclusions

Length and width of the prosoma, opisthosoma and sternum, and length of the legs were measured for 54 individuals of *Geolycosa vultuosa*, which is a large-sized burrowing wolf spider species, occurring predominantly in open sandy habitats. Total body length of females varied between 15.57 and 22.05 mm, and that of males between 14.65 and 18.65 mm. The body length of females was significantly greater than that of males, and this is due to the larger size of the opisthosoma, with an area of 51.36±11.67 in females, compared to 29.83±5.54 in males. The

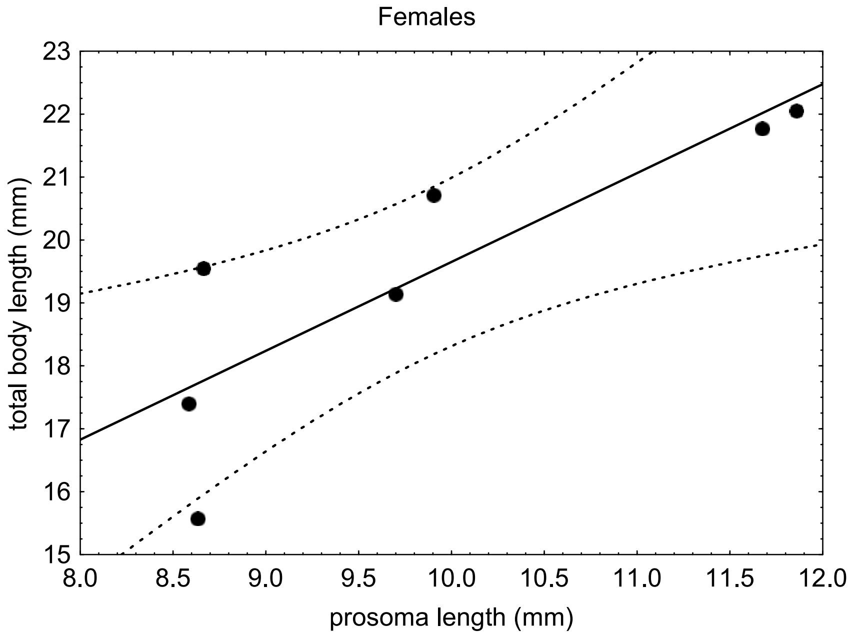

Figure 7. Correlation between prosoma length and body length in females.

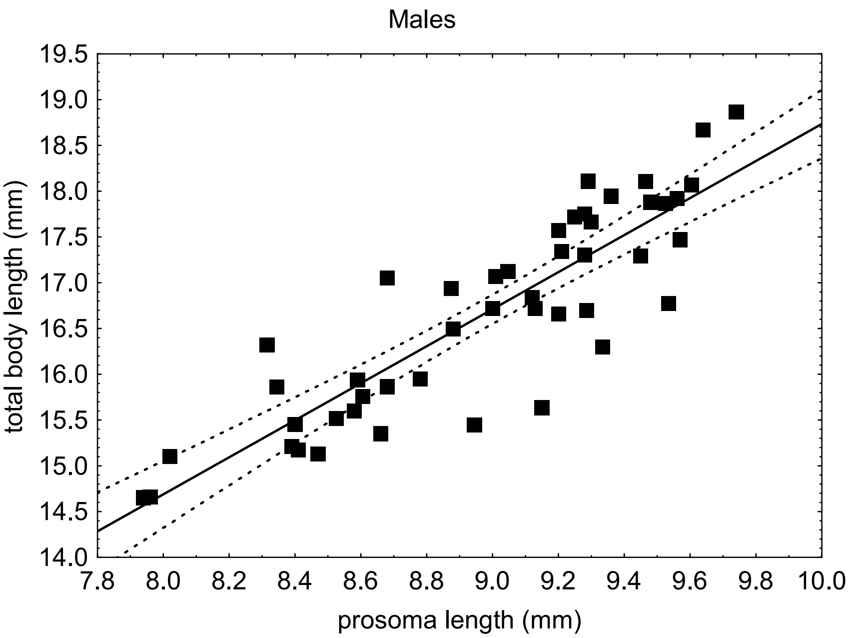

Figure 8. Correlation between prosoma length and body length in males.

opisthosoma expands if the spider eats, and in autumn females prepared for hibernation and egg development, thus accumulated energy reserves. Males had significantly longer legs and a greater rough area. Longer legs may facilitate movement in order to find the right sexual partner, and to avoid predators.

Weight of male spiders varied between 210 and 670 mg, with an average of 670 mg. Pairwise analyses showed statistically significant correlations ($p<0.05$) and positive in all cases in males, but weight was only moderately correlated with the other measured parameters. In the case of females, statistically significant ($p<0.05$) and positive correlations were obtained for the prosoma length with its width, and with opisthosoma width and body length. According to our results, the best parameter to predict body size of *G. vultuosa* is prosoma length.

The sexual size dimorphism, although exists in the case of this species too, is not that marked. There is a female-biased SSD in the case of prosoma and opisthosoma length and width, and total body length and a male-biased SSD in the other considered indices.

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NYMPHAEA Folia naturae Bihariae	XLVI-XLVII	107-126	Oradea, 2020

Cauzele distrugerii rezervației Pețea

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Rezumat. Distrugerea ecosistemullui termal din rezervația naturală Pârâul Pețea (inclusă în situl Natura 2000 Lacul Pețea) a fost cauzată de activitățile umane din zonă. Cauza secării izvorului termal a fost extracția excesivă de apă termală, mult peste limitele stabilite prin studii hidrogeologice, și nu fluctuațiile recente și regionale ale cantităților de precipitații, așa cum susține un studiu părtinitor.

Introducere

Spre sfârșitul anului 2011, custodele de atunci al rezervației naturale Pârâul Pețea, totodată sit Natura 2000 (Muzeul Țării Crișurilor), a constatat oprirea funcționării izvorului sublacustru care alimenta cu apă termală lacul denumit Ochiul Mare (care de fapt era un golf al pârâului Pețea).

Existentă din timpuri geologice și cunoscută de secole – după cum atestă o serie de lucrări și studii științifice valoroase – zona izvoarelor termale naturale din Băile Episcopiei (denumită în perioada comunistă Băile 1 Mai) a fost distrusă de interese financiare și de indolența instituțiilor a căror sarcină era ocrotirea și menținerea în condiții optime a acestei zone unice, în ciuda atenționărilor repetate din partea custodelui. Speciile endemice care trăiau în acest ecosistem special au ajuns pe calea extincției sau sunt menținute în condiții artificiale. Agonia izvorului, care alimentează din când în când Ochiul Mare lipsit de speciile ocrotite, durează de peste 10 ani și în afară de declarații sonore nu s-a făcut și nu se face nici un efort oficial pentru reabilitare. O asemenea încercare a avut loc din partea unor organizații locale, în cadrul oferit de programul comunitar Interreg V-A România – Ungaria. Lipsa sprijinului instituțiilor centrale de resort și refuzarea colaborării din partea celor doi titulari de licențe care dețin și utilizează majoritatea forajelor termale din zonă au frânat substanțial realizarea integrală a celor prevăzute – care de fapt urmau să aibă efecte pozitive și asupra activității lor.

