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Dynamics of the Felix – 1 Mai thermal aquifer (Bihor county, Romania)

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Abstract. The investigations performed indicate that all the wells in Felix-1 Mai area are in interference, supporting the idea that there is present a unique thermal aquifer in the Lower Cretaceous limestones. The vertical movement of the piezometric surface of the aquifer depicts a wave-like shape with an amplitude of about 2.5 m in 2015-2016 time interval and a periodicity being directed by the extension of the hydrological cycles. The thermal aquifer is fed from Pădurea Craiului and Bihor Mountains and the transit of cold mountains underground waters to the thermal reservoir is mainly through the regional drain represented by the Galbena fracture system. The thermal aquifer is confined and the oscillation of its surface has a complex state of motion influenced by natural factors, including the quantity and time distribution of precipitations and by anthropic factors, including the volume of thermal water extractions. The thermal aquifer has a karstic–fissured feature with very large local variations of transmissivity. The deformation of the thermal aquifer surface generated by the exploitation through wells is rapidly transmitted within the whole aquifer area, especially by fractured, fisured and karstified routes. The Ochiul Mare lake is in direct connexion with the thermal aquifer, is located on a main drainage axis of the reservoir and manifests rapidly the effects of natural recharge-discharge cycles and of drawdowns produced by wells development.

Key words: hydrogeology, thermal waters, piezometric surface, Peța lake

Introduction

The Peţa (Peţea) lake, or the so-called Ochiul Mare lake, is included within a Natura 2000 site coded ROSCI0098 since 2007. The site is the only place in Romania where a natural thermal ecosystem hosted several endemic or rare species, such as *Nymphaea lotus* var*. thermalis*, *Melanopsis parreyssi* and *Scardinius erythrophtalmus racovitzai*. A severe deterioration of the natural status of the Ochiul Mare protected area has been observed starting mainly from 2012.

To clarify, update and identify the actual status of geothermal resources in the area the National Agency for Mineral Resources (NAMR – ANRM), which is the governmental body managing and controlling the geothermal groundwater resources at national level, has entitled the Romanian Association of Hydrogeologists (RAH, AHR) with the design and the implementation of a hydrogeological study in the Felix-1Mai area.

The main objective of the RAH study was to provide the updated knowledge on the geothermal aquifer characteristics and its general behaviour in order to eventually conciliate the conflicting objectives of certain economic (commercial) entities on one side and the protection of the (thermal) groundwater dependent ecosystem i.e. the Natura 2000 ROSCI0098 site on the other side.

The thermal aquifer in Felix-1Mai area is the southern compartment of a larger geothermal aquifer system, namely Oradea – Băile Felix – 1Mai, that is hosted by dolomites and limestone of Triassic (Oradea area) and Cretaceous (Felix-1Mai) age(s).

The thermal aquifer of Felix-1 Mai area is located in lower Cretaceous limestones covered locally by calcareous mudstones and by Sarmatian – Panonian mostly impervious deposits with thicknesses up to 138 m in the South of Felix zone and only up to 12 m in the northern part of 1 Mai zone. The temperature of the water ranges between 32.1 and 47.1 ^{O}C.

The present paper will present and provide an interpretation of the data obtained in the field by following the evolution of the piezometric surface and temperature of the thermal aquifer by means of sensors introduced in the wells, as well as the contribution brought by these new data to the knowledge of the genesis of this reservoir. The results of the first investigations were previously published (Orăşeanu & Malancu 2016).

1. Historical data

The information about the evolution in time of the piezometric surface of the thermal aquifer is rare and it is mainly found in the reports of execution of the wells. The data about the flow-rates of water springs and boreholes are more numerous and their synthetic presentation was made in 1985 by G. Paal and I. Cohut based on the data collected by the County Office of Tourism Bihor, the authors underlining „the enhanced fall of the flow-rate potential of the sources from the hydrogeothermal perimeter Felix -1 Mai between 1983-1985" (Cohut & Paal 1985).

In its natural state, i.e. before 1885 when Balint well was drilled, the whole system was thought to be discharging through some springs, out of which the Ochiul Mare spring located in the Peţa Brook area was the most important one. The gradual development of the spa facilities exploiting the geothermal water at Felix-1 Mai through an increasing number of wells led to the continuous lowering of the hydraulic head in this compartment of the system. Subsequently, all the thermal springs in the area dried out.

A number of 21 exploitation wells were drilled in Felix – 1 Mai area before 1990 (Vasilescu & Nechiti 1964, Flamaropol 1975), while other 8 wells were more recently drilled, i.e. after 2002; out of which only 13 are still operational. After 1990 an unknown number of wells were also (unlawfully) drilled and presumably periodically operated but no NAMR (ANRM) licence has been requested by, or granted to their owners.

Between 1973-1987 the piezometric level of the thermal aquifer in Felix – 1 Mai area severely dropped with 8.8 m, followed by a more reduced decline of around one meter until 2015. The actual hydraulic head in the area is fluctuating above or below the (average) ground level, i.e. 154.5 m (Fig. 1).

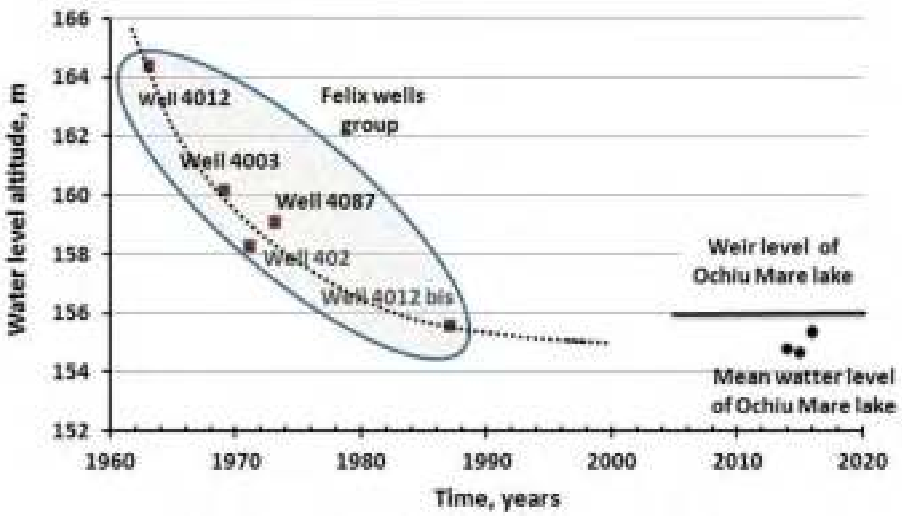

Figure 1. Decrease of the thermal aquifer piezometric level of Felix – 1 Mai zone as new boreholes were drilled.

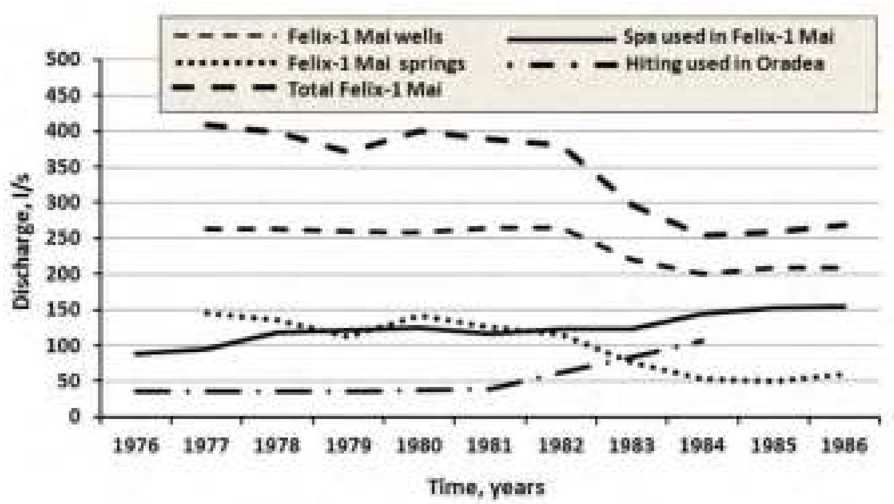

Figure 2. Flow-rates of water discharged from the thermal aquifer through springs and artesian wells, between 1977-1986. (After Cohut & Paal, 1985).

In 1963, by drilling the well 4005, thermal water was found in the subsoil of Oradea, (Vasilescu & Nechiti 1968), 10 more boreholes being drilled until 1993.

In 1985 Cohut & Paal presented the evolution of the flow rates of the springs and wells (all with free overflows) by means of which the thermal aquifer of Felix-1 Mai area is discharged. At the end of 1964, the thermal aquifer disharged freely at 398 l/s, 216 l/s through springs and 182 l/s through wells. In 1973 these values reached 449, 181, respectively 268 l/s. After 1976, the total flow discharged from the aquifer was constant around the value of 258-265 l/s until 1982, when there an enhanced decrease was noticed, reaching values of 86 l/s in 1984 (Fig. 2).

The fall of the flow rate potential of the thermal aquifer between 1982-1983 was attributed to the exploitation of thermal water from Oradea, and this is underlined by the above mentioned authors by the interpretation of the results of the interference tests between Oradea – Felix -1 Mai reservoirs, conducted in 1984. The period between 1982-1983 was critical from pluviometric point of view, the year 1983 being the most droughty in the last 50 years and that is the reason why we consider drought has played a significant part in the decrease of the flow rates of thermal waters from Felix -1 Mai area. This is illustrated in Fig. 3, where the evolution of the source discharges and the variation of precipitations (annual amounts) at two pluviometric stations, namely Stâna de Vale and Zecehotare, are illustrated.

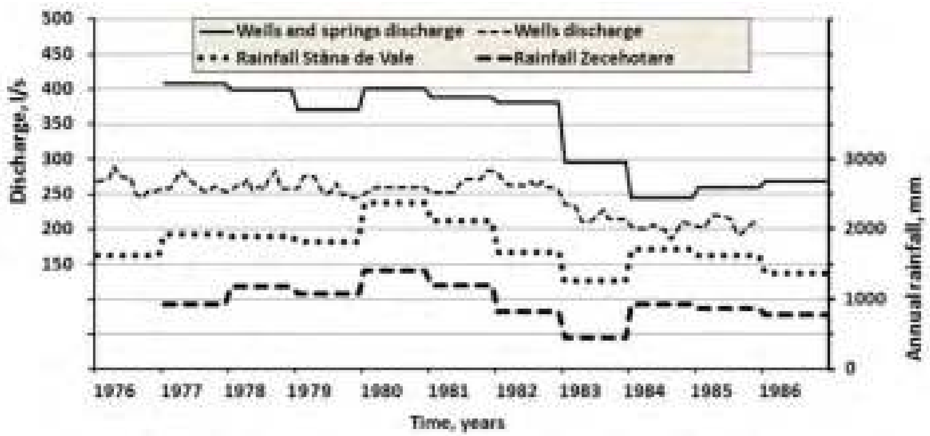

Figure 3. Evolution of the flowing potential of the thermal aquifer based on Cohut & Paal (1985), together with the annual amounts of precipitations at Zecehotare and Stâna de Vale between 1976-1986.

The feeding of the thermal aquifer with the precipitations fallen in the mountain zone developed to the East is supported by most researchers, among the first ones proposing this possibility being Paucă (1958) and Vasilescu & Nechiti (1968).

During the last period of 1986 until September 2014 no measurements were performed regarding the position of the piezometric surface level of the geo-thermal aquifer.

The exploitation of the thermal aquifer of Felix -1 Mai area is performed by 13 wells authorized by NAMR and by illegal drilling holes whose number and characteristics are not known. The development is carried out using suction and submersible pumps. 8 wells are exploited by SC Turism SA Felix, and the water volumes extracted by this company are measured. In the period September 2014 – October 2016 the volumes of water extracted from the other leased wells were also monitored.

2. Results

The hydrogeological investigation started in September 2014 with the installing of pressure and temperature sensors in the wells authorized by NAMR in Felix-1 Mai area (Table 1, Fig. 4), in the well 1730, Cihei from Oradea and in Ochiul Mare lake. In the piezometer drilled in 2015 near Ochiul Mare (Piezometer AHR), a sensor was also introduced. In a separate piezometer, situated near the AHR piezometer, the phreatic aquifer level was measured on a monthly basis too. The sensors record the pressure data (water column above the sensor + atmospheric pressure) and the water temperature. They were set to store the data every 1 hour, and for the correction of the deviations caused by the variation of the atmospheric pressure, a suitable sensor was installed. To verify the records, measured on a monthly basis, the level of the thermal aquiferous from all the monitored wells from Felix -1 Mai area were using a level meter. The data recorded by the sensors were downloaded and processed on a monthly basis.

Table 1. Characteristic data for the monitored wells

No.	Wells	Drilling	Co-ordinate, m			Depth,	Stratigraphic intervals	Open interval, m	T
		year	X, North	Y, East	Z	m			°C
1	Balint	1885	614526,9	270423,1	156,51	47,17	0,0-42,8, Pliocene; 42,8-47,17, K1	n.c.i.: 42,79-47,17	47,18
2	4011	1962	614998,3	270483,7	149,50	153,00	0,0-48,5, Pliocene; 48,5-153, K1	s.c.: 145-153	46,23
3	4003	1969	614553,2	270487,6	152,17	69,00	0,0-45, Pliocene; 45-69, K1	s.c.: 57-69	42,45
4	4087	1973	614117,0	270521,4	158,70	200,00	0,0-112, Pliocene; 112-200, K1	s.c.: 125-190	39,58
5	Fp2, Izbuc	1985	615233,9	272084,9	157,69	100,00	0,0-23, Pliocene; 23-100 K1	p.c.: 25-40; n.c.i.: 40-100	37,51
6	Fp3, Strand cu valuri	1986	614955,3	272467,3	161,20	500,00	0,0-20, Pliocene; 20-500, K1	p.c.: 190-247; n.c.i.: 253-500	32,09
7	Fp1, Venus	1986	615509,5	271288,7	157,66	500,00	0,0-70, Pliocene; 70-500 K1	p.c.: 230-298; n.c.i.: 300-500	37,47
8	4012 (Fp4), CFR	1987	615302,9	270488,0	152,41	650,00	0,0-106, Pliocene; 106-650 K1	n.c.i.: 300-650	40,26
9	SC ARCASIAN, Iulia Hotel	2002	615671,0	270876,0	150,08	102,00	22,5-77, Pliocene; 77-102, K1	n.c.i.: 82,5-102	38,60
10	F1 PSC Cordău, President Hotel	2003	613512,5	270762,2	155,16	172,00	6-72, Pliocene; 72-128, Sm; 128-172, K1	n.c.i.: 85-172	38,97
11	F2 PSC Cordău, Nicoleta Hotel	2003	613903,3	270766,1	157,94	92,00	5-70, Pliocene; 70-80, Sm; 80-92, K1	n.c.i.: 71-92	38,74
12	SC PRO QUADRIGA, Afrodita	2008	615720,2	270796,1	147,00	110,00	10-90, Pliocene; 90-110, K1	90-107, Plastic Johnson screen	40,60
13	F. Alin Bogdan, Perla Hotel	2014	615852,8	271888,3	162,41	100,00	6-23, Pliocene; 23-100 K1	n.c.i.: 96-100	36,13
14	Aqua, President Hotel	2014	613247,6	270713,0	157,19	160,00	12-87, Pliocene; 87-110 Sm; 110-160 K1	s.c.: 110-119,5; n.c.i.:120-160	35,89
15	AHR Piezometer	2015	615225,0	272216,0	158,10	70,00	6,9-9,5, Pliocene; 9,5-70, K1		32,20

s.c. = slotted casing; p.c. = perforated casing; n.c.i. = no casing interval; T=water temperature.

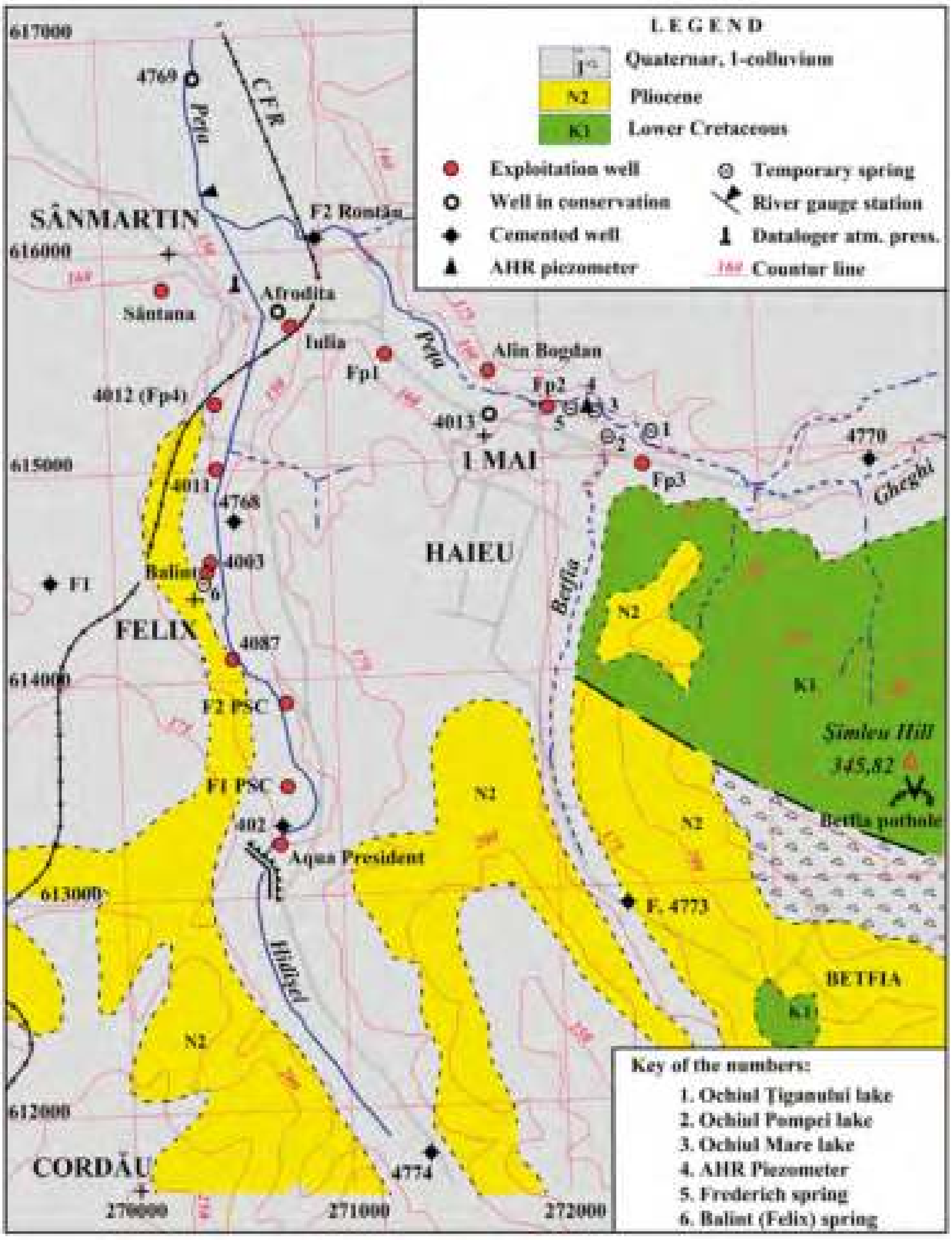

Figure 4. Geological map of Felix-1 Mai area (after Istocescu et al., 1967-1968)

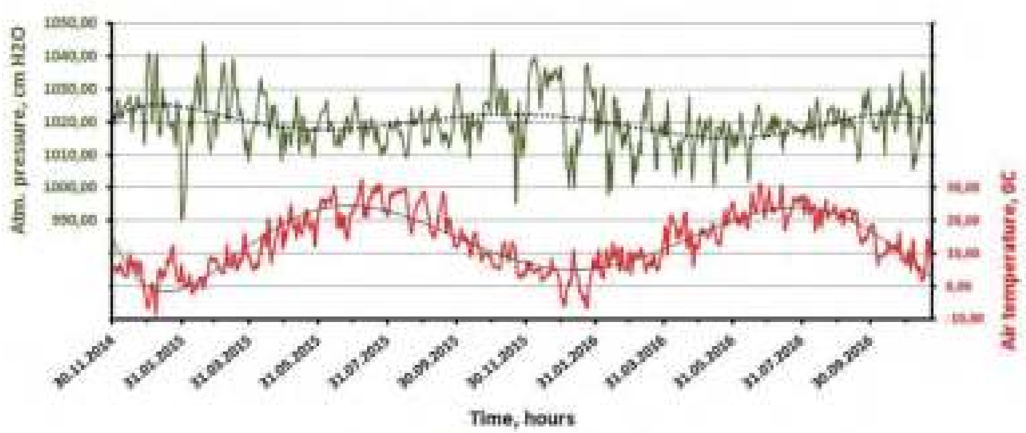

Figure 5. Evolution of the atmospheric pressure and air temperature within Felix -1 Mai area during the study period.