Dacă în perioada declarării rezervației naturale și cu multe secole înainte Pârâul Pețea era un curs de apă însemnat, care antrena zeci de mori, spre sfîrșitul sec. XX. doar izvorul sublacustru din Ochiul Mare a mai rămas activ, alimentând un afluent neînsemnat al pârâului Hidișel (care de fapt drenează apele uzate din Băile Felix).

Practic, rezervația există doar pe hârtie. Ceea ce a rămas din ea este o baltă umplută cu apă de ploaie, din când în când și cu apă termală (după revenirile episodice ale izvorului sublacustru), lipsită de speciile endemice pentru ocrotirea și salvarea cărora a fost înființată.

Formarea lacului Ochiul Mare

În zona Băilor Episcopiei, izvoarele termale erau cunoscute și căutate încă din evul mediu (unele indicații presupun uzilizarea lor încă din timpul romanilor) pentru efectele lor terapeutice deosebite. Primul document care atestă existența și importanța zonei datează din 1221, din care reiese că aici funcționa o adevărată stațiune balneară.

Se cunosc o serie de documente din evul mediu care descriu această stațiune și efectele tămăduitoare deosebite ale apelor de aici. Drept dovadă prezentăm doar un singur exemplu: harta Regatului Ungariei întocmită în Anglia de John Speed în anul 1626, pe care este trecută stațiunea balneară, denumită atunci „Terme", lângă Sânmartin (Marton) și Oradea (Wardeyn) (Fig. 1).

Documentele menționate se ocupau în primul rând de proprietățile chimice și terapeutice ale izvoarelor termale captate în bazine. Modalitatea de captare utilizată în acele vremuri era construirea unui bazin (de obicei din grinzi de brad) chiar deasupra izvorului, asigurînd în acest fel schimbul permanent de apă. Pe harta băilor termale ale Episcopiei din Oradea întocmită în 1775 (Fig. 2) se disting cele patru bazine existente atunci, fiecare cu câte un canal de evacuare. Cum puternicul izvor din albia Peței nu putea fi amenajat în acest fel și nu era vizibil la suprafață, harta nu indică locul lui.

Abia pe harta realizată în cadrul campaniilor topografice militare ale Imperiului austro-ungar (care au avut loc în perioada 1819-1869) se poate observa

Figura 1. Fragment din harta lui John Speed, 1626 cu zona Oradea.

Figura 2. Harta Băilor Episcopiei, din 1775 (sursa: maps.hungaricana.hu/en/OSZKTerkeptar/706/).

deja golful Peței, denumit ulterior Ochiul Mare, cu alura unui lac și cu două insule construite artificial, legate cu podețe (Fig. 3).

În anul 1861 a apărut cea mai amplă descriere monografică a Băilor Episcopiei. Autorul, Antal Mayer, era medicul oficial al stațiunii și în lucrarea să a reușit să descrie toate detaliile naturale, balneare și turistice din aceea vreme, de la formațiunile geologice până la prețul biletelor de intrare la bazine. Din harta aferentă cărții am decupat zona cu izvoarele termale. La vest de Ochiul Mare erau opt izvoare amenajate, captate în băi, iar la est șapte izvoare puternice, la unele din ele cu urmele unor amenajări balneare (Fig. 4).

Se disting și aici golful cu cele trei insule (cu verde), precum și izvoarele superioare Ochiului Mare, ale căror debite erau suficiente pentru acționarea hidraulică a unei uzine. Comparând harta din 1775 cu cele două ulterioare se deduce că în porțiunea Ochiului Mare au fost efectuate intense modificări, s-au construit insule artificiale, canale, îndiguiri etc., finalizând morfologia și aspectul cunoscut la începutul sec. XX. (redat pe multe cărți poștale).

Această imagine a Ochiului Mare s-a schimbat destul de mult în sec. XX, din lipsa îngrijirii și a unui stăpân gospodar. Podețele dintre cele trei insulițe, precum și cele care înconjurau zona izvorului sublacustru s-au deteriorat, lăsînd în urmă doar cioturile stâlpilor, care apar după scăderea nivelului apei.

Izvorul sublacustru

Geologul austriac A. Wolf a realizat în 1863 prima secțiune al zonei Ochiului Mare (Fig. 5). A remarcat foarte corect alura vetrei în jurul punctului de izvorâre, care are forma unei pâlnii largi din centrul căreia are loc afluxul puternic al apei termale.

Tot în monografia lui Mayer găsim și prima descriere detaliată a acestui izvor. Autorul remarcă ascensiunea puternică a unei coloane de apă fierbinte, de aproximativ 1 m diametru, din adîncimea de 6 m („3 stânjeni") a pâlniei izvorului. Apa în ascensiune este plină cu cochilii de melci și suspensii foarte fine („praf, cenușă"), după cum remarcă autorul. Trebuie subliniat că aceeași adâncime de aproape 6 m s-a măsurat și în 1963 de către scafandrii amatori care curățau lacul de plantele invazive. După 2011, palnia de izvor a devenit vizibilă de foarte multe ori, mai bine zis a fost vizibilă preponderent, pe tot cursul anilor. Din păcate, Pârâul Glighii, acest curs de apă temporar, aducând dinspre est apele de precipitații adunate de pe pantele dealului Șomleu, și-a creat drum spre izvor, contribuind substanțial la colmatarea pâlniei. Alimentarea artificială a lacului pentru compensarea izvorului secat și salvarea speciilor, printr-un furtun din forajul apropiat, a avut efecte identice, erodand sedimentele din fundul lacului. Conform măsurătorilor recente, pâlnia nu mai are decât 2 m adâncime (Fig. 6).

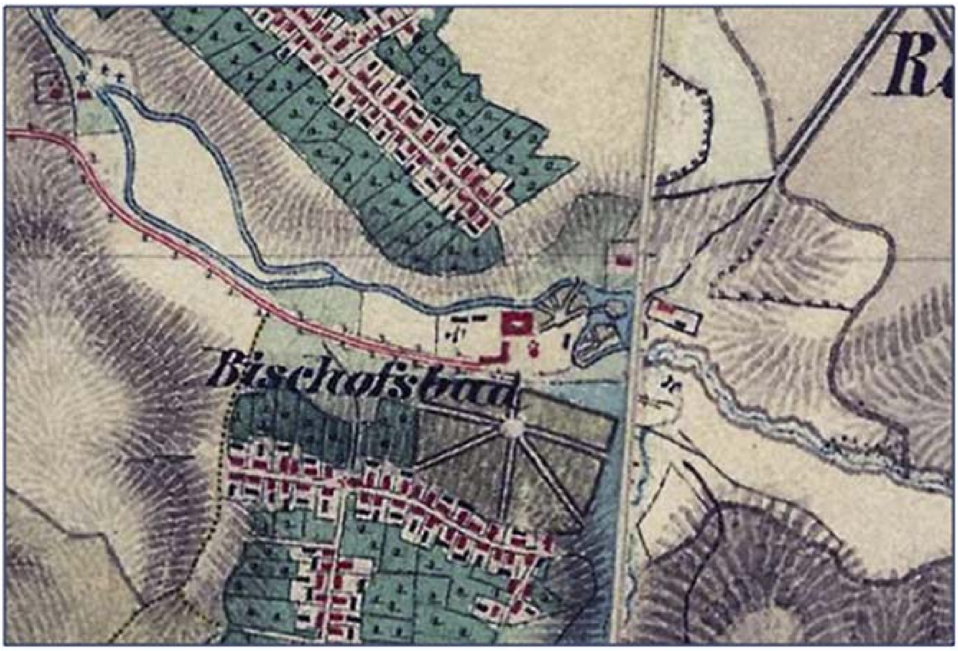

Figura 3. Fragment din harta campaniei topografice militare.

Figura 4. Harta Băilor Episcopiei, din anul 1861 (sursa: A. Mayer,1861).

Cadrul geologic-hidrogeologic

Detaliile geologice, structurale și hidrogeologice ale zonei au fost în detaliu prezentate în volumul 40 al anuarului Nymphaea (Paál 2013). Întrucât studiul comandat de ANRM a spicuit doar cîteva aspecte din această prezentare, reamintim detaliile cele mai importante ale funcționării acestui sistem hidrogeotermal, hotărâtoare pentru întelegerea catastrofei ecologice:

- acviferul termal utilizat în cele două stațiuni formază un sistem unitar din punct de vedere hidraulic, având în trecut foarte multe, iar în prezent doar un singur punct de descărcare naturală (izvor termal);
- în 1979, în cadrul singurului test de interferență executat asupra zonei, a fost determinat debitul de 300–350 l/s al realimentarii, cu ape provenind din afluxul ascendent al apelor termale de profunzime;
- datele cercetărilor complexe au stat la baza formulării ipotezei realimentării zonei Băilor din acviferul termal de sub Oradea, cantonat în roci de vârstă triasică. Toate trăsăturile hidrochimice, geotermice, hidroizotopice, radiologice etc. au susținut această legătură. Dar și cercetările prin foraje executate în jurul stațiunilor au indicat realimentare ascendentă, acviferul neavând continuitate pe orizontală;
- ipoteza mai sus menționată a fost verificată pe cale experimentală, în cadrul unui test hidrodinamic executat la Oradea în 1984;
- legătura celor două acvifere, precum și condiționarea lor structurală a fost indicată și de efectele cutremurului din 15 oct. 1834 din Valea Ierului, precum și de efectele hidrochimice apărute în urmă cutremurului din 4 martie 1977;
- cercetările hidroizotopice au confirmat originea comună a apelor din ambele acvifere, ca aparțînînd de aceleași hidrostructuri regionale, cu realimentare din zona Apusenilor de vest și cu circulație lentă dar activă, care justifică spectrul hidrochimic. Vârsta de peste 5.000 – 10.000 de ani a apelor susține modelul traseului îndelungat, dar s-a constatat intinerirea lor în urma supraexploatării;
- din compoziția apelor lipsesc izotopii, care ar justifica participarea apelor recent infiltrate.

În Fig. 7 prezentăm secțiunea hidrogeologică prin zona stațiunii Băilor Episcopiei, în scopul demonstrării rolului elementelor structurale în dirijarea afluxului ascendent al apei termale înspre zona izvoarelor. Chiar și din această secțiune este lesne de înțeles că extragerea forțată a apei din sonde determină scăderea nivelului piezometric, implicit secarea izvorului. Sondele F1 Alin Bogdan și Fp-2 sunt în poziții deosebit de defavorabile din acest punct de vedere, la fel și sonda Fp-1, care deservește Ștrandul Venus.

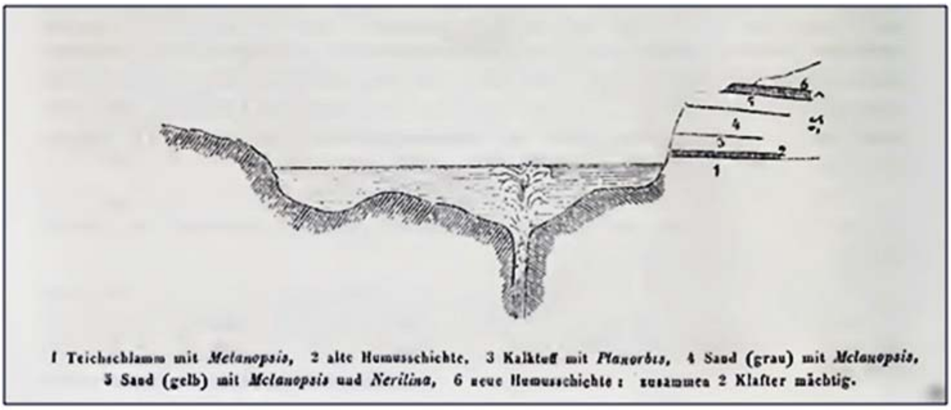

Figura 5. Secțiune prin zona izvorului sublacustru.

Figura 6. Balta din pâlnia izvorului, în data de 9.02.2019.

După cum s-a speciificat în lucrarea privind sinteza particularităților hidrogeologice (Paál 2013), traseul ascendent exact al apelor dinspre Oradea spre zona stațiunilor este greu de precizat. Constituția litologică a teritoriului și trăsăturile tectonice sugerează posibilitatea ca pe acest traseu să fie traversate și alte acvifere (care însă nu au fost descoperite de forajele adânci din zonă), ale căror ape modifică ușor calitățile chimice ale apelor din zona Oradea. Cu toate că s-au săpat sonde de mare adîncime în scopul detectării acestor eventuale afluente din alte acvifere, problema este atât de minimal cercetată încât afirmațiile studiului ANRM și ale mai multor publicații (Orășeanu 2015, Orășeanu & Malancu 2017) despre existența unui dren care leagă direct zonele de infiltrație din Apuseni cu zona Băilor, denumit „Falia Galbenă”, țin deocamdată de domeniul imaginației. Cu atât mai mult cu cât această falie nu este prezentă nici pe harta oficială geologică și tectonică a țării, întocmită de Institutul Geologic, dar nici în lucrările anterioare valoroase ale autorului referitoare la aceste zone.

Dereglările funcționării izvorului sublacustru

După cum au dovedit cercetările paleontologice, botanice și geografice, izvoarele termale funcționau nestingherit cel puțin din timpul ultimei glaciațiuni. Indiferent de climă, de condițiile meteorologice, de secete și precipitații, mediul acvatic termal, prielnic supraviețuirii speciilor endemice, a rămas neschimbat până spre sfârșitul secolului al XIX-lea.

Înainte de 2011, în funcționarea continuă a izvorului din Ochiul Mare au intervenit câteva perturbații episodice, cauzate de săparea forajelor. Prima asemenea intervenție antropogenă a avut loc în 1885, când la Băile Felix s-a săpat prima sondă de apă termală. Erupția care a avut loc la interceptarea unei fisuri din calcare avea debitul de 190 l/s. Potrivit unei monografii din 1901, debitul izvoarelor din Băile Episcopiei s-a redus substanțial în urma acestei erupții, revenind la valorile anterioare abia după trei luni.

Evenimente analoage au avut loc după 1962, odată cu începerea campaniei de executare a forajelor din cele două Băi. În majoritatea cazurilor, odată cu interceptarea la diverse adîncimi a calcarelor fisurate avea loc același șir de evenimente: interceptarea unei fisuri sau a unui gol, câteodată cu căderea garniturii pe cîțiva metri adâncime; pierderea totală a noroiului de foraj, urmată de erupții vehemente de apă termală. Aceste erupții aveau debite de peste 100 – 200 l/s, în funcție de poziția fisurii și poziția forajului respectiv în cadrul hidrostructurii.