The atmospheric pressure was recorded using a sensor located to the Northern–Western side of 1 Mai locality, and it recorded the air temperature, too. In Fig. 5 the variations of the daily means of the two parameters are represented for the two year monitoring period, together with their polynomial trends of order 6. The two parameters indicated a reverse cyclic variation, the atmospheric pressure decreasing during the hot seasons and increasing during the cold ones and reaching maximum values in the middle of the winter. The maximum variation gap of the atmospheric pressure was about 55 cm H_2O.

Related to the amplitude of the oscillation of the piezometric level of the thermal aquifer recorded in the period of our monitoring activity (about 2.5 m) at a first estimation, it can be said that the variation of the atmospheric pressure could be responsible for about 20 % of it.

The sensors were introduced in wells beneath the maximum unevenness obtained during pumping operations, the hydraulic head recorded by them comprising the pressure of the water situated above them and the atmospheric pressure. The pressure of the water column is obtained by deducting from the total pressure the atmospheric pressure recorded by a separate sensor (Fig. 6).

2. 1. Evolution of the piezometric surface of the thermal aquifer

The wells drilled in the Felix -1 Mai area have the bottom in Lower Cretaceous limestones, except for the borehole 4768 which crossed through these deposits down to 1300 m followed by Jurassic deposits down to 1904 m and Triassic down to 3196 m. The borehole drilled in 1975 was abandonned.

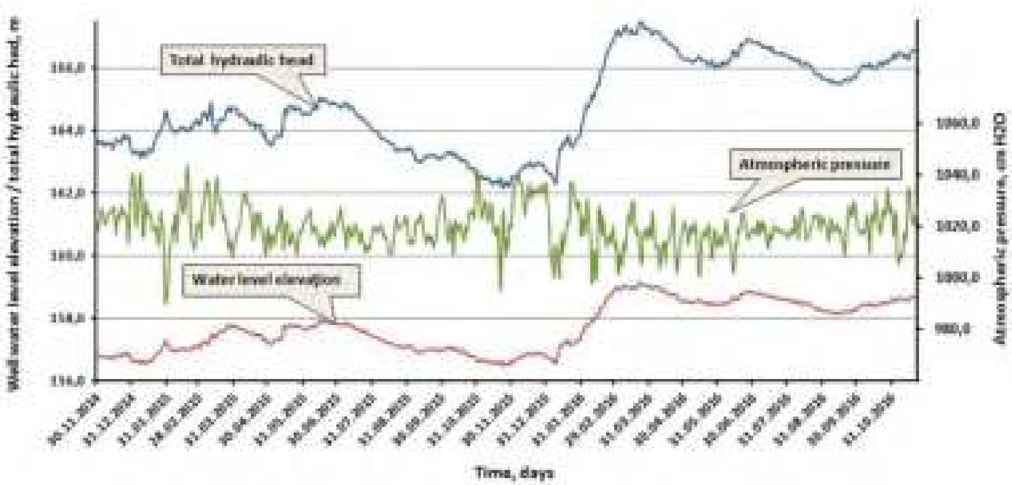

Figure 6. The total and measured heads in Afrodita well and atmospheric pressure at station 1 Mai for november 2014 to november 2016 time period.

The investigations performed indicated that all the wells are in interferrence no matter the level where they open the Lower Cretaceous reservoir, supporting the idea that a unique aquifer is present in the Lower Cretaceous limestones and covered localy by calcareous mudstones and by Pliocene deposits.

The Afrodita well, situated at the North-West end of Felix-1Mai perimeter is in conservation stage, the records of the level oscillations are not influenced by its exploitation and are suggestive to illustrate the dynamics of the piezometric surface of the whole Lower Cretaceous thermal aquifer (Fig. 7). They will be taken into account as milestones in the currrent presentation. Fig. 7 also presents the evolution of the piezometric water level in the conservation well 1730 Cihei, situated to the East side of Oradea. For both boreholes, the evolution of surfaces was averaged by using the polynomial trend method (order 6).

The movement of the piezometric surface of the aquifer of Felix -1 Mai area is a wave-like shape with an amplitude of about 2.5 m in 2015-2016 and a periodicity of about one year. The maximum levels occur during May–June, and the minimum ones in December –January, their position being directed by the extension of the hydrological cycles. The thermal aquifer is fed from Pădurea Craiului and Bihor Mountains, while the seasonal distribution of the precipitations generate oscillations of the underground water level within the feeding zones translated through the pressure waves recorded in the wells.

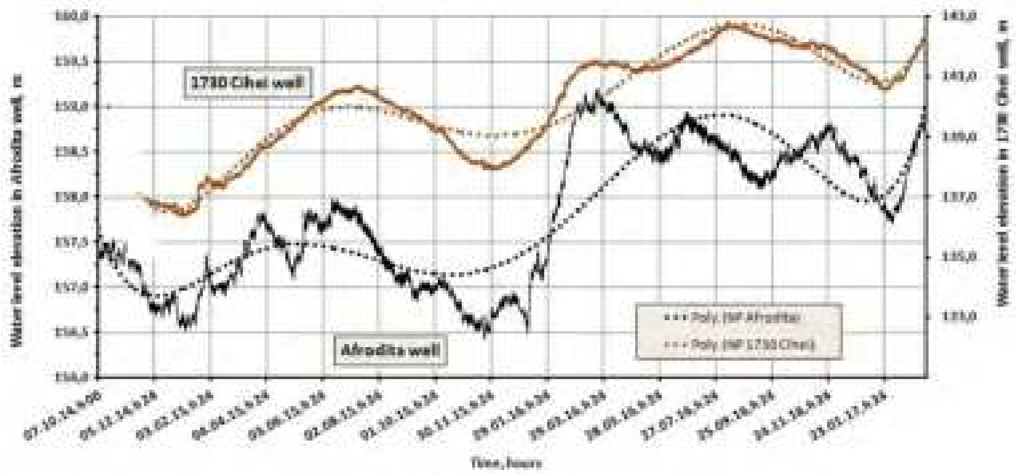

Figure 7. Fluctuations of the thermal aquifer level recorded in Afrodita and 1730 Cihei wells.

The hydrographers of the rivers are a direct indicator of the distribution of the precipitations and of the position of the piezometric surface of underground waters in the respectiv watershed. The crossed correlations performed between the flow rates of Crişu Pietros at Pietroasa and Vida stream at Luncasprie and the levels of the piezometric surface of the thermal aquifer measured in Afrodita borehole (rows of daily values for the period XI. 2014-XII. 2015) are highly reliable (0.357, respectively 0.25), reaching maximum values after 59 respectively 51 days, values interpreted as minimum transit times of high flows between the watersheds and the thermal aquifer of Felix -1 Mai area (Orăşeanu 2016). The transit of cold, mountain underground waters to the thermal water reservoir is mainly through the regional drain represented by Galbena fracture system (Orăşeanu 2015).

The oscillation of the thermal aquifer surface has a complex shape, influenced by natural factors, quantity and time distribution of precipitations and by anthropic factors, such as the volume of thermal water extractions. Each exploitation well causes pointwise trough of the piezometric surface and such depressions are rapidly transmitted within the whole aquifer area.

The impact of thermal water exploitation on the piezometric level between 07.10-18.11.2014 is shown in detail in Fig. 8. The time scale is expressed in days, the beginning of the weeks being marked by specifying the date. The minimum levels are recorded at the end of each week as these are the periods when the tourists' influx is maximum, and the pumped flow-rates are likewise. The levels

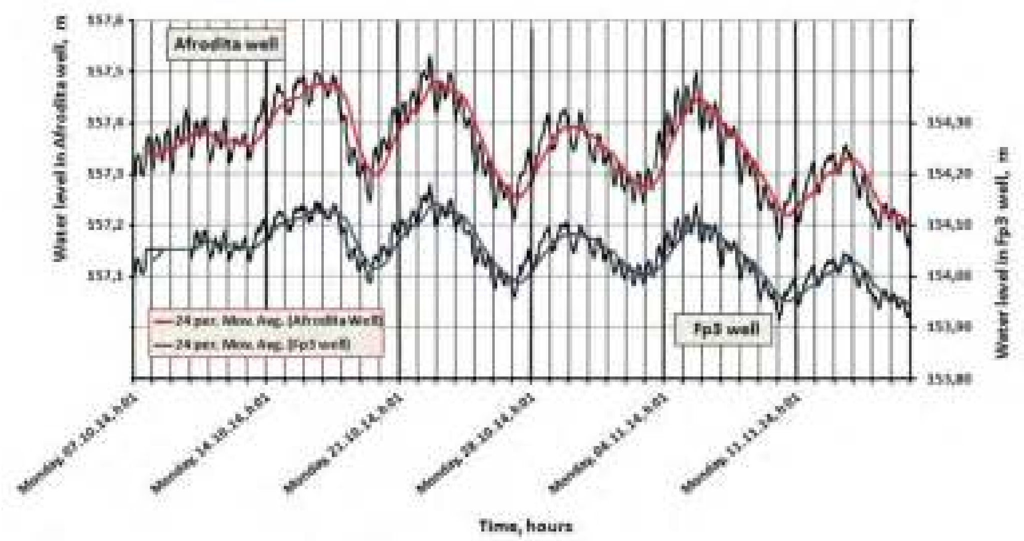

Figure 8. Weekly fluctutations of the thermal aquifer level measured in Afrodita and Fp3 wells.

increase then, in the first days of the week by reducing the pumped flows, their diminution by the end of the week being repeated. The amplitude of the weekly oscillations generated by aquifer exploitation is about 30 cm in Afrodita well and about 20 cm in Fp3 well. The drawdowns produced in the exploited wells are quickly driven also in the Ochiul Mare lake, the lake surface exhibiting fluctuations with amplitudes up to 30 cm.

The high oscillations in Fig. 8 are accompanied by low oscillations generated by the earth tides. In the presented period Afrodita and Fp3 wells were not exploited. The averaging of the trends of the oscillations of the piezometric surface by means of the moving averages with a 24 hours period cut off the oscillations caused by the earth tides, underlying their semi-diurnal nature.

The deformation of the thermal aquifer surface generated by the exploitation through wells is variable because of the lack of homogeneity of the hydraulic characteristcs of the collector and the varied regime of exploitation (flow-rates, periods and pumping times), and the amplitude of unevenness is not proportional to the extracted flow. For illustration purpose we elaborated the maps with the isopiestic aspects of the thermal aquifer within two distinct periods. In February 2015, the maximum depression of the piezometric surfaces has developed around the well PSC2 (Fig. 9), and in July 2015 around the 4011 well (Fig. 10).

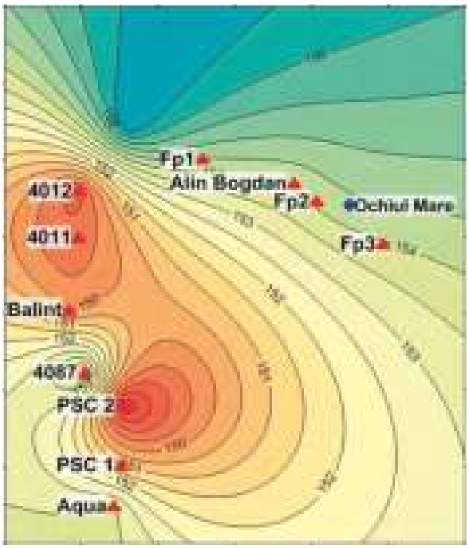

Figure 9. The spectrum of the thermal aquifer isopiezis between 23-28 February 2015

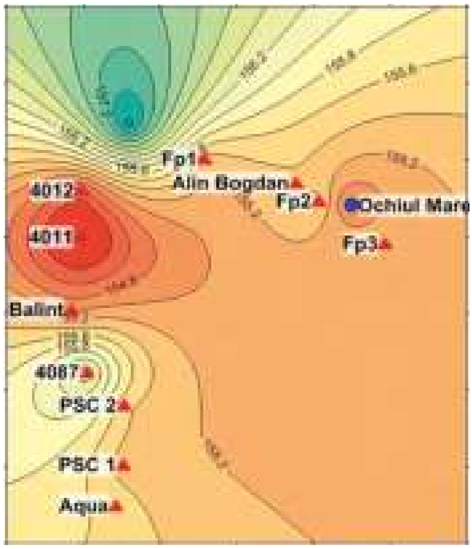

Figure 10. The spectrum of the thermal aquifer isopiezis in the period 16-25 July 2015

Taking into account only the above mentioned aspect, we could draw wrong conclusions. The dynamic level of underground waters is very different because of the karstic – fissured feature of the aquifer with very large local variations of transmissivity. Some wells pump 25 l/s, generating drawdowns lower than 1 m, while others must pump with a drawdown of 7-8 m in order to extract 5 l/s (Fig. 11). Finally, the exploitation impact on the whole piezometric surface is proportional to the volume of water extracted from the well and not with the drawdown produced.

The map of the specific flow-rates (drawdown / discharge) indicate the lack of area uniformity of the hydrogeological parameters of the thermal aquifer, the most „productive" zones being revealed by the wells Fp2 (Izbuc), Alin Bogdan and PSC1 (Fig. 12).

The area distribution of the values of the hydrogeological parameters presented in Figs 9-12 is only indicative of the interpolation method considering the aquifeorus an homogenous and continuous environment. Actually, the aquifer of Felix -1Mai area, of fissure – karstic type, is heterogenous and discontinue, with a drainage axis oriented along the fault systems. The existence of two systems oriented along the valleys of Hidişel and Peţa streams is presumable.

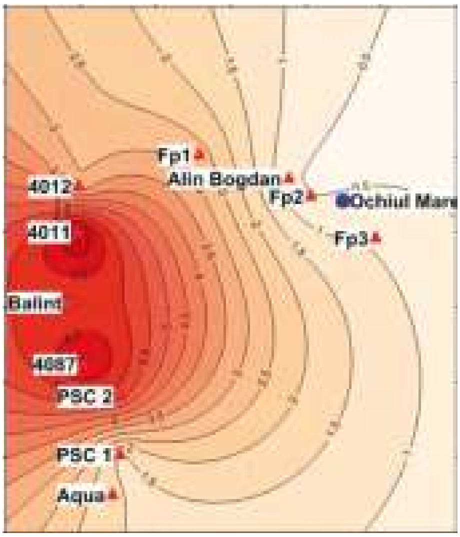

Figure 11. Area distribution of the unevenness of the piezometric surface between 16-25 July 2015

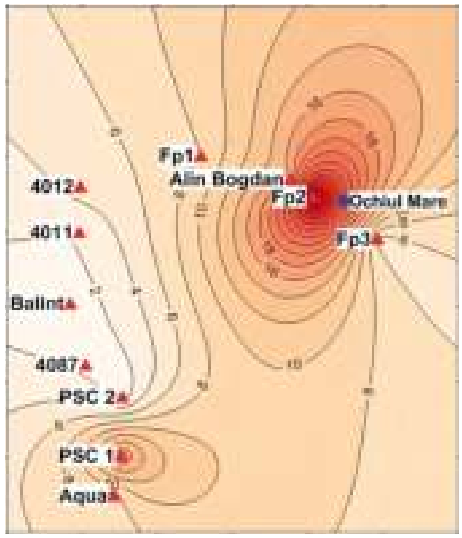

Figure 12. Area variation of the specific flow-rates, l/s/unevenness meter for the period 16-25 July 2015

In a quasi-stationary system, in Felix zone the level of the thermal aquifer is situated a little above the ground, and in 1 Mai zone is beneath the ground level by about 1 m, this being revealed by the diminution of the water level in Ochiul Mare lake („ochi” means a small pond formed by a sublacustrine spring).

The level oscillations of Ochiul Mare lake water (Fig. 13) reflect as a whole the oscillations of the thermal aquifer level to which it is connected through a fissure /karstic void continuing to the surface with a discontinuity of the deposits clogged by permeable detritus. The oscillations generated in the lake by the oscillations of the piezometric surface of the thermal aquifer are „disturbed” by the water contributions from the phreatic aquifer developed in the detrital deposits, by the temporary surface course of Peţa stream and the uneven supply of thermal water pumped from well Fp2 (Izbuc) or AHR piezometer to support the thermophylic flora and fauna.

To know the level of the thermal aquifer of the lake perimeter, a piezometer hole of 70 m deep was drilled at 42 m West from the staff gage placed in the middle of the lake, called „AHR piezometer” (Fig. 14). The drill hole crossed through the peat layer with intercalations of black clays (2.0-3.8 m), sapropelic mud (4.0-6.8 m), greenish clay (6.8-7.0 m), coarse sand (8-8.5 m), blackish plastic clay (8.5-

9.5 m), blackish calcareous mudstones (9.5-25.0 m), white and gray limestones (25.0-43.0 m) and compact limestones (47.0-60.0 m). At the m 70 level, in the gray limestones, a highly fractured zone with thermal water circulation was intercepted. To measure the phreatic aquifer level, a perforated plastic tube was placed, attached to the drill hole tubing.

In the middle of Ochiul Mare lake a staff gage is placed with the „0" level placed at 156.1 m above sea level. The evolution of the level and temperature of the water from Ochiul Mare lake was monitored with a diver type sensor immersed at the bottom of the lake using a plastic tube perforated at the base attached to the staff gage in the middle of the lake. The sensor records were carried out until 22.04.2016. On the occasion of the field trip on 29.06.2016 the sensor was taken out of the tube. The level of the lake water is read on daily basis on the staff gage by an employee of the Țării Crişurilor Museum and we could have access to these records due to the kindness of the above mentioned institution.

Based on the proposal made in 1965 by G. Vasilescu and G. Nechiti, to limit the thermal water losses of the aquifer through Ochiul Mare in the Peţa brook (200 l/s, 32^{o}C), at about 310 m downstream Ochiul Mare, near the Rontău metal culvert, a concrete notch weir was built with a spillway situated at 156 m level. At present, beneath the spillway there are permanent infiltrations, their values ranging between 5 and 10 l/s. The spillway is rarely overflown when there are high water flows. The infiltrations are supplied from Ochiul Mare by passing through the alluvial deposits which are clogging the Peţa stream route downstream the lake. The rehabilitation of the weir seal is limiting these losses.

In 2015 the level of the lake water was permanently beneath 156 m reaching the minimum value (153.6 m) at the end of the said year and beginning of the next one and during this period the water surface on the botttom of lake cone temporary froze (Fig. 15). In case of heavy precipitations, the Ochiul Mare area is flooded by Peţa stream water for a short time as these waters infiltrate rapidly in the thermal aquifer through the alluvial material from lake bottom. Most of the year Peţa stream is dry.

The minimum levels of the water in Ochiul Mare were recorded in February 2015, a month when precipitations actually were absent. The significant precipitation amounts fallen in January and February 2016 in the whole mountain area led to the raise of the thermal aquifer levels and water level in Ochiul Mare lake by 2,26 m, from 154,14 m on 27.12.2015 to 156.4 m on 24.02.2016, and after that the lake level slowly decreased and stabilized at 155.95 m until 22.04.2016, which is the date of the last record. At 155.8 m level the thermal water spillage enhanced a string influx of air bubbles marking at the lake surface, the vertical of the access

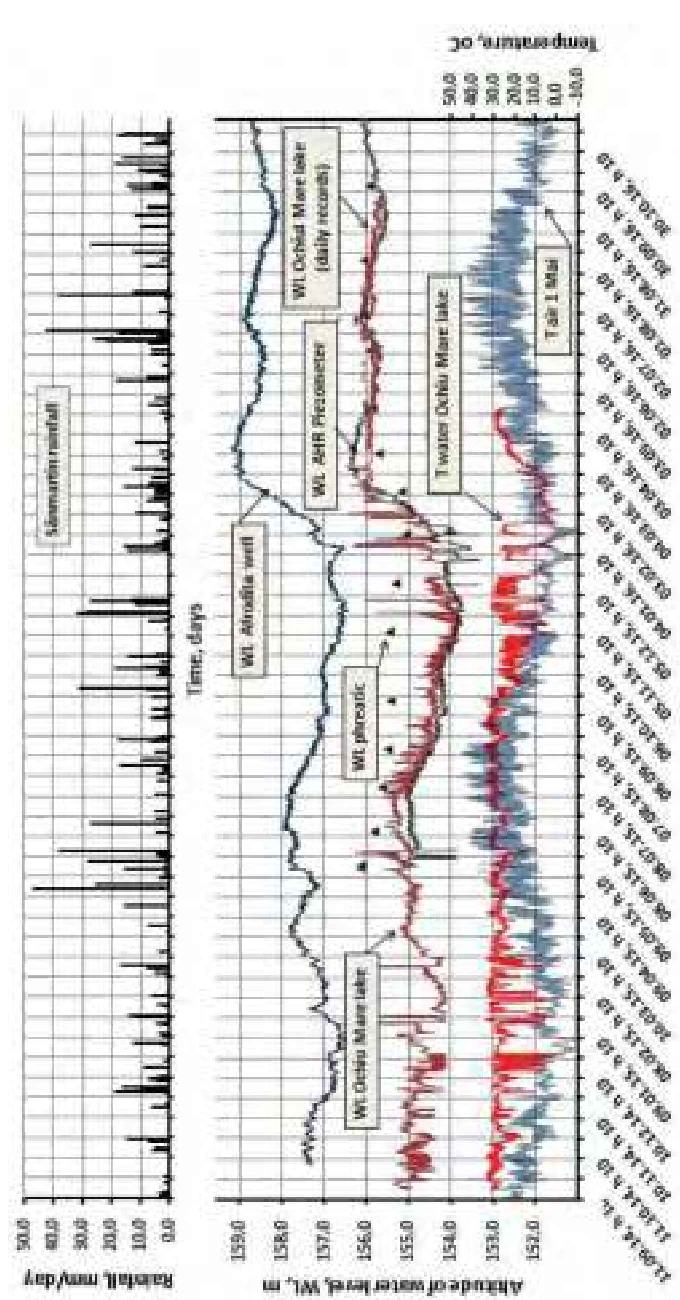

Figure 13. Fluctuation of the water level and temperature in Ochiul Mare lake and representation of the parameters obtained from other investigated points.