În studiul deja menționat am detaliat influența acestor fenomene, care determinau de fiecare dată scăderea debitului izvorului din Ochiul Mare (precum și al tuturor izvoarelor naturale mai mici din zonă) sau chiar și secarea lor.

Pe baza interpretării acestor date s-a putut stabili că efectul erupțiilor în jur de 50 l/s se resimte imediat la izvoare, dar ele nu au efect în părțile mai adînci ale acviferului (asupra sondelor), nici după 3 zile. Erupții în jur de 100 l/s opresc funcționarea izvoarelor naturale și produc scăderea debitului tuturor sondelor, cu excepția forajului 4003, restabilirea debitelor începând după cel mult o zi. Erupții mai mari de 150 l/s produc dereglarea întregului acvifer și secarea instantanee

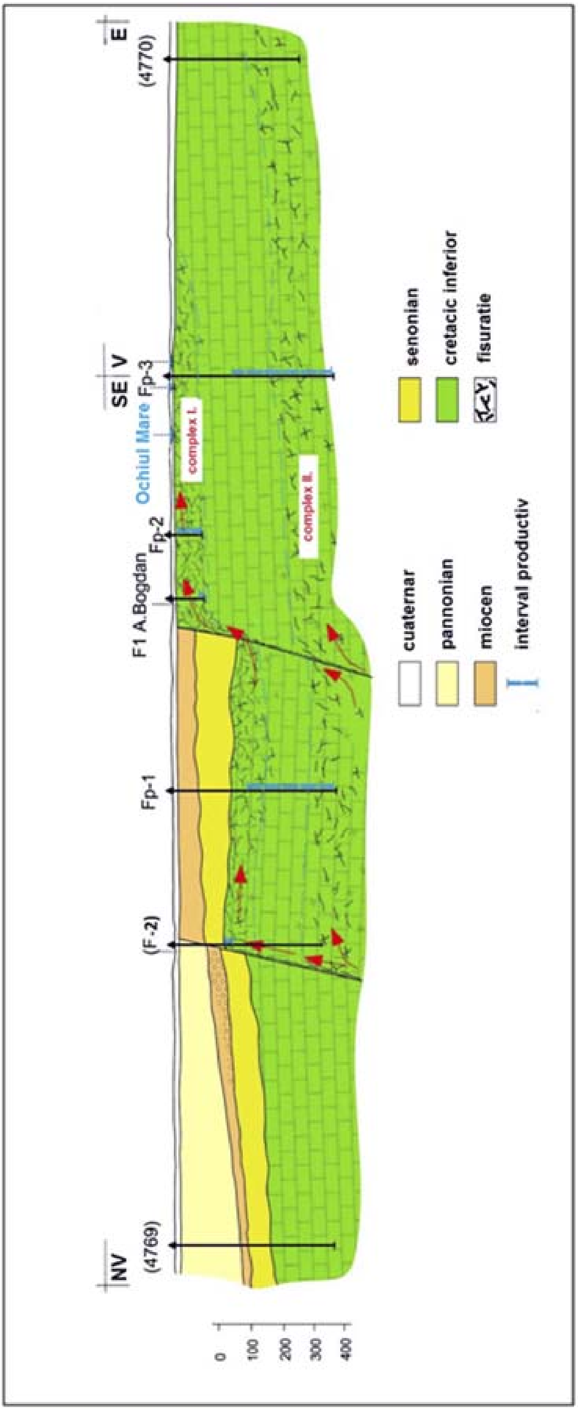

Figura 7. Secțiune hidrogeologică prin zona Băilor Episcopiei.

a izvoarelor, scăderea accentuată a debitelor forajelor intervenind după cel mult o zi. După oprirea erupțiilor, revenirea debitelor variază între 4 și 8 zile, ceea ce poate indica existența căilor de alimentare separate ale forajelor, situate chiar și la distanțe foarte mici (de exp. 4003 și Balint).

În afară de aceste situații episodice, izvorul sublacustru din Ochiul Mare și celelate izvoare au funcționat permanent, dar a avut loc un declin lent al debitelor, legat de executarea forajelor de apă termală din Oradea. După 1981, până când cele patru sonde din municipiu debitau artezian în total 35 l/s, au fost săpate și date în folosință la Oradea încă șapte sonde, debitul artezian ajungând la 132 l/s în 1984 (Cohut 2013). Zona izvoarelor naturale a resimțit imedit această creștere: în partea a doua a anului 1982 au secat izvoarele mai mici din Băile Episcopiei, situate la est de Ochiul Mare, iar sonda Izbuc nu a mai produs artezian. Modificările de la Oradea au influențat negativ și debitul artezian al sondelor din cele două Băi, care a scăzut de la 260 l/s (în 1982) la 200 l/s (în 1984).

Agonia rezervației a început în 7 decembrie 2011, când custodele de atunci (Muzeul Țării Crișurilor) a observat oprirea funcționării izvorului sublacustru din Ochiul Mare. Faptul a fost confirmat și prin măsurători efectuate de scafandri. În perioada geroasă din februarie, suprafața lacului a înghețat complet (8 februarie), dovedind lipsa afluxului de apă termală, situația menținându-se până în data de 25 martie.

Această ciclicitate caracterizează și anii următori, până în prezent. Repornirea izvorului avea loc cu regularitate, de obicei în a doua parte a lunii martie sau în aprilie. Singura excepție s-a constatat în anul 2019, când repornirea obișnuită de primăvară a întârziat mult și a avut loc în 23 iunie. În 2012, izvorul a rămas activ aproape cinci luni de zile, până în 8 august. Perioadele active din anii următori erau în schimb mult mai scurte și durau până la începutul sezonului estival, adică până spre sfârșitul lunii aprilie și începutul lunii mai, indicând efectul umplerilor dese sau permanente ale bazinelor. Trebuie menționat că în 2013, în afară de activarea din martie și secarea în aprilie, a avut loc încă o repornire excepțională, în data de 13 iulie, izvorul fiind activ până în data de 25 noiembrie.

Nu este greu de înțeles că acest ritm relativ constant observat în funcționarea izvorului nu poate avea tangențe cu condițiile meteorologice extrem de variabile și tot mai capricioase – după cum susțineau și susțin din păcate și în prezent reprezentanții instituțiilor de resort, precum și specialiștii angajați pentru studierea și monitorizarea acviferului în perioada 2014-2016. Indiferent de mersul vremii, reactivarea izvorului avea și are loc la sfîrșitul perioadei de încălzire pe bază de apă geotermală a locuințelor, după cum secarea izvorului coincide cu începutul sezonului estival, iar în toamnă cu începutul încălzirii. Cauzele dereglării izvorului și distrugerii rezervației sunt deci antropogene și au la bază exploatarea nerațională și exagerată a resurselor, precum și gospodărirea greșită și necontrolată din partea instituției de resort (ANRM).

Secarea din 2011 a declanșat – după insistențele custodelui de atunci - câteva acțiuni din partea instituțiilor responsabile, dar fără rezultate concrete. Prefectura, de exemplu, a organizat două campanii pentru detectarea forajelor ilegale din zona stațiunilor, dar nici metodica aplicată, nici lipsa perseverenței nu au dat rezultate. După insistențele repetate ale custodelui de atunci (Muzeul Țării Crișurilor), Ministerul Mediului și Schimbărilor Climatice a organizat în februarie 2013 o echipă de experți, care doar după o scurtă vizită la Băi a și enunțat cauzele posibile ale catastrofei, reflectând lipsa cunoștințelor lor detaliate asupra problemei.

În timp ce exemplare din speciile ocrotite au fost salvate din rezervație în mai multe acvarii din țară și din străinătate, iar lacul se transformă într-o baltă, la nivel ministerial se purtau discuții despre necesitatea unui studiu asupra situației actuale a rezervelor. Rezervația fiind în patrimoniul Ministerului Mediului, dar existența ei fiind condiționată de apele termale gestionate de ANRM, interesele erau antagoniste. Totuși, în final s-a ajuns la soluția executării unui studiu comandat și plătit de ANRM, adică de instituția care nu a reușit să managerieze și să gospodărească rezervele de apă termală în așa fel încât să mențină și rezervația în condiții favorabile. Este aceeași instituție care, în ciuda studiilor și încheierilor de rezerve din anii trecuți, nu a respectat siituația hidrogeologică a zonei și a continuat să anunțe noi și noi concesiuni în zona Băilor, chiar și după agravarea situației.

Studiul executat de Universitatea București, Facultatea de Geologie și Geofizică și Asociația Hidrogeologilor din România (AHGR) în perioada 2014-2016 (denumit în continuare Studiu) nu a fost nici publicat (doar un rezumat a apărut pe internet, studiul „in extenso” fiind consultabil numai la sediul AHGR), nici discutat cu partenerii interesați, în primul rând cu Ministerul Mediului sau cu Academia, nemaivorbind de instituțiile locale. Totuși, se pare că el a devenit instrumentul oficial de lucru în activitatea ANRM din zona stațiunilor. Numai în acest fel se poate explica eliberarea în continuare a licențelor pentru noi foraje, ultimele două fiind executate la Felix în 2019.

Cu toate că Studiul prezintă inventarul real al problemelor, cauza acestora este pusă pe seama condițiilor meteorologice și climatice, nu pe seama exploatării exagerate. După cum era de așteptat (cel mai plauzibil din cauza finanțării de către ANRM), studiul nu putea ajunge la concluzii în detrimentul Agenției. În afară de protejarea intereselor Agenției, cealaltă tendință clară era negarea sau diminuarea rezultatelor testului din 1984, care a dovedit legătura hidraulică dintre acviferul de la Oradea și cel de la Băi (deși titlul Studiului este: Studiu hidrogeologic privind situația actuală a resurselor sistemului geotermal Oradea–Băile Felix-1 Mai și posibilitățile de protejare a sitului comunitar ROSCI 0098, Lacul Pețea).

Carențele, confuziile și greșelile Studiului au fost prezentatea în *Nymphaea* 44 (Cohut & Paál 2018). Dintre ele amintim doar reactivarea izvorului sublacustru din martie 2016, explicată pe baza precipitațiilor relativ abundente din ianuarie–martie. În acest scop se prezintă graficul precipitațiilor înregistrate la stația Sânmartin (nu este justificată alegerea acestei stații, pe când în Studiu zona de realimentare precizată este în partea vestică a Apusenilor), fără să explice de ce nu au avut nici un efect precipitațiile din 2014 și 2015 asupra izvorului, care era aproape tot timpul secat (Fig. 8).

Legarea activității izvorului sublacustru de precipitațiile recente putea fi dovedită prin analize hidro-izotopice adecvate. Determinarea vârstei absolute, precum și a conținutului de tritiu, dădeau indicații precise în acest sens. Dar pe parcursul executării Studiului nu s-au efectuat determinări de vârstă (fără motivare), iar în privința tritiului doar la două sonde s-au decelat cantități minime, care nu confirmă legătură directă cu precipitațiile.

În schimb, subliniem faptul că în cadrul proiectului INTERREG menționat în introducere au fost prelevate probe pentru o serie de analize izotopice speciale, cu ocazia revenirilor izvorului din 2018 și 2019. Analizele și prelucrările detelor sunt în curs, dar pe baza primelor rezultate se poate afirma că apa izvorului sublacustru, cu ocazia revenirii din martie 2018, avea vârsta absolută între 5.000 și 10.000 de ani. Rămîne o enigmă în ce măsură au putut influența precipitațiile actuale ale primului trimestru reactivarea izvorului cu ape atât de vechi.

Tendențiozitatea de a nega rezultatele singurului test hidrodinamic din 1984 reiese și din explicarea creșterii debitelor surselor din Băi după terminarea testului și deschiderea primei sonde din Oradea. Cu toate că Studiul descrie influența pozitivă a închiderii sondelor din Oradea asupra celor din Băi (creșterea debitului de curgere liberă cu 35 l/s), pentru a pune sub semnul întrebării legătura hidraulică dintre cele două acvifere le da o altă explicație, bazată pe datele unui pluviometru din Apuseni, cel de la Luncasprie, care se află la peste 30 km distanță. Autorii presupun că precipitațiile din septembrie 1984 de la Luncasprie ar putea explica creșterea debitelor surselor de la Băi în perioada opririi sondelor de la Oradea. Se trage deci concluzia potrivit căreia interferența constatată și măsurată dintre Oradea și Băi nu poate fi susținută, eventual ea având doar rol secundar, acoperit în totalitate de efectul alimentării directe din precipitații (căzute la Luncasprie, n.a.).

În privința conexiunii dintre regimul precipitațiilor de la Luncasprie și sursele din cele două stațiuni, Studiul rămâne dator cu explicarea lipsei influențelor unor perioade cu precipitații însemnate asupra debitelor surselor din stațiuni, sau chiar și a unor efecte contrare (Fig. 9).

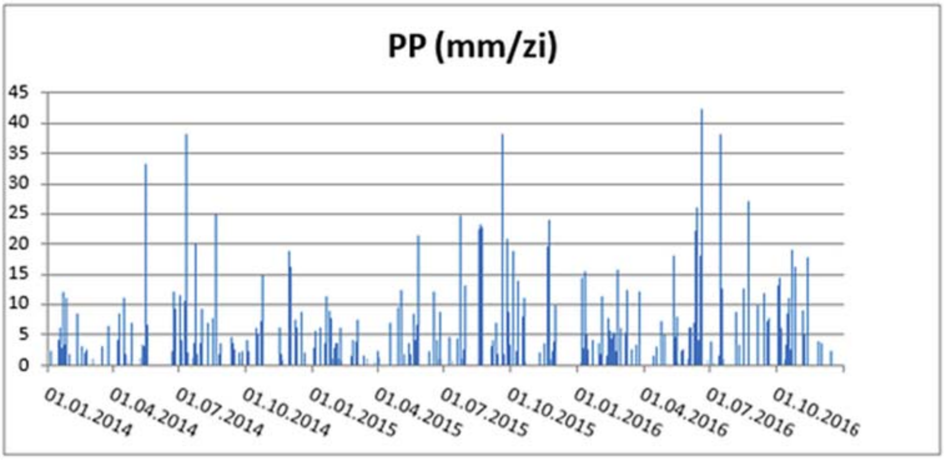

Figura 8. Precipitațiile înregistrate la stația Sânmartin, 2014 – 2016 (sursa: Studiul ANRM).