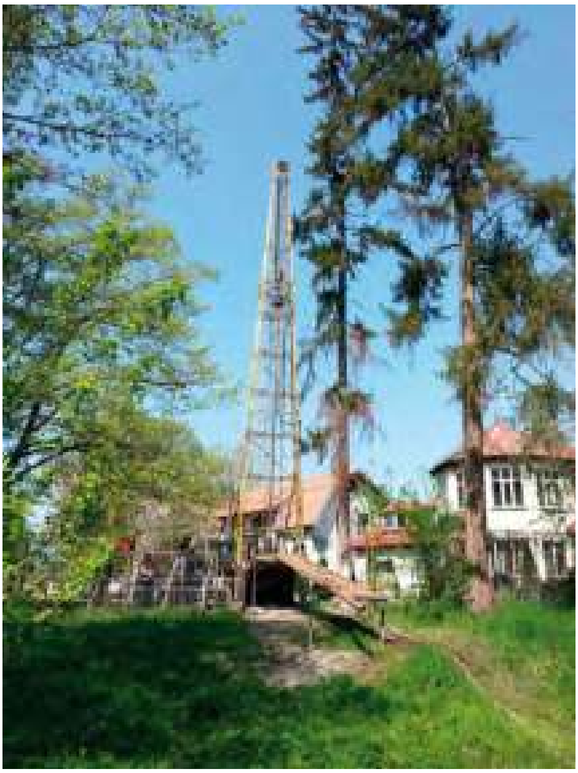

Figure 14. Aspects from the execution of the AHR piezometer in April 2015

Figure 15. Ochiul Mare lake at different stages of filling on 20 Jan, 2015 (up), 25 April, 2015 (middle) and 19 Jan, 2016 (bottom)

place of the thermal waters through its bottom The time of the upward thermal water flowing starting through the connection channel with the thermal aquifer is marked by the start up of the lake water heating, this reaching the maximum value of 29.7 ^{O}C on 17.04.2016. On 22 April 2016 the thermal water outflow from the Ochiul Mare was supplying Peţa stream with a 8.0 l/s flow-rate, the shallow course being dry upstream the lake.

On 10 March 2016 the thermal aquifer in the AHR piezometer reached the maximum level of 156.47 m. It is also noticeable that on 18.03.2016 the level of the thermal aquifer from the piezometer was by about 0.6 m above the level of the water in the lake. After reaching the maximum level, the level of thermal aquifer slowly decreased so that on 21 April 2016 its level was at the same level with lake surface (155.93 m), very close to the phreatic aquifer level (155,89m).

The increase of the thermal aquifer level resulted in:

- Filling of the depression basin of Ochiul Pompei and reactuation of the water flowing; it stopped in April 2016;
- On 21.04.2016 at the bottom of the hexagonal basin of the spring with „*Rana dalmatina*" (so called by Slăvoacă and Feru in 1961), there was a water layer 10 cm deep, situated at 125 cm beneath the Southern border of the basin. Usually the basin is dry;
- Actuation of Frederich spring;
- Increasing the flow-rate of Felix spring of the Felix resort, its surface being agitated by significant influxes of water and air bubbles.

The increase of the piezometric level of the thermal waters at the beginning of 2016 (Fig. 13) is attributed to the high amounts of precipitations fallen in January and February 2016 in the mountain zone, as the regime of the exploitation of the thermal aquifer did not justify such increase (Fig. 16). Between January and February 2016 at Luncasprie there fell 189,2 mm precipitation compared to 95.6mm in January–February 2015, at Pietroasa 220.2 vs 90.9 mm, at Călăţea 164.1mm vs 91.5 mm, and at Sânmartin 123.4 vs 74.5 mm. The correlation between the cumulated values of the precipitations fallen at Luncasprie and the increase of the thermal aquifer level in Afrodita borehole is linear and indicates a very high reliability (R^2=0.98), underlining the significant impact of precipitations on the thermal aquifer level (Fig. 17).

The water level of the phreatic aquifer of the lake was measured on a monthly basis (Fig. 13). It is in a permanent supply – drainage relation with the Ochiul Mare lake (Fig. 12). Until 05.02.2016 the phreatic supplied the lake, its piezometric level decreasing slowly as a result of rainfall deficiency. After that date until the end of April 2016 the lake water infiltrated in the phreatic aquifer, and further on the le-

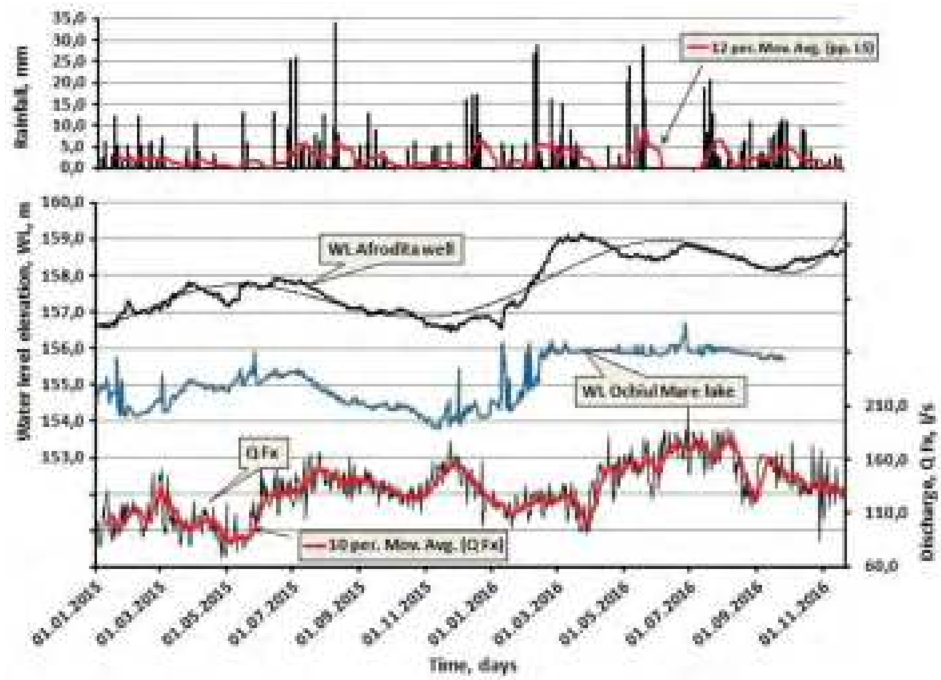

Figure 16. Distribution of precipitations at Luncasprie, variation of the thermal aquifer level in Afrodita well and of Ochiul Mare lake surface as well as the daily flow-rates extracted from the aquifer at Felix -1Mai (Q Fx), through the wells licensed in the period January 2015 - November 2016.

vels of the lake water, the thermal and phreatic aquifer are situated at close levels.

The well 1730 Cihei is situated at the East side of Oradea at about 4.2 km North-West from the Afrodita borehole in 1 Mai resort. The depth of the borehole is 2,800 m and opens the Triassic collector with a slotted casing over the interval 2080-2750 m. The borehole is in preservation stage and indicates low methane release. The pressure sensor introduced in the borehole indicates a wave-like variation of the opened aquifer level, similar to the Lower Cretaceous aquifer of Felix -1 Mai area, but with double amplitude (Fig. 7).

The similar shape of the pressure waves recorded at the two previous wells indicates the location of their feeding zone in the same mountain areas, but with different altimetry positions, with a similar temporary distribution of precipitations. Both in Pădurea Craiului mountains and in Bihor mountains, the Triassic deposits are at higher altitudes, with superior values of precipitations.

In all monitored wells, the opened aquifers are under pressure and indicate

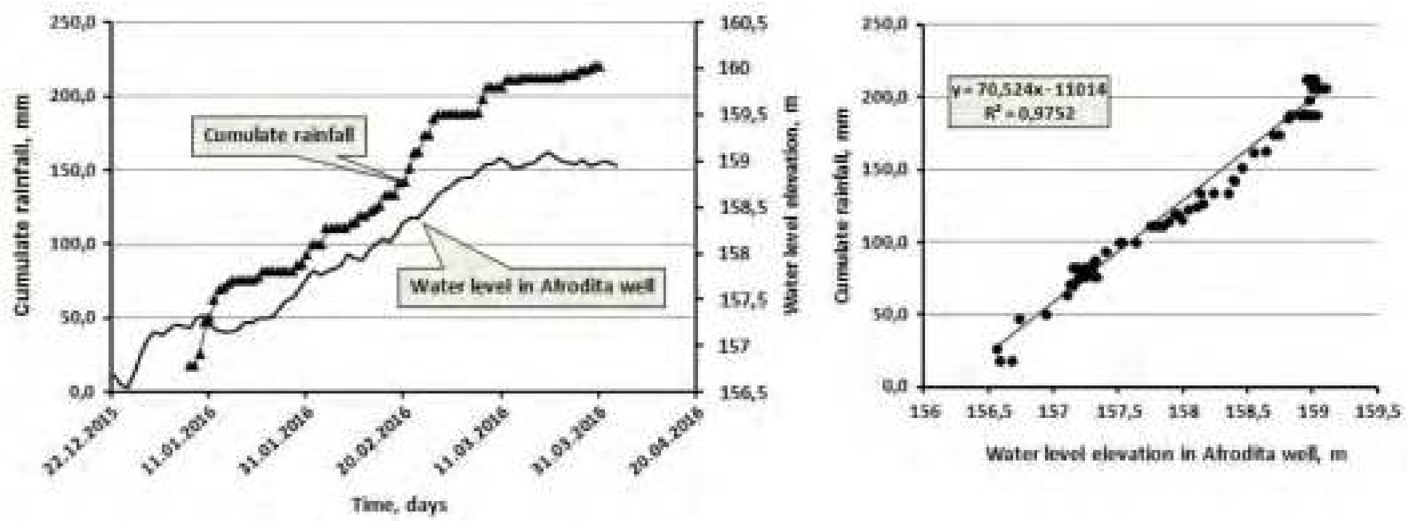

Figure 17. Time distribution of the precipitations cumulated at Luncasprie and of the thermal aquifer level in Afrodita borehole (left). To the right, there is the correlation between the rows of values mentioned.

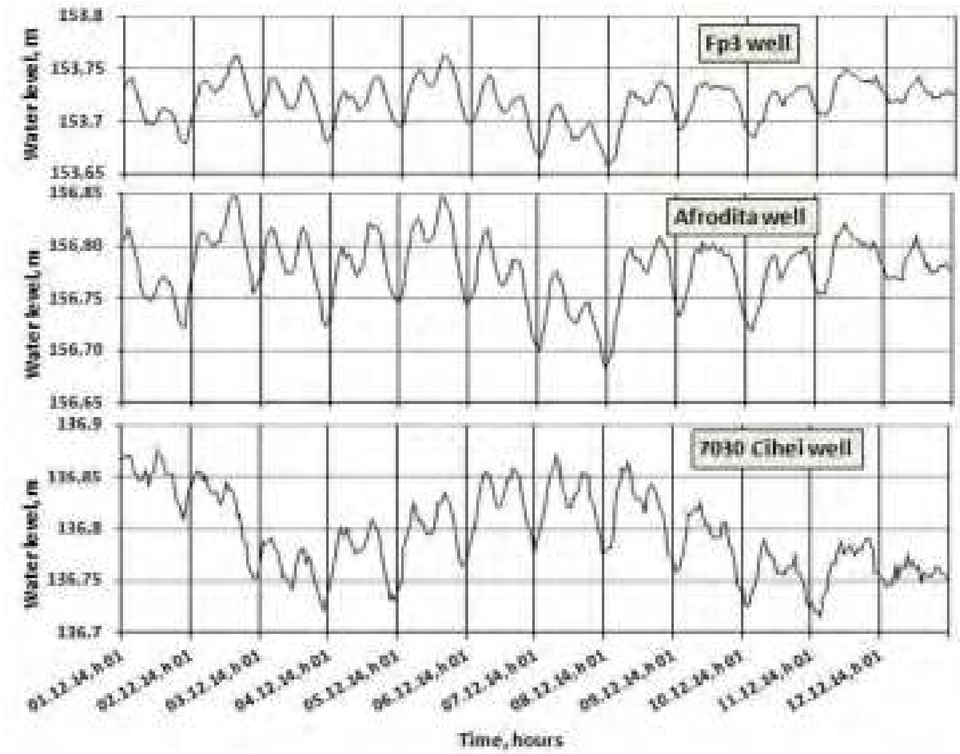

Figure 18. Fluctuations of the thermal aquifer level caused by earth tides.

rhythmic oscillations of the thermal aquifer elevation level because of the earth tides. The amplitude of 5-6 cm is found at Fp3 well, reaching 10 cm in Afrodita and 1730 Cihei wells (Fig. 18). The graphics illustrate the semi-diurnal nature of the tides. The period between two successive records of the levels is one hour.

The earth tide harmonic oscillations of thermal aquifer level are recorded also at the surface of Ochiul Mare lake, with an amplitude of 10 cm and a distorted shape produced by nearby exploited wells.

2. 2. Thermal water temperature

In the monitoring wells, the thermal aquifer is under pressure, and the depth where it is intercepted by the wells varies between 20 and 128 m. The pressure and temperature sensors are introduced in the wells casing below the limit of the exploitation dynamic level, which is situated at maximum 8-9 m from the ground surface. The water circulates through the casing only during exploitation (either by pumping or by aspiration), and during this period the actual temperature of the thermal water is recorded. During the repose periods the water is stationary on the column and its temperature slowly decreases to the temperature of the contiguous rock temperature. Table 2 presents the characteristics recorded by the sensors introduced in the boreholes in the period of observations, namely Sept. 2014 – Nov. 2016. The temperature values of the thermal waters pumped from the aquifer are considered as belonging to the maximum temperature value range.

Table 2. Average, minimum and maximum termperatures recorded by the sensors introduced in thermal water wells.

	Fp1	Fp2	Fp3	Alin Bogdan	4012	4011	4003	Balint	4087	F2 PSC	F1 PSC	Aqua Presid.
Media	33,73	36,47	22,75	35,36	35,75	44,66	41,85	46,05	38,84	37,73	38,86	35,08
Min.	24,10	36,12	19,53	33,20	34,48	44,03	41,55	45,39	38,52	32,72	38,37	33,12
Max	37,47	37,51	32,09	36,13	40,26	46,23	42,45	47,13	39,53	38,74	38,97	35,89
Avedev	3,72	0,10	3,43	0,26	0,87	0,33	0,12	0,31	0,11	0,57	0,06	0,14

The temperature of the thermal waters extracted from the wells indicates a significant variation in the area. The water with the highest temperature is coming from Balint (47.1 ^{O}C) and 4011 (46.2 ^{O}C) wells, the temperatures decreasing radially, with the minimum values encountered to the East end of 1 Mai zone (table 2 and Fig. 19). For the elaboration of the map in Fig. 19 we used the data acquired during the period September 2014–February 2016 and the data from the exploration drilling contiguous to the investigation zone.

Fig. 20 presents the evolution of the temperature of the water pumped from the wells that continuously operated for longer periods of time. As the pumping period increase, the water temperature indicates a constant trend of increases at some wells and decrease at others. The increase of the water temperature was recorded at Balint (+0.369 ^{O}C/year), 4003 (+0.277 ^{O}C/year) and 4087 (+0.231 ^{O}C/year) wells. The increase trends of the pumped water temperature occurred at Aqua President and F1 PSC wells, too. The most significant decrease of the water temperature was recorded at wells 4011 (-0.554 ^{O}C/year), followed by Alin Bogdan (-0.277 ^{O}C/year) and Fp2 (-0.231 ^{O}C/year). It is to be underlined that the wells where the temperature of thermal pumped water increased are situated at the center of Felix resort along the alignment of 4003-Balint-4087-Aqua President, considered the main ascending way of thermal waters to the surface.

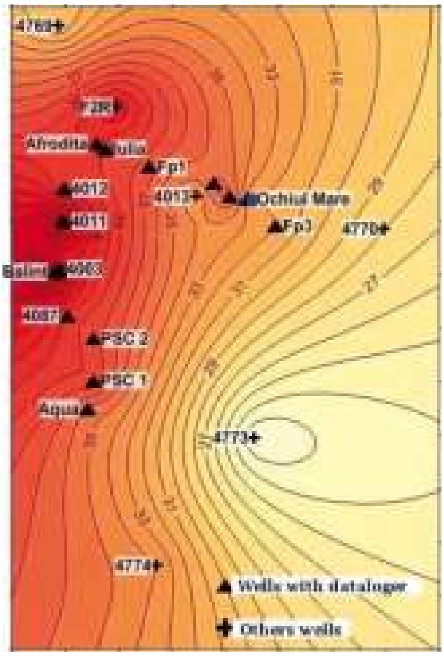

Figure 19. Area distribution of the temperature of thermal waters extracted through the wells in Felix -1 Mai area between September 2014 – February 2016.

No time relation has been noticed between the oscillations of the piezometric level of the Lower Cretaceous thermal aquifer of Felix -1 Mai area and the temperature of the thermal waters extracted from the wells.

During exploitation of Balint borehole between March–April 2015, the water temperature varied between 46 and 47 ^{O}C, the pumping periods being accompanied by the decrease of water temperature (Fig. 21). In the summer season of 2015 the pumping operation was actually a permanent one with variable flow-rates, the water temperature ranging around 45.7 ^{O}C.

At borehole 4011, which is permanently pumping with varyable flow-rates, the weekly fluctuations of water temperature during the above mentioned period can be found but their amplitude is 0.2-0.3 ^{O}C (Fig. 21). During summer season of 2015 the water temperature decreased by about 0,2 ^{O}C below the mean value of 45 ^{O}C. Since the fall of 2015 a constant decrease of the temperature of the pumped water was recorded, namely up to 44.03 ^{O}C in November 2016.

The temperature of the thermal water from wells had actually maintained constant since the time of their drilling until 1985. The average temperatures measured in the period IX.2014-II.2016 are lower by about 2 ^{O}C compared to those of 1985 (Table 2).

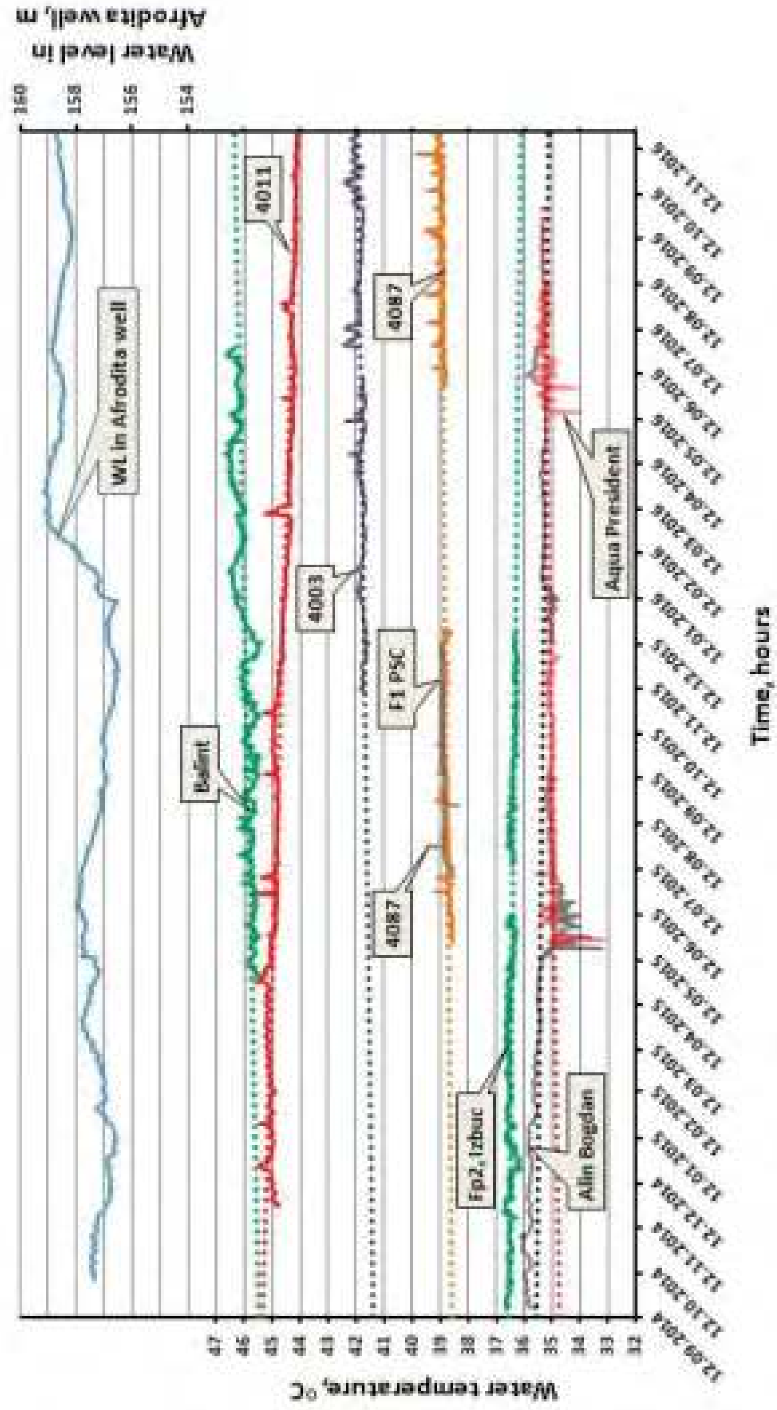

Figure 20. Evolution of thermal water temperature from some wells with continuous pumping.