Cauzele distrugerii

Declinul izvoarelor naturale, început în 1982, a fost amplificat de supraexploatările sondelor din Băi, precum și de creșterea substanțială a debitelor extrase din sondele de la Oradea, fără aplicarea reinjectării.

Debitul eruptiv natural al izvoarelor și sondelor din cele două Băi (potrivit testului de interferență executat în 1979) era de 300–350 l/s, ceea ce reprezenta afluxul realimentarii naturale. Cercetările complexe au indicat că această realimentare are loc pe verticală, prin sisteme fisurale aferente aliniamentelor tectonice majore ale zonei, acviferul neavând continuitate laterală în nici o direcție (cercetată prin foraje). Sursa cea mai plauzibilă a acestei ascensiuni era acviferul termal din subsolul orașului Oradea, după cum au dovedit cercetările complexe: geologice, goefizice, hidrochimice, izotopice etc. Ipoteza de lucru enunțată în 1975 a fost acceptată de instituțiile de resort (Ministerul Minelor, Petrolului și Geologiei, Comisia Republicană de Rezerve Geologice, Institutul Geologic), iar după verificarea și confirmarea printr-un test hidrodinamic executat în 1984 a devenit instrumentul de lucru al Comisiei Republicane de Rezerve Geologice.

Aceste dovezi au fost acceptate și în nouă structura organizatorică de după 1990, dar după anul 2000 – din motive necunoscute – s-a schimbat interpretarea lor, cauzând efecte grave. Debitele exploatabile stabilite în 1987 sunt în vigoare și în prezent, dar sunt total greșit interpretate de instituția de resort. De fapt, întreaga dereglare a sistemului Oradea–Felix se datorește acestei interpretări nejustificate a debitelor exploatabile. Valorile de 90 l/s (fără reinjectare) pentru Oradea și 207 l/s pentru Băi reprezentau debite instantanee, care nu puteau fi depășite fără efecte negative asupre zonei stațiunilor și asupra rezervației. Numai interesele economice legate de extinderea valorificării puteau motiva trecerea de la debite exploatabile instantanee la debite medii anuale – ceea ce permite depășirea substanțială și de durata a debitelor exploatabile stabilite pe baza testului. Modificarea a permis dublarea exploatării în scopuri de încălzire în cazul municipiului și dublarea exploatării în scopuri de agrement și balneo-terapie la Băi.

În acest scop, atât sondele din stațiuni, cât și cele din Oradea au fost echipate cu pompe submersibile de mare capacitate. Astfel, deși debitul exploatabil de către SC Turism Felix SRL este de 207 l/s, pompele instalate în cele opt sonde ale societății au capacitatea de 430 l/s, adică dublul debitului stabilit în licență. Funcționând cu această capacitate în sezonul estival și iarna la debite mai reduse, media anuală rămâne sub valoarea prescrisă – dar acest mod de interpretare a debitului exploatabil nu este corect.

Începând cu anul 1993, mai multe sonde din Oradea au fost echipate cu pompe cu ax (islandeze, în cadrul unor proiecte din Fonduri Nordice), în acest fel capacitatea actuală totală de exploatare este de 198 l/s, în timp ce debitul exploatabil stabilit este de 90 l/s fără reinjectare. Majoritatea sondelor din Oradea fiind utilizate în scopuri energetice (încălzire și preparare de apă caldă menajeră), în sezonul rece aceste sonde sunt utilizate la maximum. Vara, în schimb, consumul este mult mai redus, astfel că modul de raportare a exploatării în „l/s medie anuală" se încadrează în valoarea fixată în licență.

Potrivit analizelor efectuate, catastrofa ecologică a rezervației Lacului Pețea în urma secării repetate a izvorului sublacustru termal a fost determinată de următoarele cauze principale:

1. Supraexploatarea sondelor din cele două stațiuni, depășind cu mult rata realimentării naturale. Analiza consumurilor medii lunare indică clar validitatea acestei afirmații. În diagrama din Figura10 am prezentat consumurile lunare din cele două stațiuni (sursa datelor: Studiul ANRM), defalcate pe perioada sezonului estival și în afara sezonului. În cazul ambelor perioade de utilizare se remarcă creșterea continuă a consumului, ceea ce ar reflecta dezvoltările efectuate. Dar gospodărirea resurselor, precum și legislația comunitară pun mare accent pe filtrarea și reciclarea apelor utilizate în scopuri de agrement, procedură probabil neaplicată în acest caz. Ceea ce este mai îngrijorător în cazul stațiunilor este creșterea mult mai accentuată a consumurilor din afara sezonului estival. Nu dispunem de date certe pentru explicarea cauzelor, după cum nici măcar cercetătorii angajați de

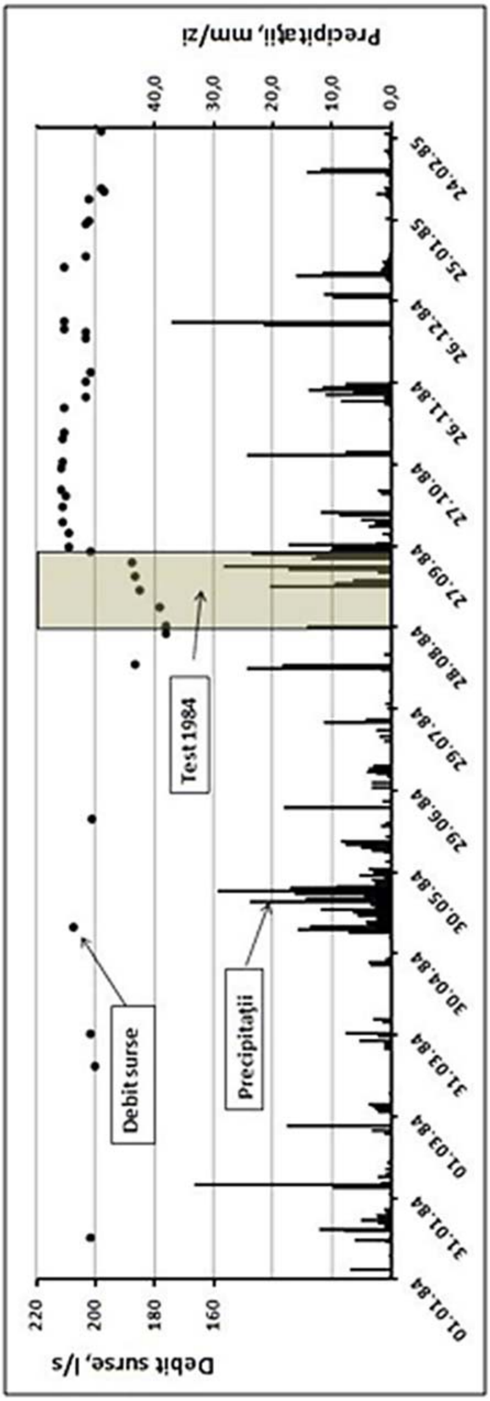

Figura 9. Evoluția debitului cumulat al surselor de la Băi și a precipitațiilor căzute la Luncasprie în anul 1984 (sursa: Studiul ANRM).

ANRM nu au avut dreptul să facă investigații în acest sens (din cauza menținerii regimului „datelor clasificate”). Cert este că deja în anii 1970 au început să fie folosite în scopuri energetice apele cu peste 40 ˚C temperatură, în special din Băile Felix. Nu se poate exclude ca această creștere din timpul iernii să fie cauzată de extinderea utilizărilor în asemenea scopuri.