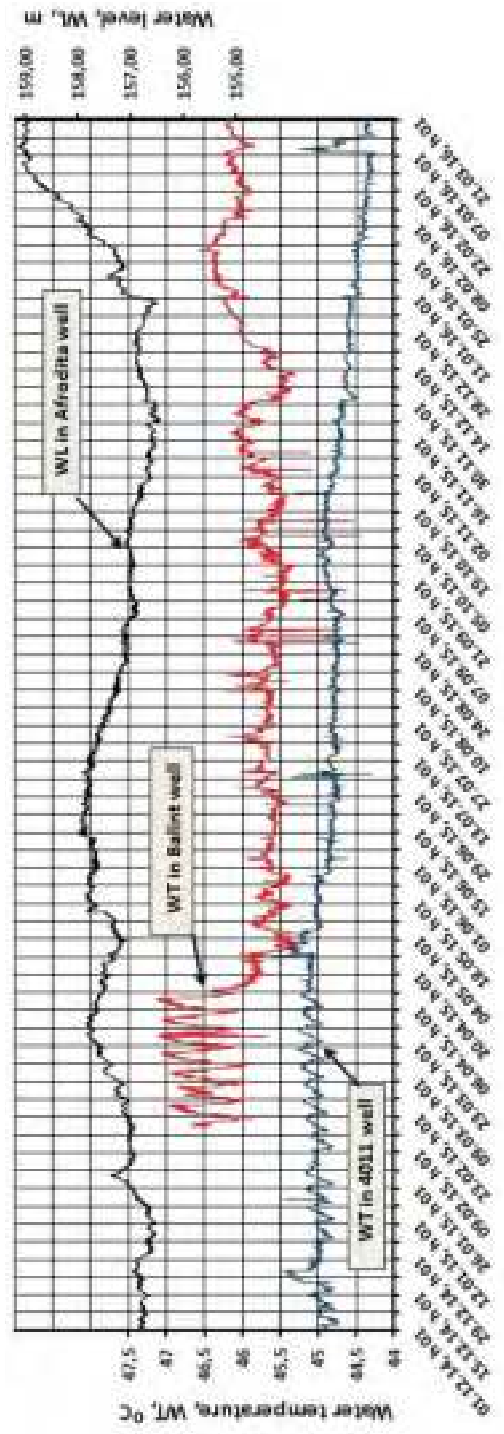

Figure 21. Evolution of the temperature of the thermal water pumped from Balint and 4011 wells and of the piezometric surface in Afrodita well.

Table 3. Evolution with the time of the temperature of thermal water discharged from wells.

No.	Well	Vasilescu, Nechiti	ISPIF		A. Tenu, 1975			Cohut, Paal	AHR
		1965	II.1966	IV. 1966	V. 1969	IX.1969	VII.1971	1985	IX.2014-XI.2016
1	Balint	49	49	49	49	49	47,8	49	47,1
2	Izbuc	42	42	42	40	40	39,4		37,5
3	4011	49			49	49	48	49,5	46,2
4	4012	39						39	40,3
6	4003				45	45	43,6	45	42,4
8	4087							42	39,5

3. Considerations regarding the interference test of 1984

The processing of the row of precipitations fallen in Pădurea Craiului Mountains and Bihor Mountains and of the piezometric surface levels of the thermal aquifer in Felix-1 Mai area indicated that the aquifer is supplied from this area, the magnitude of the aquifer level fluctuation being directly related to the precipitation regime. On the other hand, the thermal water exploitation generates significant unevenness of these surfaces, the piezometric level representing the difference between the contributions made by the precipitations and the magnitude of these exploitations.

After the discovery of the Triassic thermal aquifer from Oradea, the investigations were focused on the clarification of the existence or non-existence of the hydrodynamic relations with the Lower Cretaceous aquifer from Felix -1 Mai, the supply route and heating method of the two aquifers.

In order to verify the hypothesis regarding the presence of a hydrodynamic connection between Oradea and Felix-1 Mai reservoirs, in 1984 an interference test was conducted consisting in the closure, on 27 August, of all the wells from Oradea zone for 28 days and in the monitoring of the flow-rates of the sources from Felix-1 Mai (Cohut & Paal 1985). Before the test period, the thermal water was pumped from the wells of Oradea at a flow rate of 93,7 l/s, whereas in May–June 1984, the flow rate was reduced by 55 l/s. At the end of September 1984 an increase by 35 l/s (about 20%) of the delivery potential of the sources which discharge the Lower Cretaceous aquifer of Felix-1 Mai was recorded, this increase being explained by the authors as an effect of the interference with the Triassic collector of Oradea (Fig. 22).

Reviewing the rainfall data recorded in the mountain zones contiguous to Felix-1 Mai resorts during the test performance of 1984, a similitude was found with those of the January–February 2016 period when heavy precipitations determined the increase of the thermal aquifer level, implicitly of the flow-rates discharged

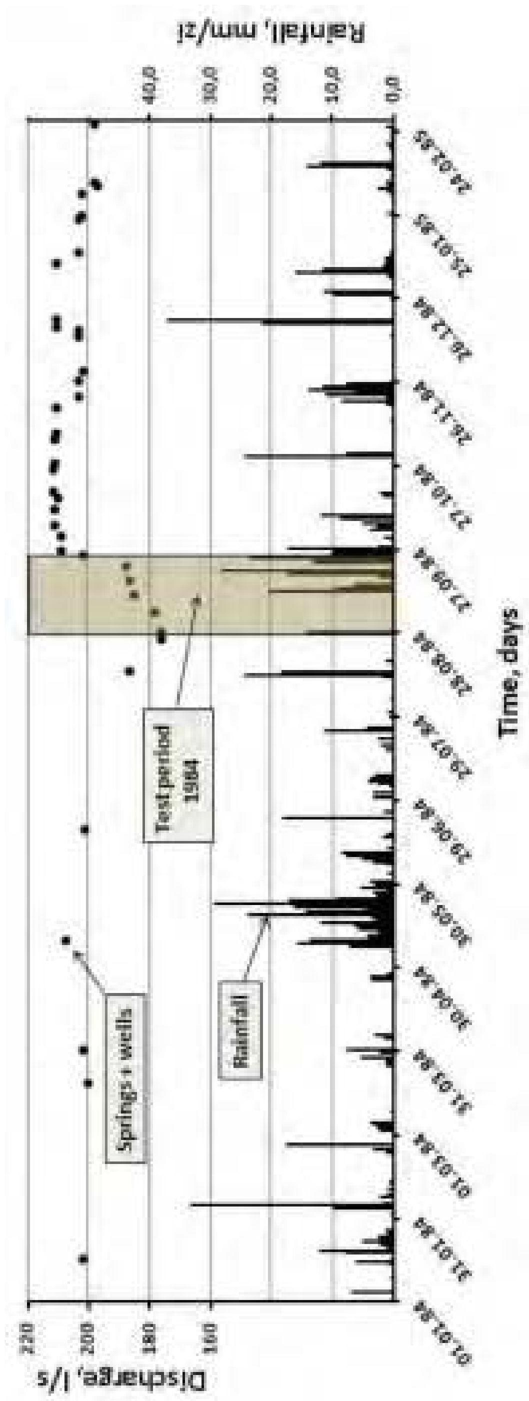

Figure 22. Evolution of the cumulated flow-rate of sources from Felix -1 Mai area and of precipitations fallen at Luncasprie in 1984

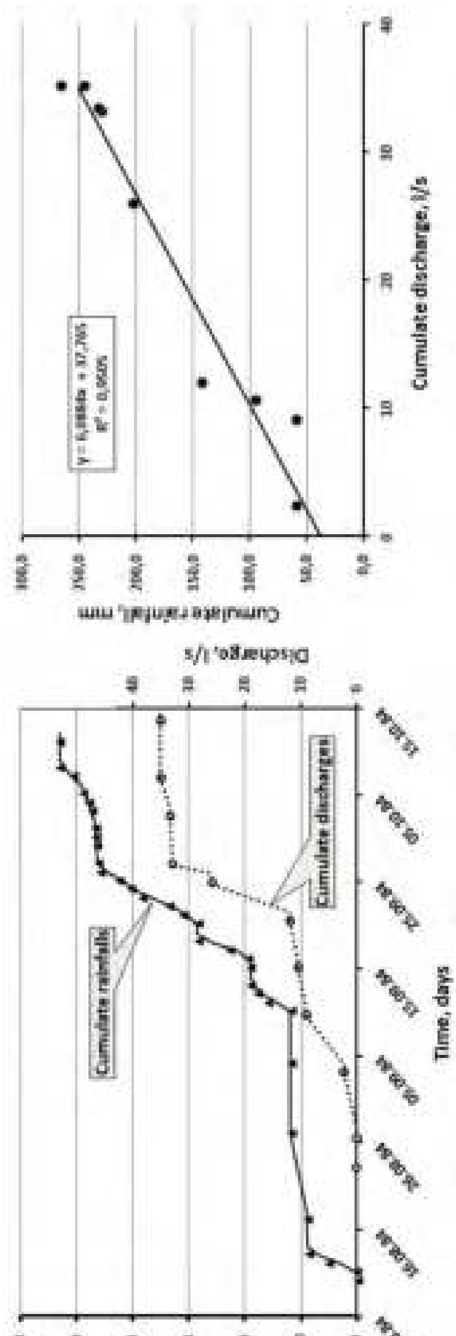

Figure 23. Distribution in time of the precipitations cumulated at Luncasprie and the growth of flow-rate of thermal water sources throughout the test of interference in 1984. To the right the correlation between the mentioned values rows is shown.

from it. In September 1984 at Luncasprie the precipitations totallized 174,4 mm (Fig. 22), the increase curve of the flow-rates of the thermal waters indicating a trend similar to the curve of the cumulated values of the precipitations (Fig. 23, left), and the correlation between the two rows of values having a high reliability (Fig. 23, right).

The increase of the flow-rates of the sources from Felix–1 Mai during the period when the wells exploitation from Oradea stopped can be explained by the high values of precipitations fallen in the mountain area, thus the interference with the boreholes from Oradea is not sustained in this case.

The results of the test conducted in 1984 together with the information offered by the isotopic determinations presented by Ţenu (1975) constituted the basis of the hypothesis issued in relation with the supplying zones, heating and discharging zones of Oradea–Felix–1 Mai thermal aquifer waters (Ţenu 1981, 2015; Cohut 1986, 2013; Paal 2013), summarized by Paal în 2013 as follows: „The aquifer of Băile Felix-1Mai represents the natural area of discharge of the hydrothermal convective system developed in the Triassic rocks from Oradea sub-soil".

The find of the Galbena fracture system playing the part of a regional dra-in for supplying cold waters to the thermal aquifer (Orăşeanu 2015) introduced a new component and implicitly new interpretations regarding its supply zone (Ţenu 2016).

Considering the particular importance of the clarification of the genesis of thermal waters of Oradea–Felix–1 Mai area for their reasonable exploitation it is necessary to do again the test under the current technical conditions of monitoring the pressure and flow-rates values.

Conclusions

The hydrogeological field investigations conducted in Felix–1 Mai area by the Romanian Association of Hydrogeologists between September 2014 – November 2016, by introducing pressure and temperature sensors in most of the wells with thermal water, involve new contributions to the knowledge on the dynamics of the piezometric surface and on the temperature distribution within the thermal aquifer area. The thermal aquifer is located in Lower Cretaceous karstic and fissured limestones. The calcareous mudstones and Sarmatian–Pliocene deposits cover the limestones providing a confined status to the thermal aquifer. All the wells drilled in the reservoir are in a hydraulic connection and the aquifer is a unique one.

The presence of the thermal aquifer was initially suggested by Balint spring of Felix resort and the bunch of springs from Peţa stream and further on, by Balint well, drilled in 1885. The exploitation wells drilled between 1962-1990, all with free overflow, determined the decrease of the piezometric level of the aquifer, the decline of the flow-rates of the sources and the drying out of most springs from Peţa stream (Cohut & Paal 1985). The drilling of new holes resulted in the continuation of the descending trend of the piezometric surface, an event enhanced between 2014-2015 by the rainfalls deficiency and revealed by the dramatic decrease of Ochiul Mare lake level.

During the study period the movement of the aquifer piezometric surface of Felix -1 Mai area is wave-like with an amplitude of about 2,5 m and a periodicity of about one year. The maximum levels occured between May–June 2015, while the minimum ones in December 2015–January 2016, their position being directed by the extension of the hydrological cycles. The thermal aquifer is supplied from Pădurea Craiului and Bihor Mountains, seasonal distribution of the precipitations producing fluctuations in the level of the underground waters within the supplying zones, reflected by the pressure waves recorded in the wells.

The transit of cold underground waters to the thermal reservoir is mainly carried out through the regional drain represented by the Galbena fracture system (Orăşeanu 2015). The average transit duration of the underground waters between the watersheds drained underground by the Galbena system and the thermal aquifer reached minimum 2 months for the watershed of Crişu Pietros stream (Orăşeanu 2016).

The oscillation of the thermal aquifer surface has a complexe shape and is influenced by natural factors, quantity and time distribution of precipitations and by anthropic factors, such as the volume of thermal water extractions. Each production well produces pointwise unevenness of the piezometric surface, an unevenness rapidly transmitted and dimmed or blurred in the whole aquifer area. The aquifer is of fissure – karstic type, heterogenous and discontinue, with drainage axes oriented along the fissure system.

The fluctuations of the level of Ochiul Mare lake water reflect the fluctuations of the thermal aquifer level to which it is connected through a fissure/karstic cavity continued towards the surface by a discontinuity of the deposits clogged with pervious detritus. In the Quaternary - Pliocene deposits contiguous to the lake, a phreatic aquifer is located, in supplying – drainage permanent relation with the lake.

To know the level of the thermal aquifer within the lake perimeter a piezometer hole of 70 m deep was drilled at 42 m West from the lake center.

The minimum levels of water in Ochiul Mare lake were recorded in December 2015. The precipitations fallen in January and February 2016 in Pădurea Craiului and Bihor Mountains determined the increase of the thermal aquifer level and implicitly of the water level in Ochiul Mare lake overflowing in the surface flow. The water level in the lake reached the maximum value in March 2016 and then a slow decrease was noticed.

The increase of the thermal aquifer level was a result of the rains fallen at the beginning of 2016, which determined the actuation of Ochiul Pompei and Frederich springs and the increase of the water level in the catching basins of ”*Rana dalmatina”* and Balint springs.

The temperature of the thermal water extracted from the drill holes indicates a significant variation. The water with the highest temperature is provided by the Balint (47.1 ^{O}C) and 4011 (46.2 ^{O}C) wells, the temperatures radially decreasing, with minimum values found to the East end of 1 Mai zone. For the wells where pumping operation lasted longer, a slow increase in time of the water temperature is noticed for those situated along the 4003-Balint-4087-Aqua President alignment (considered as the main ascending way of thermal waters towards the surface), and a slow decrease for those situated in the periphery zones.

The increase of the source flow-rates discharging the Lower Cretaceous aquifer of Felix -1 Mai area interpreted within the interference test in 1984 as being caused by the the fact that the exploitation of the Triassic aquifer of Oradea was stopped (Cohut & Paal 1985) can be also supported by the large contributions of the precipitations fallen in the Eastern contiguous mountain zones, an event similar to that monitored by us at the beginning of 2016. Considering the particular importance of the clarification of the genesis of the thermal waters from the area for their reasonable explotation, a reprise of the interference test in Oradea–Felix–1 Mai is needed under the current technical conditions of pressure and flow-rate monitoring.

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References

Cohut, I., Paal, G. 1985. – Raport. Arhiva IFLGS Bucureşti.

Cohut, I. 1986. – Sistemul hidrogeotermal Oradea-Felix. *Nymphaea*, p. 617-628.

Cohut, I. 2013. – Dinamica sistemului hidrogeotermal Oradea – Felix – 1Mai, *Nymphaea* **40**: 109-125.

Flamaropol, V. 1975. – Raport geologic. Arhiva ISLGC Bucureşti.

Istocescu, D., Mihai, A., Diaconu, M., Istocescu, F. 1967-1968. – Studiul geologic al regiunii cuprinse între Crişul Repede şi Crişul Negru. Dări de seamă ale şedinţelor 55(5), Tectonică şi geologie regională, IGG Bucureşti: p. 89-106.

Orăşeanu, I. 2015. – Groundwater dynamics of Beiuş Basin basement and its surrounding mountain areas. *Nymphaea* **42**: 5-18.

Orăşeanu, I. 2016. – Hidrogeologia carstului din Munţii Apuseni. Ed. Belvedere, Oradea, 300 p.

Orăşeanu, I., Malancu, F. 2016. – Date preliminare privind dinamica acviferului termal din zona Felix-1 Mai, Bihor, Romania. Proceedings of the IAH Central European Groundwater Conference-2015, Groundwater risk assessment in urban areas, October 14-16, 2015, Constanţa, Romania: 63-80.

Orăşeanu, I., Tenu, A, Iurkiewicz, A., Malancu, F. 2017. – Studiu hidrogeologic privind situaţia actuală a resurselor sistemului geotermal Oradea-Băile Felix-1 Mai şi posibilităţile de protejare a sitului comunitar ROSCI 0098, Lacul Peta. RAPORT FINAL_FELIX_2017 (Rezumat), http://www.ahgr.ro/Proiecte/Felix-Oradea-2014.

Paal, G. 2013. – Sinteza particularităţilor hidrogeologice ale acviferului termal de la Băile Felix-1 Mai. *Nymphaea* **40**: 83-107.

Paucă, M. 1958. – Izvoare termale de la vest de Munţii Apuseni. Natura, vol.. X, nr. 2, Bucureşti

Preda, I., 1972. – Contribuţii privind geneza apelor termominerale de la Oradea. *Analele Univ. Bucureşti*, anul XXI, p.159-173.

Slăvoacă, D., Feru, M. 1961. – Prospecţiuni hidrogeologice din zona Băilor Victoria şi 1 Mai. Arhiva SC Prospecţiuni SA, Bucureşti.

Ţenu, A. 1975. – Cercetări hidrogeologice complexe asupra apelor termale din zona Băilor Felix şi 1 Mai. *Studii de Hidrologie*, XII, p. 75-133. I. M. H.

Ţenu, A. 2015. – Oradea-Felix &1 May spa area: Some new data regarding conceptual model of geothermal hydrostructure. Proc. Abstract of the IAH Central European Groundwater Conference-2015, *Groundwater risk assessment in urban areas*, October 14-16, 2015, Constanţa, Romania: p. 54-55.

Ţenu, A. 2016. – Date noi privind modelul conceptual al structurii geotermale Oradea-Felix & 1 Mai. Proceedings of the IAH Central European Groundwater Conference-2015, *Groundwater risk assessment in urban areas*, October 14-16.

Vasilescu, G., Nechiti, G. 1965. – Cercetări hidrogeologice în zona staţiunilor balneare „Felix” şi „1 Mai”, judeţul Bihor. *Dări de Seamă, IGR*, vol. 51/2, p. 115-133, Bucureşti

Vasilescu, G., Nechiti, G. 1968. – Contribuţii la cunoaşterea geologiei şi hidrogeologiei zonei oraşului Oradea. *Bul. Soc. de stiinţe geologice din R. S. Romania*, vol. X, p. 291-307, Bucureşti.

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Amphibians and squamates from the early Vallesian of Crețești (Vaslui County, E-Romania)

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Abstract. Here we describe a fossil assemblage of lissamphibians and squamate reptiles from the fossil locality Crețești-Dobrina 1 (Vaslui County, E-Romania) that has been discovered during the works carried for renewing the national road 24B, linking Crasna and Huși. The sedimentary succession in that locality, consisting of greenish mudstone interleaved occasionally with silty sand, may be considered as belonging to an ancient floodplain, where the sedimentation progressed by fallout from suspension during periodic floods. The locality has yielded a rather diverse vertebrate assemblage, rich in large and small mammals, tortoises and large vipers (*Macrovipera* sp.) of late Miocene age (MN 9, early Vallesian) representing the first report on these groups from the territory of Moldova. The sediments have yielded also lissamphibians (Salamandridae indet., *Pelobates* sp., Bufonidae indet., Anura indet.), lizards (*Lacerta* (s.l.) sp., *Chalcides* sp., *Ophisaurus* sp.) and colubrid snakes (*Coronella* cf. *miocaenica* and *Hierophis* sp.), consisting mainly of fragmentary cranial bones and vertebrae. Based on the fossil assemblage, the palaeoenvironment

may be interpreted as a savannah-like one, with open grassy areas, but rare trees could be also present. The forested areas were probably common on the fluvial banks. There is no evidence of swamp areas. The climate was warm temperate, but compared to the Middle Sarmatian (Bessarabian) the rainfall decreased.

Introduction

In Eastern Romania, the [illegible] Miocene formations of the Moldavian Platform are part of the last sedimentary megasequence (3rd sedimentary cycle), which started in the middle Miocene (Badenian). In the Sarmatian s.l. (Barbot De Marny 1869), the waters of the Eastern Paratethys that once covered this area of the Dacic Basin regressed and the evolution of the terrestrial environments started on these new emerged lands. Until now, very scarce data were available on the Vallesian terrestrial vertebrates mostly being based on scattered, fortuitous finds. However, in recent years due to regular geological surveys in Vaslui County, new Vallesian localities have been discovered. The most illustrative is by far the fossil locality of Crețești Dobrina 1 (CR) (Vaslui County, E-Romania), that has been discovered during the works carried for renewing the national road 24B, linking Crasna and Huși. At CR locality, the Khersonian deposits crop out on a rather small area, on the roadside (Fig. 1). The thickness of the sedimentary succession exposed is about two meters only. In dominance there is greenish mudstone, interleaving with few centimeters of silty sand. These rocks are rich in vertebrate remains, but apart from vertebrates it worth to notice the presence of freshwater gastropods (e.g., *Planorbis* sp.). The sedimentary structure of this heterolithic deposit is the horizontal lamination. Based on the sedimentology these rocks may be interpreted as an ancient floodplain, where the sedimentation progressed by fall-out from suspension, during periodic floods. The bones were accumulated probably by floods, but they were not carried on too long distances. The anatomical connections are rare and refer only to partial skeletons, excepting turtles, where the limb bones and skulls are often preserved. The large mammalian remains occur together with medium and even with small vertebrates, indicating that there was no grading process due to the water streams. Before the definitive burial, at least part of these bones and teeth were exposed to weathering long enough to suffer damages (numerous teeth enamel fragments were detached and buried at small distance of their initial origin, in skulls and mandibles).

In addition to lissamphibians and squamate reptiles, described in this paper, the preliminary list of vertebrate taxa includes also tortoises (‘*Protestudo*’ sp.,

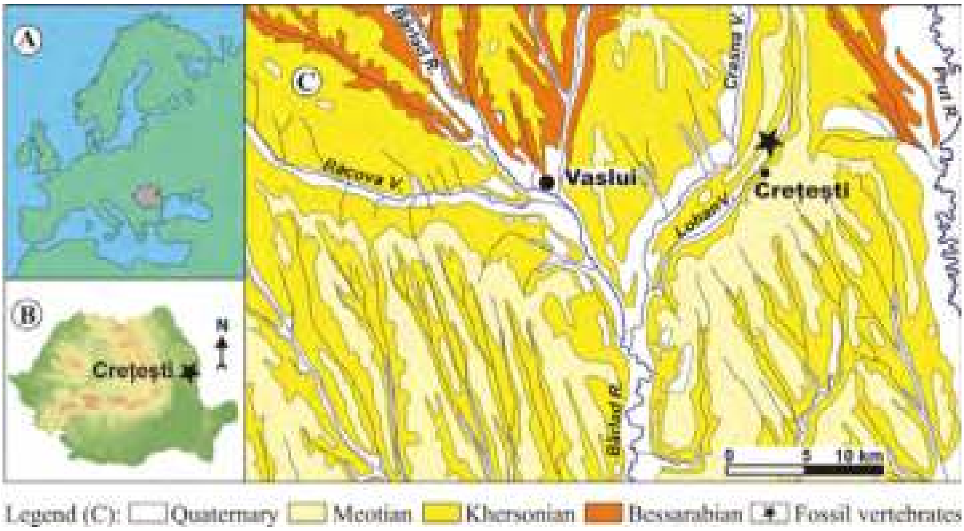

Figure 1. Geologic map and location of the fossil site Crețesti-Dobrina 1 (Moldova, E-Romania).

extremely frequent), birds (Aves indet.), and mammals (Erinaceomorpha: *Schizogaleryx* sp.; Sciuridae: *Spermophilinus bredai*; Lagomorpha: ?*Proochotona* sp.; Carnivora: *Adcrocuta eximia* (Roth & Wagner, 1848), *Metailurus* sp.; Proboscidea: *Choerolophodon pentelici* (Gaudry & Lartet, 1856); Perissodactyla: '*Hipparion*' sp., *Acerorhinus* sp.; Artiodactyla: *Hippopotamodon* sp., *Tragoportax leskewitschi* (Borissiak, 1914), *Paleotragus* sp.) (Ursachi et al. 2015).

The above fauna is typical for the Vallesian in this region of Europe, showing similarities with the ones already reported from Republic of Moldova. There, two Khersonian levels were coined: Katerlezskii (lower, part of the 'Keinar complex') and Mitridatskii (upper, in the 'Poleshetskii complex') the last one dominated by fluvial-lacustrine deposits. Crețești-Dobrina 1 could be related to this upper level. In Republic of Moldova, this level is considered as 'late Vallesian, MN 10' (Lungu & Rzebik-Kowalska 2011). However, according to Vangengeim & Tesakov (2013), it may be correlated with the early Vallesian (MN9).

In the present paper, we (1) describe the remains of lissamphibians and squamate reptiles, except those of *Macrovipera* published elsewhere (Codrea et al. 2017) and (2) outline their palaeogeographical relationships and palaeoenvironmental preferences.

Material and methods

The available material consists of isolated fragmentary bones of the skull roof (*Ophisaurus*), suspensorium (*Macrovipera*), jaws (anurans, lizards and indetermined colubrid snakes), vertebrae (lissamphibians and snakes) and ribs (*Macrovipera*). Part of the specimens of *Macrovipera* were mechanically prepared, whereas the remaining fossils were recovered by screen washing and, where possible, the broken parts were restored in the lab. The digital photographs were taken at the Țării Crișurilor Museum, Oradea, Romania, using a Canon EOS 400D digital camera equipped with a Canon EOS 60 mm macro lens. Standard anatomical orientation system is used throughout this paper; the anatomical nomenclature of lissamphibians and lizards follows those of Venczel & Hír (2013); the anatomical nomenclature of the snake vertebrae follows Szyndlar (1984), whereas the methodology of measurements of the snake vertebrae follows Auffenberg (1963) and Codrea et al. (2017). All the material described in this study is stored in the "Vasile Pârvan" Museum, Department of Natural History, Vaslui, Romania.

Abbreviations used: CL = centrum length; CR – Crețești-Dobrina 1 fossil locality; NAW = narrowest width of the centrum.

Systematic palaeontology

URODELA Duméril, 1805
SALAMANDRIDAE Goldfuss, 1820
Salamandridae indet.
(Figs 2A-D)

Material: CR.5660/1-2, fragmentary trunk vertebrae; CR.5661, fragmentary caudal vertebra

Description and comments: In CR.5660 specimen, corresponding to a small sized individual, the anterior part of a presacral vertebra is preserved. The centrum is opisthocoelous and the neural spine is of relatively low height. The condyle is cylindrical and incompletely isolated from the centrum. Most part of the subcentral area is broken off. The remnants of the neural spine are extremely thin and there is no indication of dorsal margin widening. The caudal vertebra, CR.5661, is small and its centrum is opisthocoelous and relatively short; the neural spine is higher

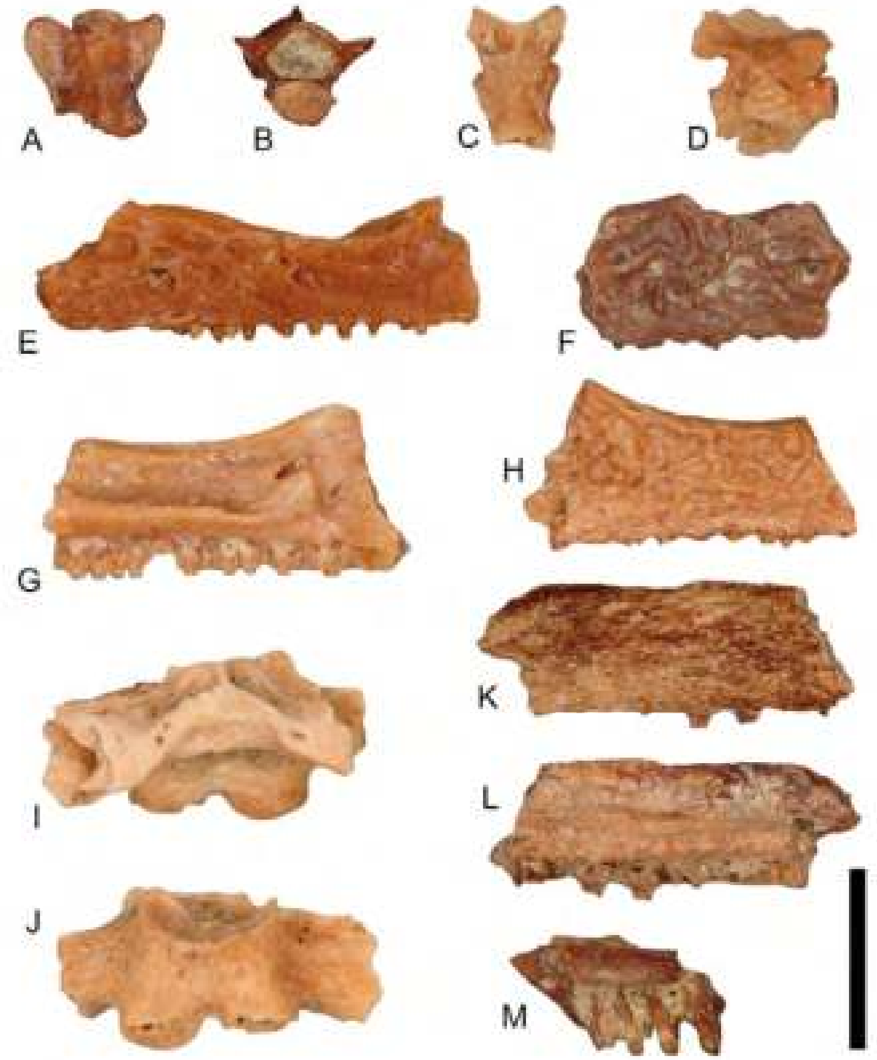

Figure 2. Lissamphibian remains from the late Miocene of CR. A, B – CR.5660/1, incomplete trunk vertebra of Salamandridae indet., in dorsal (A) and anterior (B) views; C – CR.5660/2, incomplete trunk vertebra of Salamandridae indet. in dorsal view; D – CR.5661, incomplete caudal vertebra of Salamandridae indet. in lateral view. E-H – CR.5662/1-4, incomplete maxillae of *Pelobates* sp. in labial (E, F, H) and lingual (G) views; I, J – CR.5663, fragmentary sacral vertebra of Bufonidae indet., in dorsal (I) and ventral (J) views; CR.5664/1-2, incomplete maxillae of Anura indet., in labial (K) and lingual (L, M) views. Scale = 2 mm.

compared to the specimens from the precaudal region; only part of the transverse processes and haemapophyses are preserved.

Trunk vertebrae of somewhat similar morphology, recovered from the Vallesian (MN 9) of Rudabánya (N-Hungary), have been described by Roček (2005) as *Triturus* sp. (type I). However, the material from CR is too fragmentary to be assigned with certainty to that salamandrid taxon.

ANURA Rafinesque, 1815
PELOBATIDAE Bonaparte, 1850
Genus *Pelobates* Wagler, 1830
Pelobates sp.
(Figs 2E-H)

Material: CR.5662/1-4, fragmentary maxillae.

Description and comments: All the specimens are toothed and may have belonged to at least three different postmetamorphic individuals. In all the specimens, the anterior and posterior margins are missing, whereas the pars facialis is moderately high. The labial surface of the maxilla is covered by a pit-and-ridge style sculpture. The sculpture is variable in shape and development, being more incipient in two specimens, probably since they may have belonged to younger individuals. In the remaining two specimens, corresponding to larger (i.e. older) individuals, the ornament is more strongly developed consisting of labially tall ridges delimiting deep pits and grooves. In all the specimens, a small band of bony surface near the crista dentalis on the labial side remains relatively smooth. The margo orbitalis in the larger specimens consists of comparatively thicker bony surface with smooth orbital margins. The palatine process is missing in all the individuals, whereas the pterygoid process is short and wide and provided with a small pit at its dorsolateral margin.

The morphology of the labial sculpture of pit-and-ridge style in the pelobatid maxillae from CR is closer to *P. sanchizi*, known from the early and middle Miocene of Central Europe (Venczel 2004, Ivanov 2008, Venczel & Știucă 2008, Venczel & Hír 2013, 2015), and Recent *P. syriacus*, consisting of almost exclusively from a network of bony ridges isolating deep pits and grooves, whereas the isolated tubercles are rare. This type of sculpture differs from those of *P.* aff. *praefuscus*, known from late Miocene (MN 13) of Solnechnodolsk, Russia (Syromyatnikova 2017), and Recent *P. fuscus* in which the labial sculpture consists mainly of isolated tubercles.

BUFONIDAE Gray, 1825
Bufonidae indet.
(Figs 2I, J)

Material: CR.5663, one fragmentary sacral vertebra.

Description and comments: The specimen corresponds to a small-sized individual. The centrum is short, moderately flattened dorsoventrally and is procoelous with two small posterior condyles. The neural canal is relatively large and roofed by a dorsally flat neural arch connected to moderately widening transverse processes; the distal parts of the transverse processes are broken off. The neural crest has a short anteroposterior extension that is connected to two cristae extending postero-laterally onto the dorsoposterior margins of the transverse processes.

In Alytidae and Ranidae, groups that potentially may have been present in the CR fossil locality, the morphology of the sacral vertebra differs from that of the above bufonid specimen in having a biconvex centrum. In contrary the sacral vertebra in pelobatid frogs has wing-like transverse processes and the centrum is procoelous and monocondylar (Venczel 2004: text-fig. 7F), or fused completely to the urostyle.

Remains of bufonid frogs from the late Miocene are rather common. Surprisingly, these frogs were not recorded in the roughly coeval Rudabánya, a locality that has yielded an extremely diverse fossil assemblage of lissamphibians (Roček 2005).

Anura indet.
(Figs 2K-M)

Material: CR.5664/1-2, two fragmentary maxillae

Description and comments: The specimens represent incomplete maxillae of two different taxa. Both specimens are toothed and their labial surface is smooth. The pars facialis in CR.5664/1 is of low height, whereas the lamina horizontalis is relatively wide with somewhat thickened lingual margins; the teeth are small and numerous, in the fragmentary specimens 12 tooth positions are preserved. The above morphology approaches that of ranid frogs (Fig. 1K, L), but the material is too fragmentary to be assigned with certainty to the above group. In CR.5664/2, representing a small part of a maxilla with seven tooth positions, the pars facialis is broken off, whereas the lamina horizontalis is thick with strongly convex lingual margin recalling the morphology of alytid frogs (Fig. 1M). The tooth pedicels are closely packed and slightly obliquely inserted to the dental parapet (e.g. compare to those figured by Roček 1994: fig. 9).

SQUAMATA Oppel, 1811
LACERTIDAE Bonaparte, 1831
Genus *Lacerta* Linnaeus, 1758
Lacerta (s.l.) sp.
(Figs 3A-F)

Material: CR.5665/1-8, maxillae; CR.5666/1-5, dentaries

Description and comments: Maxilla: CR.5665/1, represents the best-preserved specimen with 10 tooth positions preserved, however the apices of the tooth crowns are strongly worn hiding in part their bicuspid or tricuspid morphology. The ascending nasal process is moderately high with concave labial surface and with the dorsal part slightly convex and bearing a faint labial sculpture; a single row of rarely dispersed nutritive foramina is preserved. The remaining specimens, CR.5665/2-6, consist of small fragments with one to four maxillary teeth. The preserved teeth are pleurodont and strongly built with their base widened labiolingually; the tooth crowns are bicuspid or faintly tricuspid without labial or lingual striations.
Dentary: In CR.5666/1-5 specimens the anterior or middle parts of the dentaries are preserved. The meckelian groove is open extending up to the symphysis; the lamina horizontalis is relatively wide with a faintly concave lingual margin in specimens preserving the anterior part of the dentary, whereas it is thin with convex lingual margin in specimens preserving the middle part of the dentary; the subdental shelf is shallow and moderately wide; in labial view, CR.5666/5 preserves the facet for the coronoid attachment. The teeth are pleurodont with their crown bicuspid without any trace of labial or lingual striations; the teeth are relatively closely packed with the tooth neck flattened mesiodistally; about one third of the tooth height projects above the dental parapet. The labial surface is smooth and convex and a single row of nutritive foramina is present.

The morphology and size of the specimens, especially those of the dentaries, resemble closely those reported from some of the late Sarmatian (MN 7/8) localities of the Felsőtárkány Basin, N-Hungary (Venczel & Hír 2013, Hír et al. 2016). Common features seen in the available dentary specimens from both fossil assemblages include: a moderately widened meckelian groove; tooth crown bicuspid or tricuspid without striations on their apical region; in the bicuspid tooth crowns the main cusp is situated distally.

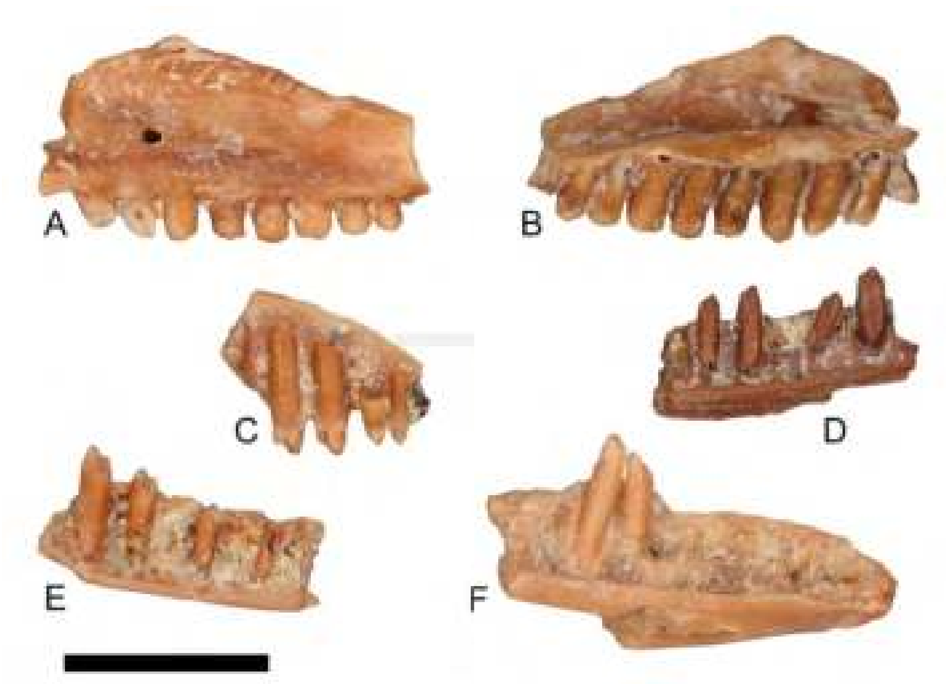

Figure 3. Remains of *Lacerta* (s.l.) sp. from the late Miocene of CR. A, B – CR.5665/1, incomplete left maxilla in labial (A) and lingual (B) views; C – CR.5665/2, incomplete right maxilla in lingual view; D-F – CR.5666/1-3 incomplete dentaries in lingual view. Scale = 2 mm.