Pe lângă creșterea permanentă a consumurilor, începând cu toamna anului 2014 se remarcă o creștere și mai accentuată a consumurilor din perioada rece. Dar această creștere din 2014 se remarcă și în cazul sezonului estival. Singura explicație plauzibilă este darea în folosință a Complexului Perla din Băile 1 Mai, care utilizează apa sondei Alin Bogdan, a cărei concesiune a fost anunțată și finalizată în toiul distrugerii rezervației: în anul 2013.

2. Supraexploatarea sondelor din Oradea fără reinjectare, ceea ce determină scăderea debitului ascensional înspre zona Băilor și implicit scăderea nivelului piezometric. În Figura 11 am prezentat consumul mediu lunar de la Oradea (sursa datelor: Studiul ANRM), defalcat pe perioada utilizării energetice și în afara acestui sezon (când de fapt mai funcționeză și utilizări energetice, de exemplu pentru prepararea apei calde menajere). Analizând consumurile lunare, este clară creșterea substanțială datorită utilizărilor energetice (adică a consumurilor de iarnă, perioadă care ține de obicei din septembrie-octombrie până în martie-aprilie). Consumul lunilor fără asemenea utilizări se menține practic constant, în jur de 25 l/s. Pe diagramă se pot remarca două valori record: în decembrie 2011 și ianuarie 2012 – adică exact perioada când izvorul sublacustru din Ochiul Mare a secat pentru prima dată.

3. Creșterea numărului sondelor particulare ilegale. După 1990 s-a declanșat un adevărat val al construirii pensiunilor și hotelurilor particulare în cele două Băi, precum și în Sânmartin. Pentru alimentarea lor cu apă termală s-au forat zeci de foraje cu pretextul alimentării cu apă rece, dar care în realitate extrag apă termală. Detaliile sunt necunoscute și par a fi nedetectabile, după cum au demonstrat cele două campanii executate la ordinul Prefecturii. Custodele de atunci al rezervației presupune existența a peste 100 de asemenea foraje clandestine, despre care nu se cunoaște nici o informație verosimilă.

4. Interpretarea eronată a valorilor debitelor exploatabile stabilite în 1987. De fapt, întreaga dereglare a sistemului Oradea–Felix se datorează acestei interpretări nejustificate a debitelor exploatabile stabilite în 1987 și neschimbate de atunci. Valorile de 90 l/s (fără reinjectare) pentru Oradea și 207 l/s pentru Băi reprezentau debite instantanee, care nu puteau fi depășite fără efecte negative, după cum am menționat anterior.

Exploatarea și utilizarea celor două acvifere prezintă o alternanță sezonie-

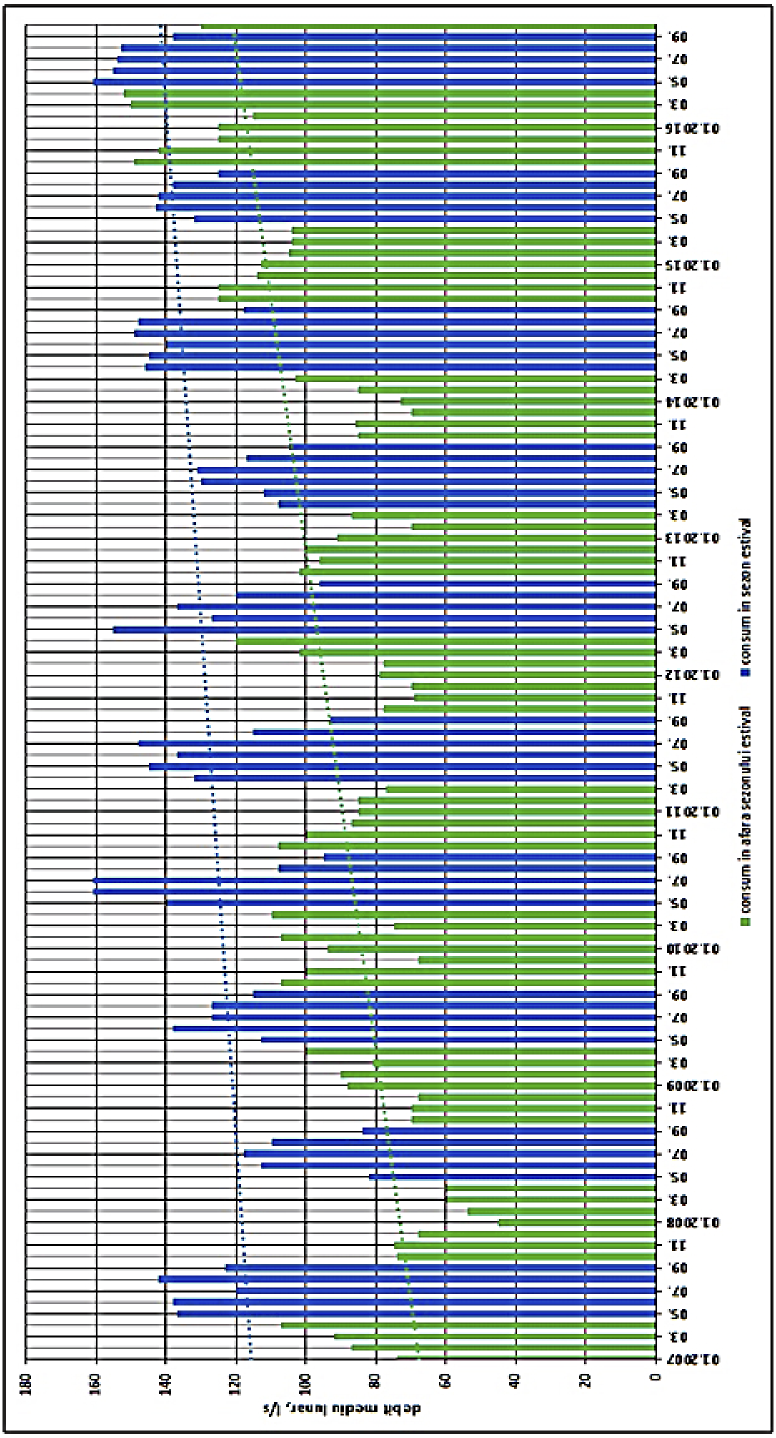

Figura 10. Consumul mediu lunar al stațiunilor.

ră: iarna se exploatează mai mult la Oradea, în scopul încălzirii locuințelor. Vara, în schimb, exploatarea este (deocamdată) maximă în zona stațiunilor, pentru alimentarea ștrandurilor. Realimentarea acviferului de la Băi, însă, are loc într-o singură direcție: dinspre Oradea spre acviferul de la Băi. În lipsa reinjectării cantităților extrase din sondele de la Oradea în sezonul de încălzire, are loc reducerea treptată a energiei de zăcământ, având ca efect reducerea volumului de alimentare a acviferului de la Băi. Scăderea realimentării (atât a volumului efectiv, cât și a presiunii) se manifestă în scăderea nivelului piezometric general, având ca urmare secarea izvorului sublacustru, care se află într-o poziție altimetrică superioară sondelor din cele două stațiuni. Pe deasupra, sondele stațiunilor funcționează și în sezonul de iarnă la capacități ridicate, pentru alimentarea bazelor de tratament și agrement, dar și în scopuri energetice – un alt domeniu extrem de puțin cunoscut, dar cu efecte marcante asupra apelor subterane, accelerând și mărind scăderea nivelului apei din subteran și implicit secarea izvorului.