Fossil members of the genus *Lacerta* are already known from the Oligocene (Augé & Smith 2009) and early Miocene of Europe (Müller 1996, Augé & Smith 2009, Čerňanský et al. 2015). A peculiar fossil record is known from the early Miocene (MN 2a) locality of Poncenat, France, from where two distinct species (*L. filholi* and *L. poncenatensis*) have been reported (Müller 1996, Augé & Smith 2009). However, according to Čerňanský et al. (2015) the above forms are close to each other, differing only in size (*L. poncenatensis* is smaller) and in some details of the tooth morphology (posterior dentary teeth are tricuspid in *L. filholi* and bicuspid in *L. poncenatensis*), and therefore possibly they may represent the same taxon.

SCINCIDAE Gray, 1825
Genus *Chalcides* Laurenti, 1768
Chalcides sp.
(Figs 4A-E)

Material: CR.5667/1-3, fragmentary maxillae; CR.5668/1-3, fragmentary dentaries.

Description and comments: Maxilla: CR.5667/1 is the best-preserved specimen representing the anterior part of a right maxilla; the ascending nasal process is only partly preserved having a convex labial surface without any trace of ornament; the remnant of the choanal shelf is wide. CR.5667/2, represents a posterior part of a maxilla, whereas in the remaining specimen (CR.5667/3) only a small part of a maxilla with four teeth is preserved. The teeth are closely inserted to each other with their shafts flattened mesiodistally and the tooth necks project below the dental parapet about one third of their depth. The tooth crowns are monocuspid bearing striations on their lingual sides only; the apices are somewhat enlarged at their apical end, compressed labio-lingually and with a concavity on their lingual side.
Dentary: Small fragmentary specimens are preserved only, representing the anterior (CR.5668/1-2), or the middle part (CR.5668/3) of the dentary. In CR.5668/1, the meckelian groove, roofed by a moderately wide subdental shelf, is open up to the symphysis extending on the ventral side of the bone; the groove remains more or less slit-like. The teeth are closely spaced and their shafts are somewhat flattened mesiodistally. The morphology of the tooth crowns is closely similar to that seen in the maxillary specimens. However, the apical region is less dilated, compared to the maxillary specimens.

Assignment of the maxillae and dentaries to the same taxon is based on their closely similar tooth morphology (closely spaced teeth with their shafts flattened mesiodistally; monocuspid tooth crowns bearing striations on their lingual side; labiolingually compressed and enlarged apical region with a concavity on the lingual side) and because they represent the same size category. Fossil dentary specimens with a similar morphology have been described under the name *Chalcides* cf. *ocellatus* and *Chalcides* sp. from the late Sarmatian (MN 7/8) localities of the Felsőtárkány Basin (Venczel & Hír 2013, Hír et al. 2016).

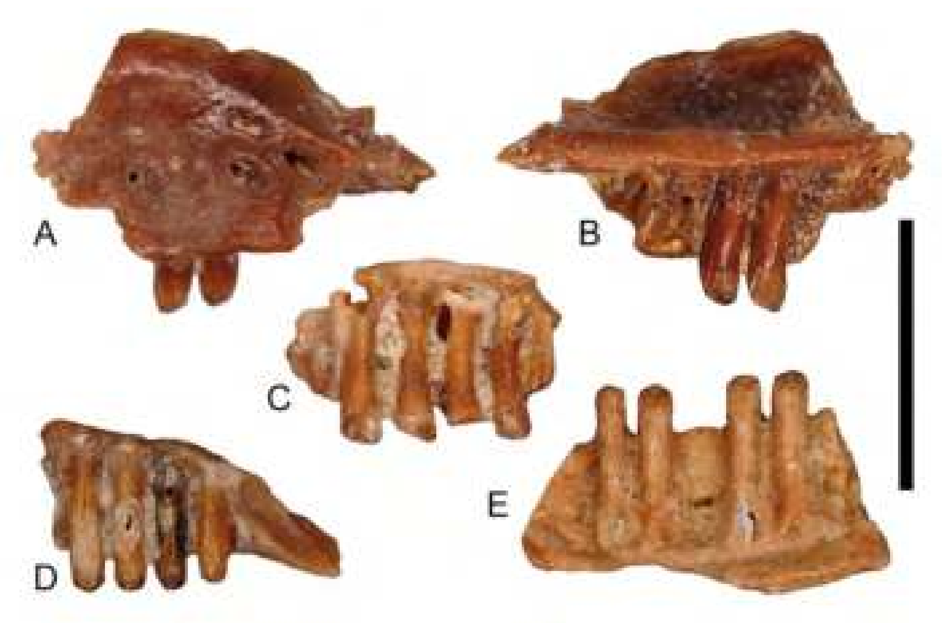

Figure 4. Remains of *Chalcides* sp. from the late Miocene of CR. A, B – CR.5667/1, incomplete right maxilla in labial (A) and lingual (B) views; C, D – CR.5667/2, 3, fragmentary maxillae in lingual view; E – CR.5668 dentary fragment in lingual view. Scale = 2 mm.

ANGUIDAE Gray, 1825
Genus *Ophisaurus* Daudin, 1803
Ophisaurus sp.
(Figs 5A-G)

Material: CR.5669, fragmentary frontal; CR.5670, fragmentary dentary; CR.5671/1-20 osteoderms; CR.5672/1- 20 osteoderms

Description and comments: Frontal: In CR.5669 specimen, the posterior half of a left frontal is preserved. The dorsal surface is covered by a dense vermiculate type sculpture; the ornaments do not reach the lateral border of the bone delimiting a smooth orbital margin on that area. In ventral view, part of the crista cranii frontalis is preserved starting at some distance from the posterior margin of the bone. Posterolaterally to the frontal shield, a small and roughly triangular frontoparietal shield is preserved. The posterolateral process extends beyond the posterior limit of the medial side of the bone.

Dentary: In the CR.5670 specimen, the anterior part of a dentary with six tooth positions is preserved. The meckelian groove extends on the ventral side up to the symphysis; the symphyseal prong is large. The tooth shaft is shallowly curved distally and somewhat compressed mesiodistally; the tooth crown is unicuspid and the apex is mediolaterally compressed and provided with mesiodistal crista.
Osteoderms: The specimens (CR.5671/1-20) are roughly of rectangular shape bearing on their outer surface a medial ridge and several lateral ridges that are anastomosing and delimiting several irregular pits and grooves. The outer surface of the osteoderms always has an ornamentation free gliding surface positioned anteriorly (Fig. 5D), or the gliding surface is continued laterally (Fig. 5E-G). These areas may correspond to surfaces that in the living animal were covered by the adjacent osteoderms (Klembara & Green 2010). Part of the osteoderms (CR.5672/1-15), differs in some details from that of the above described morphology, their outline being rounded and the dorsal surface lacking a medial ridge.

The morphology of the dentary is somewhat reminiscent of *Ophisaurus spinari*, the tooth crown lacking striations on the lingual side and provided with prominent mesiodistal crista (Böhme 2002). Frontals with a somewhat similar morphology of the frontal shield (anterior margin not reaching the lateral margin of the bone), known from the early Miocene (MN 2a) Amöneburg, Germany, have been assigned to *Ophisaurus* sp. by Čerňanský et al. (2015). However, the specimen from CR differs from those of Amöneburg in having a distinctly longer posterolateral process (Fig. 5A, B).

SERPENTES Gray, 1825
COLUBRIDAE Oppel, 1811
Genus *Coronella* Laurenti, 1768
Coronella cf. *miocaenica*
(Figs 6A-D)

Material: CR.5673/1-3, trunk vertebrae.

Description and comments: CR.5598/1 specimen represents a trunk vertebra of a fully adult individual. The left posterolateral part of the neural arch and the right prezygapophysis are broken off. The centrum is moderately long (CL = 3.54 mm, NAW = 2.3 mm; CL/NAW = 1.53) and the neural arch is moderately vaulted; the zygosphene is moderately wide and convex dorsally; the anterior margin preserves

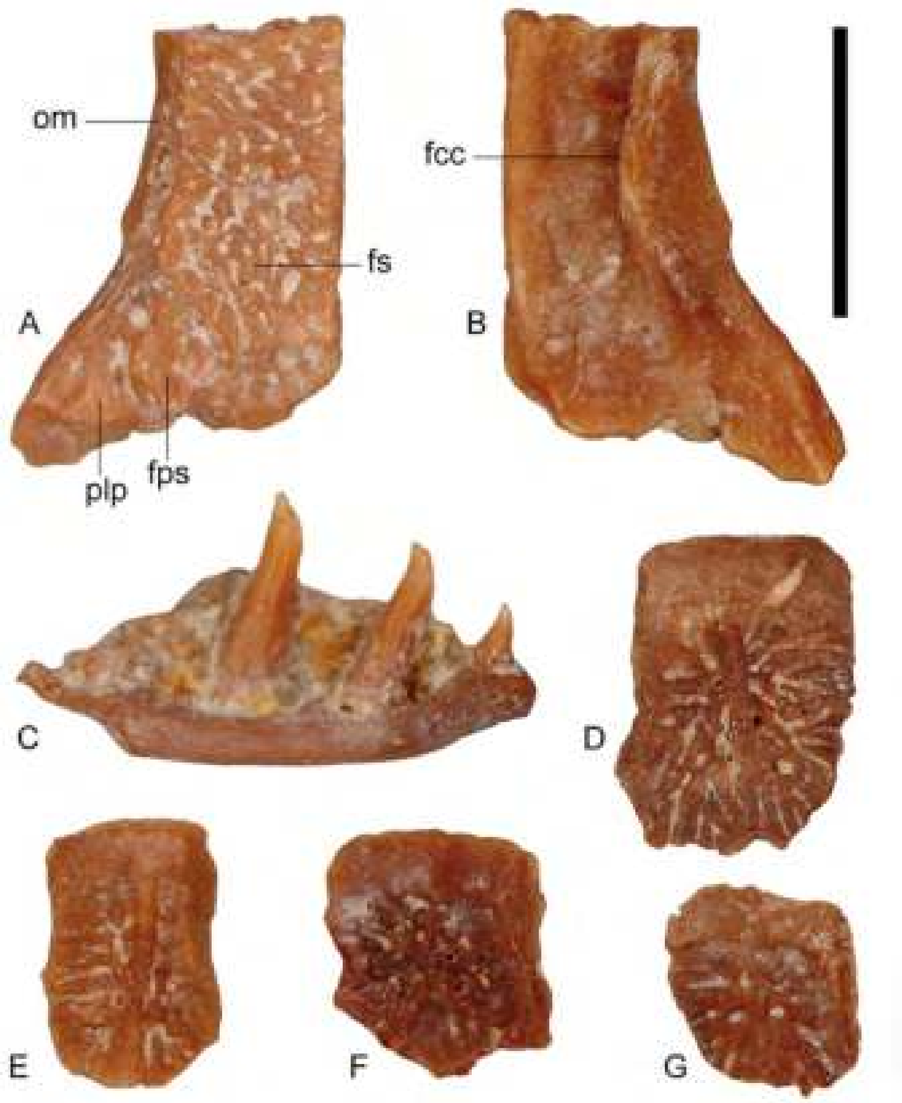

Figure 5. Remains of *Ophisaurus* sp. from the late Miocene of CR. A, B – CR.5669, incomplete left frontal in dorsal (A) and ventral (B) views; C – CR.5670, incomplete left dentary in lingual view; D-G – CR. 5671, osteoderms in dorsal (outer) view. Abbreviations: fcc, frontal cranial crest; fps, frontoparietal shield; fs, frontal shield; om, orbital margin; plp, posterolateral process. Scale = 2 mm.

an indistinct median and two lateral lobes. The dorsal margin of the neural spine is damaged, but presumably was also relatively high. The haemal keel is flattened and spatulate shaped; the parapophyseal part in the paradiapophysis is distinctly longer than the diapophysis. The subcentral area is more or less flat and with weakly defined subcentral ridges. The prezygapophyseal process is short and blunt distally. The CR.5598/1 specimen is distinctly smaller (CL = 2.42 mm, NAW = 1.7 mm; CL/NAW = 1.42) apparently belonging to a younger individual. The neural spine is long and of low height; the haemal keel is flattened and the parapophysis is distinctly longer than the diapophysis; the prezygapophyseal processes are missing.

Remains of *C. miocaenica*, aside from the type material from the late Miocene (MN 13) of Polgárdi 4"Lower", Hungary (Venczel 1998), are known from the late Sarmatian (MN 7/8) of Tauț, Romania (Venczel & Știucă 2008). Other small colubrids reminiscent of *Coronella*, known from the Central Paratethys area, are *Texasophis* and *Telescopus* (e.g. see Venczel 2011). Remains of *Texasophis* have been reported from the middle Miocene (MN 6) of Litke, Sámsonháza and Mátraszőlős (Hír et al. 2016). The trunk vertebrae of *Texasophis* differ from those of *Coronella* in having their haemal keels and the subcentral ridges more prominent delimiting deep concave subcentral areas on both sides of the haemal keel. *Telescopus bolkayi* is known from the early Vallesian (MN 9) locality of Rudabánya (N-Hungary) (Szyndlar 2005) and their trunk vertebrae are somewhat larger than those of *Coronella*, the CL of the largest specimens exceeding 4 mm in length. Furthermore, the haemal keel and the subcentral ridges are strongly developed producing strongly concave subcentral areas; the ventral margin of the haemal keel is distinctly flattened and provided with a distinct constriction closely behind the paradiapophyses (Szyndlar 2005).

Genus *Hierophis* Fitzinger, 1843
Hierophis sp.
(Figs 7A-D)

Material: CR.5674/1-5, trunk vertebrae

Description and comments: The vertebral centrum is moderately vaulted, elongated and provided with a relatively long and low neural spine. The anterior margin of the zygosphene is with a faint convexity or nearly straight; the prezygapophyseal facets are oval; the prezygapophyseal processes are trending anterolaterally but in all the specimens their distal end is missing. The haemal keel is prominent

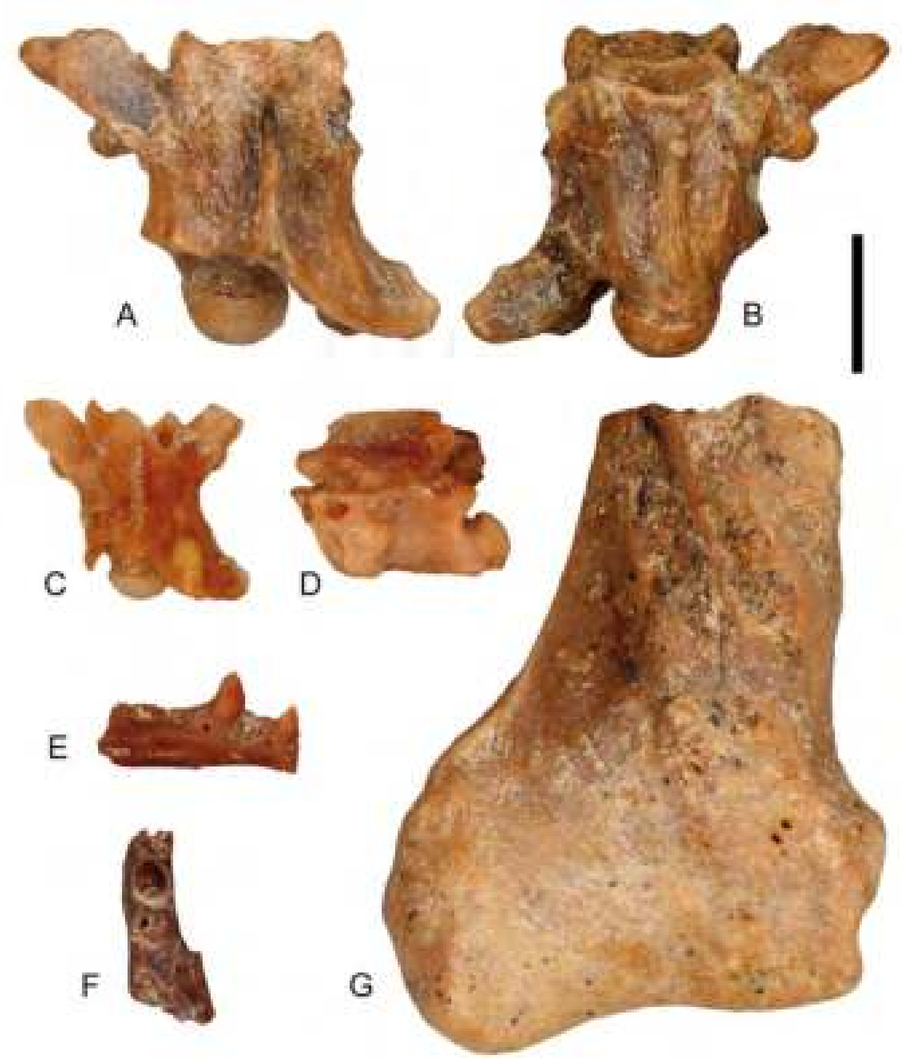

Figure 6. Snake remains from the late Miocene of CR. A-D – CR.5673/1-2, incomplete trunk vertebrae of *Coronella* cf. *miocaenica*, in dorsal (A, C), ventral (B) and lateral (D) views; E – CR.5676, fragmentary left dentary of Colubrinae indet. in lingual view; F – CR.5675, fragmentary right maxilla of Colubrinae indet. in ventral view; G – CR.5678, fragmentary distal quadrate of *Macrovipera* sp. in lateral view. Scale = 2 mm.

and narrow with parallel margins and the ventral margin is hemicylindrical; small, paired tubercles are present near to the subcotylar lip. The specimens are relatively small, the CL of the largest measurable specimen (CR.5674/1) reaching 4.78 mm in length (NAW = 3.14; CL/NAW = 1.52); another specimen (CR.5674/2) with similar morphology is distinctly smaller (CL = 3.9 mm; NAW = 2.81 mm; CL/NAW = 1.38).

The available specimens are somewhat reminiscent of *Hierophis* (=*Coluber*) *hungaricus* reported by Szyndlar (2005) from the the early Vallesian (MN 9) locality of Rudabánya (N-Hungary) and by Venczel & Știucă (2008) from the late Sarmatian (MN 7/8) of Tauț, Romania.

Colubrinae indet.
(Figs 6E, G)

Material: CR.5675 maxilla, CR.5676, fragmentary dentary; CR.5677/1-40, 40 vertebrae.

Description and comments: In the CR.5675 specimen, a posterior fragment of a right maxilla is preserved. In ventral view four tooth positions are preserved and between the posteriormost teeth a short diastema is present; the distal margin of the ectopterygoid process is broken off. The above morphology is reminiscent of colubrid snakes. In the CR.5676 dentary specimen is of low height and curved medially; the anteriormost part of the meckelian groove is visible in lingual view; six tooth positions are preserved; only two recurved teeth are preserved with their distal end missing.

VIPERIDAE Laurenti, 1768
Genus *Macrovipera* Reuss, 1927
Macrovipera sp.
(Fig. 6H)

Material: CR.5678, one fragmentary distal quadrate; CR.5679/1-12, trunk vertebrae; CR.5680/1-6, ribs.

Description and comments: Quadrate: CR.5678 specimen is the only cranial bone of *Macrovipera* recovered from CR. It corresponds in size with the remaining material (vertebrae and ribs) assigned to *Macrovipera*. The quadrate condyle is rather robust and connected to a sharp edged dorsal crest of relatively low height. The stem of the bone is anteroposteriorly compressed; the proximal part is missing

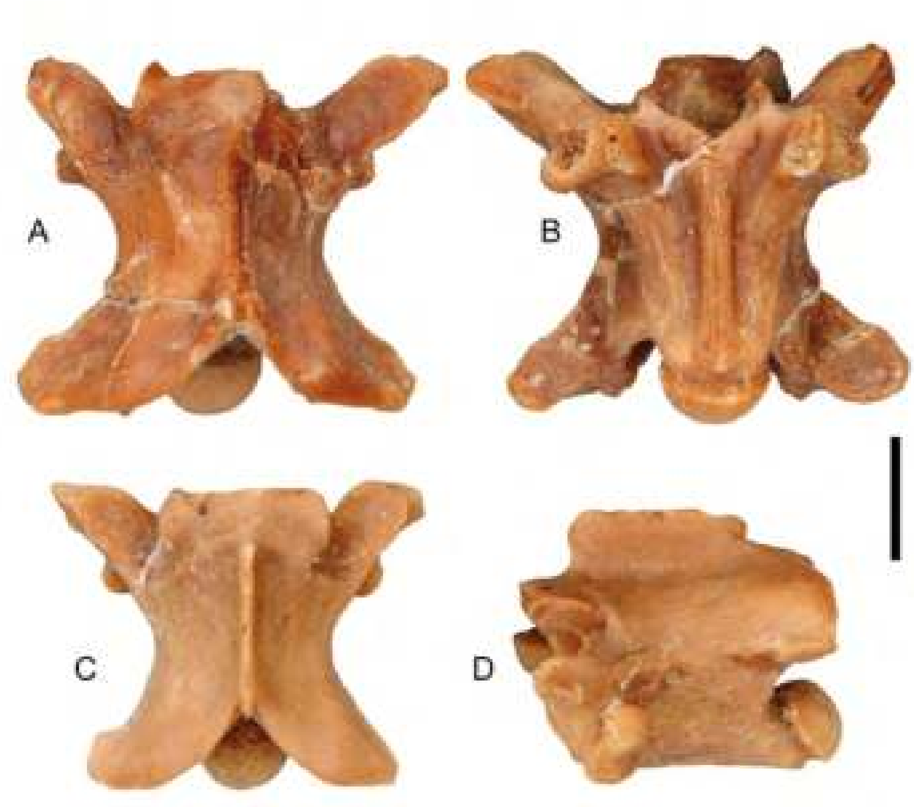

Figure 7. Trunk vertebrae of *Hierophis* sp. from the late Miocene of CR. A, B – CR.5674/1, mid-trunk vertebra in dorsal (A) and ventral (B) views; C, D – CR.5674/2, mid-trunk vertebra in dorsal (C) and lateral (D) views. Scale = 2 mm.

and, as is indicated a surface of fracture, probably was broken off and lost during the processing of the material.