Pandemia de CoViD-19 a oferit ocazii deosebite pentru verificarea celor menționate. Izvorul sublacustru, ca și în anii anteriori, s-a reactivat primăvara (în 23 martie 2020). Însă presupunerile actuale care au explicat această reactivare prin starea de urgență care a restricționat toate activitățile nu sunt justificate, fenomenul respectând tendințele din anii trecuți. În schimb, după introducerea restricțiilor, activitatea izvorului a rămas continuă și la apropierea sezonului estival, în aprilie-mai. Dar imediat după ridicarea parțială a restricțiilor, adică după 15 iunie, au apărut primele semne ale reducerii debitului, iar ele în mod sigur vor duce din nou la secarea izvorului.

Pandemia a oferit o unică ocazie din punct de vedere hidrogeologic, datorită nefuncționării îndelungate a sondelor din cele două stațiuni. Doar o singură dată, în 1979, s-a mai reușit închiderea tuturor sondelor din Băi, în scopul determinării rezervelor exploatabile. Oprirea extragerii apei termale n-a durat însă atunci decât 24 de ore, dar măsurătorile executate înainte și după închidere au permis evaluarea debitului realimentării naturale, care atunci avea valoarea de 300–350 l/s. Acest debit se varsă prin izvoarele termale din Băile 1 Mai în pârâul Pețea, pe cale naturală, cu o zi după închiderea sondelor.

Nefuncționarea sondelor din cauza pandemiei a fost însă de lungă durată, întregul debit care realimentează acviferul fiind deversat prin izvorul sublacustru din Ochiul Mare. Debitul Peței, măsurat în aceste condiții în data de 14.05.2020 era de 108 l/s, adică doar o treime a debitului din 1979 – ceea ce este un semnal clar al scăderii realimentării.

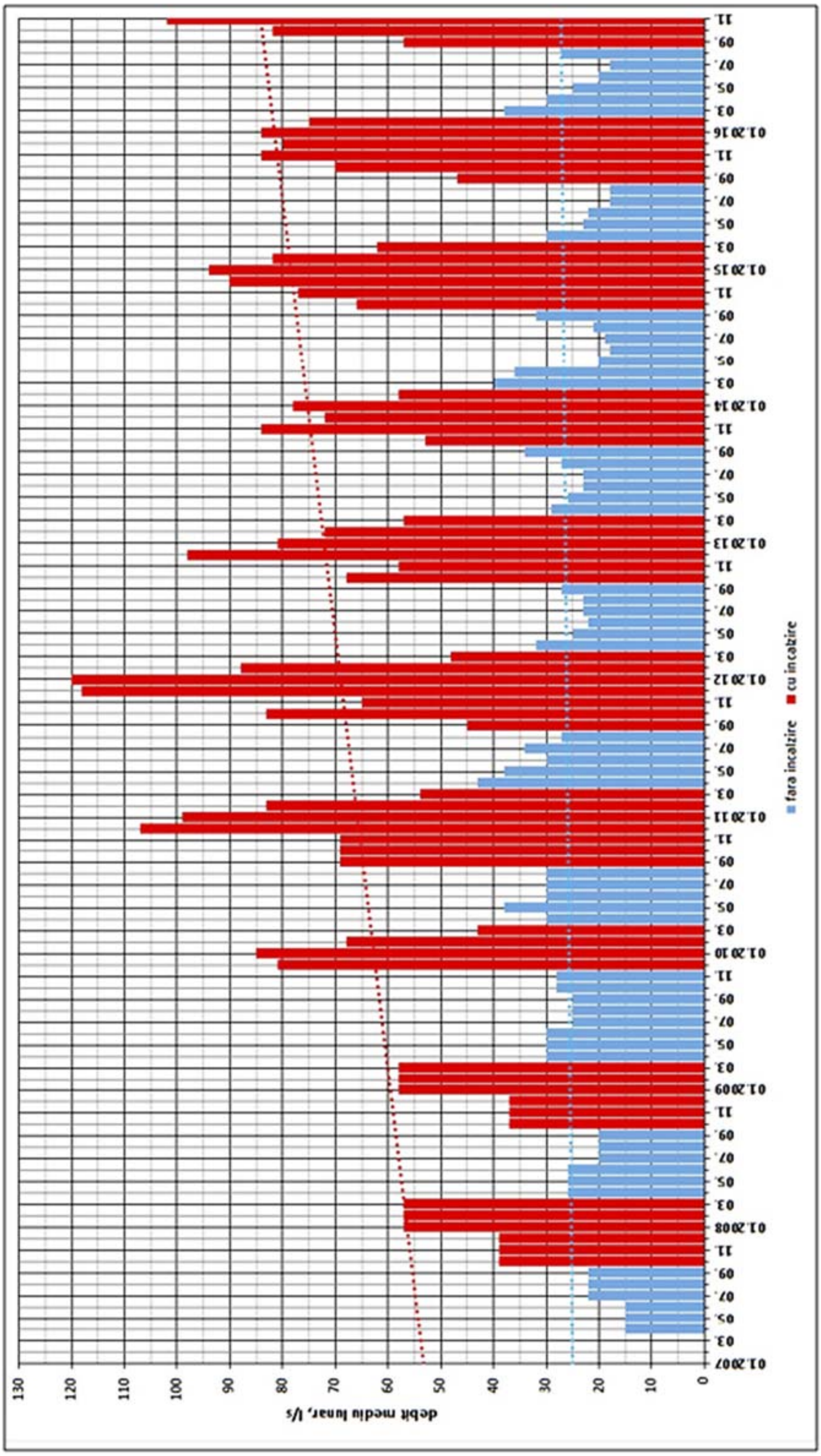

Figura 11. Consumul mediu lunar al utilizărilor din Oradea.

Concluzii

În ciuda încercărilor repetate de a se explica distrugerea rezervației prin condițiile meteorologice și climatice, se poate afirma că singura cauză a distrugerii este de natură antropogenă: supraexploatarea și gospodărirea nerațională a resurselor de apă termală.

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Abstract

The destruction of the thermal ecosystem in the Pârâul Pețea natural reserve (included in the Lacul Pețea Natura 2000 site) in recent years was caused by human activities in the area. Excessive extraction of thermal water well over the limits established by hydrogeological studies was the cause for the drying up of the thermal spring, and not the recent, regional fluctuations in rainfall claimed by a biased study.

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Textul manuscrisului va fi aranjat în felul următor: titlu; rezumat; cuvinte cheie (opţional); textul articolului integrând la final şi eventualele mulţumiri către persoane sau instituţii; lucrări citate; tabele; figuri; explicaţia figurilor.

Titlul lucrării va fi scurt şi informativ, cu caractere de 12 pct. boldate, centrat; prenumele şi numele autorilor, cu caractere italice, vor fi însoţite de adresa lor (inclusiv e-mail).

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.), 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 (diagrame, desene, fotografii) vor fi produse în format electronic (preferabil cu extensie în TIFF, EPS sau PDF) 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.