The trunk vertebrae are large-sized and robustly built. The neural spines are extremely high; the hypapophyses are straight and project posteroventrally; the parapophyseal process protrude anteroventrally. The ribs assigned to this taxon correspond in size to the size of the *Macrovipera* specimens.

The material of *Macrovipera* (part of the mid-trunk vertbrae and ribs, embedded in the matrix, are still closely associated to each other keeping their original positions in the vertebral column) has been described in detail recently (Codrea et al. 2017). During the late Miocene, the genus *Macrovipera* might have had a large distribution all over the eastern and central part of Europe. Reviews on the fossil record of this genus have been published previously by Szyndlar (1991) and Georgalis et al. (2016).

Concluding remarks

The material of lissamphibians and squamate reptiles, discovered at CR, is dominated quantitatively by the remains of the large-sized vipers (*Macrovipera* sp.), consisting of vertebrae, ribs and a single cranial bone. However, the remaining specimens, despite of their fragmentary nature and of distinctly smaller absolute size, represent at least eight different families (Salamandridae, Pelobatidae, Bufonidae, Lacertidae, Scincidae, Anguidae, Colubridae and Viperidae).

The remains of *Macrovipera* sp. suggest the presence of savanna-like palaeoenvironments rich in grass, whereas those of bufonid frogs, lacertid and anguid lizards and colubrid snakes indicate forested environments, at least along the fluvial banks. The presence of water source is indicated by the salamandrid newts and by frogs that were linked to aquatic habitats for their reproduction. Part of the herpetofauna were represented by burrowers (pelobatid frogs and scincid lizards) probably inhabiting sandy soils along the fluvial banks.

References

Auffenberg, W. 1963. - The fossil snakes of Florida. - *Tulane Studies in Zoology* **10**: 131–216.

Augé, M., Smith, R. 2009. - An assemblage of early Oligocene lizards (Squamata) from the locality of Boutersem (Belgium), with comments on the Eocene–Oligocene transition. *Zoological Journal of the Linnean Society* **155**: 148–170.

Böhme, M. 2002. - Lower vertebrates (Teleostei, Amphibia, Sauria) from the Karpatian of the Korneuburg basin - palaeoecological, environmental and palaeoclimatical implications. *Beitrage zur Paläontologie* **27**: 339–353.

Čerňanský, A., Rage, J-C., Klembara, J. 2015. - The Early Miocene squamates of Amöneburg (Germany): the first stages of modern squamates in Europe, Journal of Systematic Palaeontology, **13**: 97–128.

Codrea, V., Venczel, M., Ursachi, L., Răţoi, B. 2017: - A large viper from the early Vallesian (MN 9) of Moldova (Eastern Romania) with notes on the palaeobiogeography of late Miocene "Oriental vipers". *Geobios* **50**: 401-411.

Georgalis, G.L., Szyndlar, Z., Kear, B.P., Delfino, M., 2016. - New material of *Laophis crotaloides*, an enigmatic giant snake from Greece, with an overview of the largest fossil European vipers. *Swiss Journal of Geosciences* **109**: 103–116.

Hír, J., Venczel, M., Codrea, V., Rössner, G.E., Angelone, C., Hoek Ostende, L.W., van den, Rosina, V.V., Kirscher, U., Prieto, J. 2016. - Badenian and Sarmatian s.str. from the Carpathian area: Overview and ongoing research on the Hungarian and Romanian small vertebrate evolution. - *Comtes Rendus Palevol* **15**: 863–875.

Klembara, J., & Green, B. 2010. - Anguimorph lizards (Squamata, Anguimorpha) from the Middle and Late Eocene of the Hampshire Basin of southern England. - *Journal of Systematic Palaeontology* **8**: 97–129.

Lungu, A., Rzebik-Kowalska, B. 2011. - *Faunal assemblages, stratigraphy and taphonomy of the Late Miocene localities in the Republic of Moldova*. - Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Krakow, 62 pp.

Müller, J. 1996. Eine neue Art der Echten Eidechsen (Reptilia: Lacertilia: Lacertidae) aus dem Unteren Miozän. *Mainzer Geowissenschaften Mitteilungen* **25**: 79–88.

Roček, Z. 1994. - Taxonomy and distribution of Tertiary discoglossids (Anura) of the genus *Latonia* v. Meyer, 1843). - *Géobios* **27**: 717–751.

Roček, Z. 2005. - Late Miocene Amphibia from Rudabánya. *Palaeontographia Italica* **90**: 11–29.

Syromyatnikova, E.V. 2017. - Redescription of *Pelobates praefuscus* Khosatzky, 1985 and new records of *Pelobates* from the late Miocene–Pleistocene of Eastern Europe. - *Historical Biology*, https://doi.org/10.1080/08912963.2017.1402015

Szyndlar, Z. 1984. - Fossil snakes from Poland. - *Acta Zoologica Cracoviensia* **28**: 3–156.

Szyndlar, Z., 1991. - A review of Neogene and Quaternary snakes of Central and Eastern Europe. Part II: Natricinae, Elapidae Viperidae. *Estudios geologicos* **47**: 237–266.

Szyndlar, Z. 2005. - Snake fauna from the Late Miocene of Rudabánya. *Palaeontographia Italica* **90**: 31–52.

Ursachi, L., Codrea, V., Venczel, M., Solomon, A., Rătoi, B. 2015. - Crețesti-Dobrina 1: a new early Vallesian locality in Moldova. Tenth Romanian Symposium on Paleontology, Cluj-Napoca, 16-17 October 2015, Abstracts and Field Guide, pp. 115–116.

Vangengeim, E.A, Tesakov, A.S. 2013. - Late Miocene mammal localities of Eastern Europe and Western Asia. Toward biostratigraphic synthesis. In: Wang X.-M., Flynn, L.J., Fortelius, M. (Eds.), *Fossil mammals of Asia: Neogene biostratigraphy and chronology*. Columbia University Press, New York, pp. 519–535.

Venczel, M. 1994. - Late Miocene snakes from Polgárdi (Hungary). *Acta Zoologica Cracoviensia* **37**: 1–29.

Venczel, M. 1998. - Late Miocene snakes (Reptilia: Serpentes) from Polgárdi (Hungary): a second contribution. *Acta Zoologica Cracoviensia* **41**: 1–22.

Venczel, M., 2004. - Middle Miocene anurans from the Carpathian Basin. *Palaeontographica Abteilung A* **271**:151–174.

Venczel, M., 2011. - Middle-late Miocene snakes from the Pannonian basin. Acta Palaeontologica Romaniae **7**: 343-349.

Venczel, M., Știucă, E. 2008. - Late middle Miocene amphibians and squamate reptiles from Tauț, Romania. *Geodiversitas* **30**: 731-763.

Venczel, M., Hír, J. 2013. - Amphibians and squamates from the Miocene of Felsőtárkány Basin, N-Hungary. *Palaeontographica Abteilung A* **300**: 117–158.

Venczel, M., Hír, J. 2015. - Lissamphibians and squamate reptiles from the early middle Miocene of Litke, Northern Hungary. *Geobios* **48**: 491–504.

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Eurycantha calcarata (Lucas, 1869), an Australasian stick-insect found for the first time in Romania

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Abstract. A giant spiny stick insect *Eurycantha calcarata* (Lucas, 1869) individual was found alive for the first time on a small street in Oradea, northwestern Romania. This is the first occurrence of this tropical species in Europe, and while it is presumably accidental, the invasive potential of the species is briefly discussed here. More strict regulations and control of the pet trade, as well as responsible husbandry are needed to prevent biological invasions.

Introduction

The giant spiny stick insect *Eurycantha calcarata* (Lucas, 1869) (Phasmatodea, Phasmatidae), is endemic to the Australasian region, being native to Papua New Guinea, New Caledonia, and the Solomon Islands, where it lives in the foliage and ground litter of warm, humid rainforests (Monteith & Dewhurst 2011, Delfosse 2013), but not in Australia, as was once thought (Nakata 1961). It is a nocturnal feeder; during the day it gathers in groups under tree bark and in other hiding places for protection from predators, and, like in other stick insects, its cryptic and cataleptic abilities are also used to evade predators (Bedford 1976a, Sivinski 1978, Buckley et al. 2008). Defensive display behavior and grasping of the disturber with the last femora and tibiae was noted in males, behaviors which are rare in Phasmatidae (Bedford 1976a, Burrows & Morris 2002).

In its natural habitat, *E. calcarata* feeds on rainforest leaves and is known as a pest of oil palm (Gibson et al. 2012), while in captivity it accepts rose, ivy, raspberry and oak leaves. It is sometimes kept as pet in terraria at an optimum temperature of 20-35 °C and it lives for 12 to 18 months. Typically, it reproduces sexually, deposits eggs subterraneously (Honan 2008) or on the ground, and hatching occurs in 3-6 months (Bedford 1976b), but in the absence of males parthenogenesis is manifested as reproductive strategy. Metamorphosis takes 4-6 months to complete and includes 5-6 instars.

Material and methods

On April 5, 2017 (a sunny day), a large, spiny, long-legged insect was observed and photographed by our colleague Dr. Sabina Horvath walking on a small street in Oradea, northwestern Romania (Crizantemelor St., near the Environmental Protection Agency of Bihor County). The peculiar insect was crossing an alley close to a wire fence which delimits an abandoned yard full of *Rosa sp.* shrubs, ruderal vegetation and cut branches. The present author found out only the next day about that observation, but collecting efforts produced no result, while in the mean time weather conditions have turned to chilly, windy and heavy rain.

On April 7, however, during somewhat better weather, Dr. Horvath and the author searched again and found the insect dead in the midst of the molting process, beyond the wire fence and among the bushes in the abandoned yard, at about 1 m from the spot where it has been first observed and photographed two days before. The insect was collected and prepared for inclusion in the entomological collection of Ţării Crişurilor Museum (Fig. 1).

Results

The specimen, a large, dark brown, wingless, spiny armored insect with long and strong legs and long antennae, was identified as a newly molted *Eurycantha calcarata* (Lucas, 1869) male. The identification was based on its general habitus, the characteristic lack of a conspicuous ventral tooth in the basal third of the hind tibia, and the relative length of the curved, defensive spikes on the underneath side of the last femur, which are visibly shorter than in the similar *E. horrida* Boisduval, 1835 (Bedford 1976a, Brock 1987, 2017, Buckley et al. 2008).

Figure 1. Habitus of the *Eurycantha calcarata* individual captured in Oradea: A – last instar nymph; B – exuvia.

Its exuvia, light brown and lacking the head part, was found stuck on its first pair of legs, indicating that the insect has died while molting. Thus it appears that the observed living individual was a last instar nymph, because of its remarkable size.

All its soft parts have been scavenged upon by ants and mites, thus only its remaining complete exoskeleton and exuvia were found intact. The exoskeleton has a body length of 90 mm and the exuvia is 85 mm long. Contacted pet shops in Oradea denied their involvement with the trade of this species as pet.

Discussion

This first and surprising find of a living Australasian insect in a street of Oradea may be accidental for the moment, as European climate and environmental conditions appear as unsuitable for a tropical, rainforest animal. There are no publications of similar finds in Europe or of *E. calcarata* as invasive species in temperate regions. That particular individual may have been previously kept as pet and most probably escaped or was irresponsibly released from captivity, as the find occurred in an urban area.

Occasionally, in its native range, dead males were found on the ground in the open, suggesting they were more active than females and possibly acting as defenders of 'colonies', and also its defensive mechanisms may not be entirely successful against non-native predators, as in the similar and critically endangered *Dryococelus australis* (Montrouzier, 1855) (Bedford 1976a).

In its native range, the tropical climate shows little change in diurnal temperature and rainfall throughout the year, while the host plants bear foliage continuously, thus no diapauses in eggs were observed (Bedford 1976b). But in the eggs of non-tropical phasmids, such as the spur legged phasmid *Didymuria violescens* Leach, 1815, common on eucalypts in temperate regions of Australia, or *Ramulus irregulariterdentatus* (Brunner von Wattenwyl, 1907) from Japan, one or two obligatory diapauses occur, enabling them to overwinter once or twice before hatching (Bedford 1976b, Yamaguchi & Nakamura 2015). A common characteristic of Phasmidae, including diapauses species, is long and variable egg periods, from several to 30 months (Kobayashi et al. 2016).

Therefore, the invasive potential of *E. calcarata* deserves further attention. Although the insect is flightless, its distribution indicates capabilities of dispersion across both land and water (Gibson et al. 2012). Despite its remarkable size and threatening appearance, its cryptic abilities and adaptable diet (also including rose, oak, ivy and other European plants), and, most important, the hypothetical possibility of adaptation to overwintering as eggs in man-made shelters pose its invasive threat to a certain degree of probability, perhaps low, but not to be entirely overlooked.

A future established population of this large insect in Europe may have considerable impact on local ecosystems, first and especially on vegetation. Thus, irresponsible keeping of pets (including *E. calcarata*) should be strongly discouraged by law (Monteith & Dewhurst 2011), first of all in the case of dangerous or invasive species, since it has led previously to biological invasions.

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References

Bedford, G. O. 1976a - Defensive behaviour of the New Guinea stick insect *Eurycantha* (Phasmatodea: Phasmatidae: Eurycanthinae). *Proceedings of The Linnean Society of New South Wales* **100**: 218-222.

Bedford, G. O. 1976b – Description and development of the eggs of two stick insects (Phasmatodea: Phasmatidae) from New Britain. *Journal of the Australian entomological Society* **15**: 389-393.

Brock, P. D. 1987 – Brief notes on *Eurycantha horrida* Boisduval and *Eurycantha calcarata* Lucas. *The Phasmid Study Group Newsletter* **30**: 7-8.

Brock, P. D. 2017 - Phasmida Species File. Version 10.7. Species File Group. Checklist Dataset https://doi.org/10.15468/8nv8vf accessed via GBIF.org on 2017-10-13.

Buckley, T. R., Attanayake, D., Bradler, S. 2008 - Extreme convergence in stick insect evolution: phylogenetic placement of the Lord Howe Island tree lobster. *Proceedings of the Royal Society, B* **276**: 1055-1062.

Burrows, M., Morris, O. 2002 – Jumping in a winged stick insect. *The Journal of Experimental Biology* **205**: 2399–2412.

Delfosse, E. 2013 – Une nouvelle espèce de Phasme du genre *Trapezaspis* Redtenbacher, 1908, de l'île des Pins (Phasmatodea, Phasmatidae). *Bulletin de la Société entomologique de France* **118** (1): 15-21.

Gibson, G. A. P., Dewhurst, C., Makai, S. 2012 – Nomenclatural changes in *Anastatus* Motschulsky and the description of *Anastatus eurycanthae* Gibson n. sp. (Eupelmidae: Eupelminae), an egg parasitoid of *Eurycantha calcarata* Lucas (Phasmida: Phasmatidae) from Papua New Guinea. *Zootaxa* **3419**: 53-61.

Honan, P. 2008 - Notes on the biology, captive management and conservation status of the Lord Howe Island Stick Insect (*Dryococelus australis*) (Phasmatodea). *Journal of Insect Conservation* **12**: 399-413.

Kobayashi, S., Usui, R., Nomoto, K., Ushirokita, M., Denda, T., Izawa, M. 2016 - Population Dynamics and the Effects of Temperature on the Eggs of the Seawater-dispersed Stick Insect *Megacrania tsudai* (Phasmida: Phasmatidae). *Zoological Studies* **55** (20): 1-10. doi:10.6620/ZS.2016.55-20.

Monteith, G. B., Dewhurst, C. F. 2011 - Does the phasmid *Eurycantha calcarata* Lucas, 1869 (Phasmida: Phasmatidae) occur in Australia? *The Australian Entomologist* **38** (4): 179-196.

Nakata, S. 1961 – Some notes on the occurrence of Phasmatodea in Oceania. *Pacific Insects Monograph* **2**: 107-121.

Sivinski, J. 1978 - Intrasexual Aggression in the Stick Insects, *Diapheromera veliei* and *D. covilleae,* and Sexual Dimorphism in the Phasmatodea. *Psyche* **85**: 395-406.

Yamaguchi, H., Nakamura, K. 2015 - Effects of environmental factors on the regulation of egg diapause in the walking-stick insect, *Ramulus irregulariterdentatus* (Phasmatodea: Phasmatidae). *European Journal of Entomology* **112** (1): 35-40.

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New data on the invertebrate biodiversity in Natura 2000 sites in Bihor county

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Abstract. In May-Sept. 2016 a faunistical survey regarding invertebrates was performed in eight Natura2000 sites in Bihor county, northwestern Romania. Seven legally protected, eight Red List and two invasive species were observed, while the extinct status of the endemic snail *Microcolpia parreyssii* was confirmed. *Carabus hampei* and *Drobacia banatica* were not observed in the Betfia site anymore.

Introduction

In May-September 2016 a faunistical survey of invertebrate species was performed in the following Natura 2000 sites in Bihor county: ROSCI0008 Betfia, ROSCI0291 Coridorul Munții Bihorului – Codru Moma, ROSCI0084 Ferice-Plai, ROSCI0098 Lacul Pețea (with the included natural reserve 2177 Pârâul Pețea), ROSCI0347 Pajiștea Fegernic, ROSCI0200 Platoul Vașcău, ROSCI0240 Tășad, and ROSCI0267 Valea Roșie (Fig. 1).

The main characteristics of those protected areas are as follows:

- 1. Betfia: situated in the continental and Pannonic bioregions, near Oradea and Sânmartin, includes a paleontological reserve on a calcareous hill, altitude 160-346 m, forests, meadows and cultivated land.

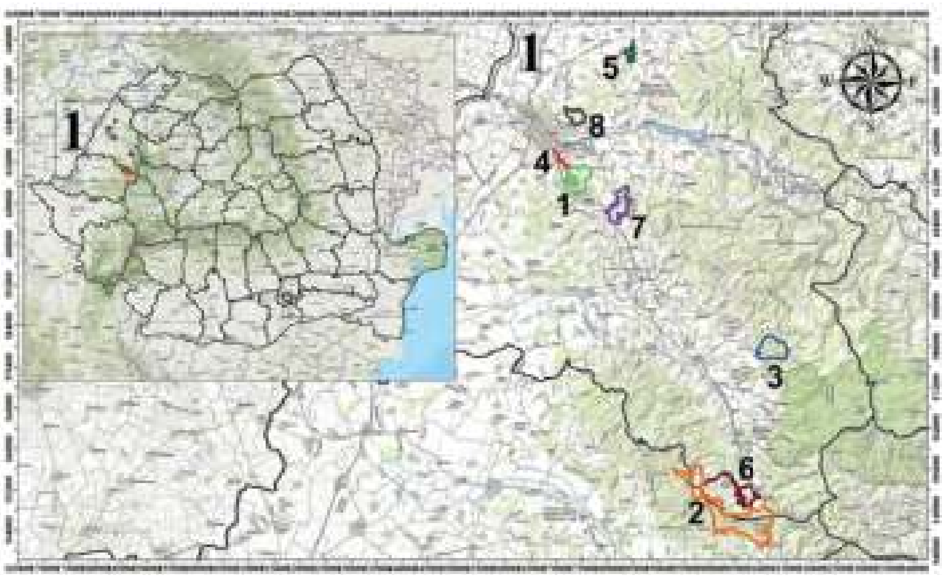

Figure 1. Distribution of the protected sites surveyed (the numbers corresponds to ROSCI sites described in the text).

- 2. Coridorul Munții Bihorului – Codru Moma: continental and alpine bioregions, altitude 255-938 m, mostly forests.
- 3. Ferice-Plai: alpine bioregion, karst, altitude 389-1206 m, mostly forests.
- 4. Lacul Pețea: Pannonic bioregion, near Oradea and Sânmartin, altitude 133-167 m, mostly cultivated areas, includes a natural reserve with a unique habitat: a small thermal lake now almost dried up (since 2011-2014) mainly because of over-extraction of thermal water for nearby resorts.
- 5. Pajiștea Fegernic: continental bioregion, altitude 128-255 m, mostly meadows.
- 6. Platoul Vașcău: continental bioregion, calcareous plateau with karst formations, altitude 325-885 m, mostly forests and meadows.
- 7. Tășad: continental bioregion, close to the Betfia site, altitude 200-420 m, karst, includes a paleontological reserve, mostly forests, cultivated land and meadows.
- 8. Valea Roșie: continental bioregion, near Oradea, altitude 158-291 m, forest, meadow and cultivated areas.

Table 1. Coordinates of Barber traps installed in the Betfia site

Barber traps	Geographic		Stereo 1970	
	Latitudine	Longitude	X	Y
1	46°59'20.94"N	22° 0'13.39"E	272245,19994	614274,097196
2	46°59'20.92"N	22° 0'13.41"E	272245,698397	614273,188137
3	46°59'20.95"N	22° 0'13.35"E	272244,452311	614274,459377
4	46°59'21.03"N	22° 0'13.28"E	272243,020315	614276,850346
5	46°59'20.85"N	22° 0'13.46"E	272246,467228	614271,378677
6	46°59'20.85"N	22° 0'13.48"E	272246,843151	614271,25314
7	46°59'20.84"N	22° 0'13.47"E	272246,758688	614271,033812
8	46°59'20.81"N	22° 0'13.46"E	272246,640486	614269,925625
9	46°59'20.78"N	22° 0'13.48"E	272246,851701	614269,472539
10	46°59'20.80"N	22° 0'13.49"E	272247,088221	614269,686096

Material and methods

Barber traps were installed in three sites (Betfia – mainly for *Carabus hampei*, and also in Coridorul Munții Bihorului – Codru Moma and Ferice-Plai), using fermented cheese as bait (Table 1). During field trips, the presence of animals was also recorded by visual observations and by taking photographs.

Results

Phylum Mollusca Linnaeus, 1758
Class Gastropoda Cuvier, 1795
Fam. Melanopsidae H. Adams & A. Adams, 1854

Melanoides tuberculata (O. F. Müller, 1774), Lacul Pețea, June 8.

Microcolpia parreyssii (Philippi, 1847), empty shells, Lacul Pețea, June 8.

Fam. Planorbidae Rafinesque, 1815

Planorbarius corneus (Linnaeus, 1758), Lacul Pețea, June 8.

Fam. Helicidae Rafinesque, 1815

Cepaea hortensis (O. F. Müller, 1774), Lacul Pețea, Sept. 28.

C. vindobonensis (Férussac, 1821), Lacul Pețea, Sept. 28; Platoul Vașcău, Sept. 28.

Drobacia banatica (Rossmässler, 1838), Ferice-Plai, June 6, Sept. 22, Sept. 28; Coridorul M. Bihorului - Codru Moma, Sept. 22, Sept. 28; Lacul Pețea, Sept. 22, Sept. 28; Platoul Vașcău, Sept. 22, Sept. 28.

Helix pomatia Linnaeus, 1758, Betfia, June 6, Sept. 28, Sept. 22; Ferice-Plai, June 6; Lacul Pețea, June 8.

Fam. Limacidae Lamarck, 1801

Bielzia coerulans M. Bielz, 1851, Ferice-Plai, June 6.

Fam. Agriolimacidae H. Wagner, 1935

Deroceras invadens Reise, Hutchinson, Schunack & Schlitt, 2011, Betfia, Sept. 22, Sept. 28.

Fam. Arionidae Gray, 1840

Arion fasciatus (Nilsson, 1823), Coridorul M. Bihorului - Codru Moma, Sept. 28.

A. rufus (Linnaeus, 1758), Lacul Pețea, Sept. 28.

Class Bivalvia Linnaeus, 1758
Ord. Unionoida Stoliczka, 1871
Fam. Unionidae Fleming, 1828

Sinanodonta woodiana (Lea, 1834), Lacul Pețea, June 8.

Unio crassus Philipsson, 1788, Lacul Pețea, June 8.

Phylum Arthropoda von Siebold, 1848
Class Malacostraca Latreille, 1802
Ord. Decapoda Latreille, 1802
Fam. Astacidae Latreille, 1802-1803

Astacus astacus (Linnaeus, 1758), Tășad, June 8.

Class Insecta Linnaeus, 1758
Ord. Neuroptera Linnaeus, 1758
Fam. Myrmeleontidae Latreille, 1802

Myrmeleon formicarius Linnaeus, 1767, Coridorul M. Bihorului - Codru Moma, Sept. 28.

Ord. Odonata Fabricius, 1793
Fam. Calopterygidae Sélys, 1850

Calopteryx virgo (Linnaeus, 1758), Coridorul M. Bihorului - Codru Moma, Sept. 28.

Fam. Coenagrionidae Kirby, 1890

Coenagrion puella (Linnaeus, 1758), Tășad, June 8; Lacul Pețea, Sept. 28.

Fam. Libellulidae Rambur, 1842

Libellula depressa Linnaeus, 1758, Betfia, June 6.

Ord. Orthoptera Latreille, 1793
Fam. Gryllidae Laicharting, 1781

Gryllus campestris Linnaeus, 1758, Betfia, June 6; Pajiștea Fegernic, June 8.

Fam. Gryllotalpidae Saussure, 1870

Gryllotalpa gryllotalpa (Linnaeus, 1758), Platoul Vașcău, Sept. 22, Sept. 28.

Fam. Tettigoniidae Krauss, 1902

Decticus verrucivorus (Linnaeus, 1758), Ferice-Plai, Sept. 28.

Tettigonia viridissima (Linnaeus, 1758), Betfia, June 6.

Ord. Hemiptera Linnaeus, 1758
Fam. Pyrrhocoridae Dohm, 1859

Pyrrhocoris apterus (Linnaeus, 1758), Betfia, Sept. 22, Sept. 28.

Ord. Coleoptera Linnaeus, 1758
Fam. Meloidae Gyllenhal, 1810

Meloe proscarabeus Linnaeus, 1758, Betfia, June 6; Ferice-Plai, June 6; Coridorul M. Bihorului - Codru Moma, June 8; Pajiștea Fegernic, June 8.

Fam. Scarabaeidae Latreille, 1820

Cetonia aurata (Linnaeus, 1758), Betfia, June 6, Sept. 22, Sept. 28.

Oxythyrea funesta (Poda, 1861), Pajiștea Fegernic, June 8.

Fam. Carabidae Latreille, 1802

Carabus arvensis Herbst, 1784, Coridorul M. Bihorului - Codru Moma, Sept. 22, Sept. 28.

C. coriaceus Linnaeus, 1758, Pajiștea Fegernic, June 8.

C. ullrichii Germar, 1824, Betfia, June 6.

C. variolosus Fabricius, 1787, Ferice-Plai, June 6.

Cicindela hybrida Linnaeus, 1758, Coridorul M. Bihorului - Codru Moma, June 8.

Pterostichus niger (Schaller, 1783), Betfia, June 6.

P. transversalis (Duftschmid, 1812), Betfia, Sept. 22, Sept. 28.

Fam. Cerambycidae Latreille, 1802

Cerambyx scopolii Fuessly, 1775, Valea Roșie, June 8.

Dorcadion aethiops (Scopoli, 1763), Betfia, June 6; Pajiștea Fegernic, June 8.

D. pedestre (Poda, 1761), Betfia, June 6; Valea Roșie, June 8; Pajiștea Fegernic, June 8.

D. scopolii (Herbst, 1784), Betfia, June 6.

Rhagium sycophanta (Schrank, 1781), Betfia, June 6.

Cerambycidae indet., larvae, Valea Roșie, June 8.

Fam. Lucanidae Latreille, 1804

Dorcus parallelipipedus (Linnaeus, 1758), Betfia, June 6; Coridorul M. Bihorului - Codru Moma, June 8, Sept. 22, Sept. 28; Lacul Pețea, Sept. 22, Sept. 28.

Fam. Geotrupidae Latreille, 1802

Geotrupes mutator Marsham, 1802, Betfia, June 6.

G. puncticollis Malinowsky, 1811 (syn. *spiniger*), Ferice-Plai, June 6; Coridorul M. Bihorului - Codru Moma, Sept. 22, Sept. 28; Platoul Vașcău, Sept. 28.

G. stercorarius (Linnaeus, 1758), Betfia, June 6; Ferice-Plai, June 6; Valea Roșie, June 8; Coridorul M. Bihorului - Codru Moma, Sept. 22, Sept. 28.

Geotrupes sp., Betfia, Sept. 22, Sept. 28.

Fam. Silphidae Latreille (1807)

Nicrophorus germanicus Linnaeus, 1758, Betfia, Sept. 22, Sept. 28.

N. vestigator Herschel, 1807, Betfia, Sept. 22, Sept. 28.

Oiceoptoma thoracicum (Linnaeus, 1758), Betfia, Sept. 22, Sept. 28.

Fam. Hydrophilidae Latreille, 1802

Hydrophilus aterrimus (Eschscholtz, 1822), Lacul Pețea, Sept. 28.

Fam. Buprestidae Leach, 1815

Chrysobothrys chrysostigma (Linnaeus, 1758), Platoul Vașcău, Sept. 28.

Ord. Lepidoptera
Fam. Nymphalidae Rafinesque, 1815

Aglais io (Linnaeus, 1758), Ferice-Plai, June 6, Sept. 22, Sept. 28; Coridorul M. Bihorului - Codru Moma, Sept. 28.

Araschnia levana (Linnaeus, 1758), Ferice-Plai, June 6.

Argynnis paphia (Linnaeus, 1758), Coridorul M. Bihorului - Codru Moma, Sept. 28.
Boloria dia Linnaeus, 1767, Pajiștea Fegernic, June 8.

Coenonympha arcania Linnaeus, 1761, Coridorul M. Bihorului - Codru Moma, Sept. 28.

Limenitis populi (Linnaeus, 1758), Platoul Vașcău, Sept. 28.

Maniola jurtina (Linnaeus, 1758), Betfia, June 6; Pajiștea Fegernic, June 8; Coridorul M. Bihorului - Codru Moma, Sept. 28.

Melitaea aurelia Nickerl, 1850, Tășad, June 8.

Nymphalis antiopa (Linnaeus, 1758), Ferice-Plai, June 6.

N. polychloros (Linnaeus, 1758), Ferice-Plai, June 6; Coridorul M. Bihorului - Codru Moma, Sept. 28.

Polygonia c-album (Linnaeus, 1758), Coridorul M. Bihorului - Codru Moma, Sept. 22, Sept. 28; Lacul Pețea, Sept. 28.

Vanessa atalanta Linnaeus, 1758), Betfia, June 6; Coridorul M. Bihorului - Codru Moma, Sept. 28.
V. cardui (Linnaeus, 1758), Ferice-Plai, Sept. 28.

Fam. Pieridae Swainson, 1820

Anthocharis cardamines (Linnaeus, 1758), Ferice-Plai, June 6; Valea Roșie, June 8.

Aporia crataegi (Linnaeus, 1758), Tășad, June 8.

Gonepteryx rhamni (Linnaeus, 1758), Ferice-Plai, June 6.

Leptidea sinapis (Linnaeus, 1758), Ferice-Plai, June 6.

Pieris brassicae (Linnaeus, 1758), Ferice-Plai, Sept. 28; Lacul Pețea, Sept. 28.

P. napi (Linnaeus, 1758), Coridorul M. Bihorului - Codru Moma, Sept. 28.

Fam. Saturniidae Boisduval, 1837

Aglia tau (Linnaeus, 1758), Ferice-Plai, June 6.

Fam. Papilionidae Latreille (1802)

Iphiclides podalirius (Linnaeus, 1758), Pajiștea Fegernic, June 8.

Papilio machaon Linnaeus, 1758, Ferice-Plai, June 6.

Parnassius mnemosyne (Linnaeus, 1758), Valea Roșie, June 8.

Fam. Lycaenidae Leach, 1815

Lycaena dispar (Haworth, 1802), Tășad, June 8.

Lycaenidae indet., Valea Roșie, June 8.

Fam. Tineidae Latreille, 1810

Euplocamus anthracinalis (Scopoli, 1763), Valea Roșie, June 8.

Fam. Hesperiidae Latreille, 1809

Pyrgus malvae (Linnaeus, 1758), Pajiștea Fegernic, June 8.

Fam. Geometridae Leach, 1815

Ennomos quercinaria (Hufnagel, 1767) (female), Coridorul M. Bihorului - Codru Moma, Sept. 28.

Ord. Hymenoptera
Fam. Apidae Latreille, 1802

Bombus terrestris (Linnaeus, 1758), Pajiștea Fegernic, June 8.

Bombus sp., Ferice-Plai, June 6.

Fam. Formicidae Latreille, 1809

Formica rufa Linnaeus, 1761, Pajiștea Fegernic, June 8.

Discussion

Besides mostly common species, several remarkable ones were observed, such as the invasive mollusks *Melanoides tuberculata* (O. F. Müller, 1774) and *Sinanodonta woodiana* (Lea, 1834). *M. tuberculata* appears to have established a population, and its high invasive potential and capability of being a host for parasite Trematoda are of concern regarding biodiversity and epidemiology (Sîrbu & Benedek 2017). *S. woodiana*, established since 2003-2006 and now the most abundant bivalve in the site, posits a significant threat to replace *Unio crassus* and the native bivalve communities (Popa & Popa 2006, Sîrbu 2006).

Legally protected species, both by national and international regulations, are as follows: *Drobacia banatica* (Rossmässler, 1838) (OUG nr. 57/2007, Annex 3, 4A), *Unio crassus* Philipsson, 1788 (OUG nr. 57/2007, Annex 3), *Carabus variolosus* Fabricius, 1787 (OUG nr. 57/2007, Annex 3, 4A), *Lycaena dispar* (Haworth, 1802) (OUG nr. 57/2007, Annex 3, 4A), *Parnassius mnemosyne* (Linnaeus, 1758) (OUG nr. 57/2007, Annex 4A), *Helix pomatia* Linnaeus, 1758, and *Astacus astacus* (Linnaeus, 1758) (OUG nr. 57/2007, Annex 5A).

Seven Lepidoptera species from the Romanian Red List (Rákosy 2002, Rákosy et al. 2003) were observed (national statuses below):
VU: *Limenitis populi* (Linnaeus, 1758), *Nymphalis polychloros* (Linnaeus, 1758), *Lycaena dispar* (Haworth, 1802);
NT: *Iphiclides podalirius* (Linnaeus, 1758), *Papilio machaon* Linnaeus, 1758, *Parnassius mnemosyne* (Linnaeus, 1758), *Ennomos quercinaria* (Hufnagel, 1767).

The identification of *Pyrgus malvae* (Linnaeus, 1758) is uncertain because the individual was not captured and the photograph taken did not show the ventral side of wings with specific characters, thus it could possibly be *P. sidae*, a species protected by national law.

Carabus hampei, previously listed at Betfia in literature, was not observed nor captured, even though the present survey included its optimal activity period. *Drobacia banatica* was not observed anymore in the Betfia site as well, probably because of the recent trend towards aridity in the area, caused by drought and deforestation.

Microcolpia parreyssii (Philippi, 1847), previously known as *Melanopsis parreyssii* and recently considered by some authors an eco-form of *Fagotia acicularis* (Sümegi et al. 2012a, b) or classified in *Microcolpia* (Neubauer et al. 2014), an endemic snail from Lake Pețea extinct in the wild since the fall of 2014, was observed only as empty shells.

Other protected invertebrates previously listed in the site (the Jersey tiger moth *Callimorpha quadripunctaria* and the rare semi-aquatic hemipteran *Mesovelia thermalis* Horváth, 1915) were not observed. The latter is presumably extinct from the reserve because of the severe decrease of water surface and disturbance of habitat in recent years, accelerated since 2011 (Sîrbu et al. 2013). The Jersey tiger moth nominate species, common in central and southern Europe, is erroneously included in European and national protection regulations because of a confusion with its subspecies *C. quadripunctaria rhodosensis*, endemic for Rhodos (Rákosy 2005).

Chrysobothrys chrysostigma (Linnaeus, 1758) is widely spread in Europe (in France, Germany, England, Sweden, Norway, Finland, and Russia), but localized as its host plant is the pine tree (Théry 1942). It is included as Endangered in the Red List of Buprestoidea from Romania and its populations are potentially threatened (risk rate 60-80 %) by removal of more or less dried trees and shrubs from its habitat, including from protected areas, therefore forest management should be performed with caution (Ruicănescu 2002).

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References

Neubauer, T. A., Harzhauser, M., Georgopoulou, E., Wrozyna, C. 2014 – Population bottleneck triggering millenial-scale morphospace shifts in endemic thermal-spring melanopsids. *Palaeogeography, Palaeoclimatology, Palaeoecology* **414**: 116-128.

Popa, O., Popa, L. O. 2006 – *Sinanodonta woodiana* (Lea, 1834), *Corbicula fluminea* (O. F. Müller, 1774) *Dreissena bugensis* (Andrusov, 1897) (Mollusca: Bivalvia): alien invasive species in Romanian fauna. *Travaux du Muséum National d`Histoire Naturelle "Grigore Antipa"* **49**: 7-12.

Rákosy, L. 2002 – Lista Roșie pentru fluturii diurni din România. *Buletinul informativ al Societății Lepidopterologice Române* **13 (1-4)**: 9-26.

Rákosy, L. 2005 – UE și legislația pentru protecția lepidopterelor din România. *Buletinul informativ al Societății Lepidopterologice Române* **16**: 89-96.

Rákosy, L., Goia, M., Kovács, Z. 2003 – Catalogul Lepidopterelor României / Verzeichnis der Schmetterlinge Rumäniens. Societatea Lepidopterologică Română, Cluj-Napoca, 447 pp.

Ruicănescu, A. 2002 – Lista Roșie a buprestidelor (Coleoptera: Buprestoidea) din România. *Buletinul informativ al Societății Lepidopterologice Române* **13 (1-4)**: 125-136.

Sîrbu, I. 2006 – The freshwater mollusca from Crișana (Criș rivers basin, Romania). *Travaux du Muséum National d`Histoire Naturelle "Grigore Antipa"* **49**: 13-28.

Sîrbu, I., Benedek, A.-M. 2017 - Native relict versus alien molluscs in thermal waters of north-western Romania, including the first record of *Melanoides tuberculata* (O. F. Müller, 1774) (Gastropoda: Thiaridae) from Romania. *Acta Zoologica Bulgarica* **69 (1)**: 31-36.

Sîrbu, I., Gagiu, A., Benedek, A.-M. 2013 – On the brink of extinction: fate of the Pețea thermal lake (Romania) and its endemic species. *Tentacle* **21**: 34-37.

Sümegi, P., Molnár, D., Sávai, S., Töviskes, R. J. 2012a – Preliminary radiocarbon dated paleontological and geological data for the Quaternary malacofauna at Püspökfürdõ (Băile 1 Mai, Oradea region, Romania). *Malakológiai Tájékoztató* **30**: 31-37.

Sümegi, P., Molnár, D., Sávai, S., Gulyás, S. 2012b – Malacofauna evolution of the Lake Pețea (Püspökfürdõ), Oradea region, Romania. *Nymphaea, Folia Naturae Bihariae* **39**: 5-29.

Théry, A. 1942 – Faune de France 41. Coléoptères Buprestides. Librairie de la Faculté des Sciences, Paris, 222 pp.

*** Ordonanță de Urgență a Guvernului României nr. 57 din 20 iunie 2007 privind regimul ariilor naturale protejate, conservarea habitatelor naturale, a florei și faunei sălbatice. Monitorul Oficial nr. 442, 29 iunie 2007, 54 pp.

NYMPHAEA Folia naturae Bihariae	XLIV	77 - 92	Oradea, 2017

Recviem pentru Rezervația Naturală „Pârâul Pețа” de la Băile 1 Mai

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Rezumat. Vestita și unica rezervație naturală Pârâul Pețа de la Băile 1 Mai de lângă Oradea, cu specii termofile endemice, relicte ale perioadelor glaciare, și-a început agonia spre sfârșitul anului 2011, după ce – în ultimele trei decenii – au avut loc mai multe episoade sporadice de oprire a debitării izvoarelor sublacustre. Singurul ecosistem termal natural din România şi singurul loc din Europa unde există, în mod natural, tipul de habitat prioritar 31A0* *Ape termale din Transilvania acoperite de lotus,* menţinea în viaţă cea mai reprezentativă specie a florei locale: nufărul termal (*Nymphaea lotus* var. *thermalis)* precum și speciile termofile de faună: peştele roşioara lui Racoviţă (*Scardinius racovitzai),* melcul *Melanopsis parreyssi* şi o specie rară de insecte, *Mesovelia thermalis.* Încetarea funcționării izvorului sublacustru (cu excepția câtorva reveniri sporadice, cu durate tot mai scurte) a cauzat dispariția treptată a ecosistemului,. În ultimii patru ani, lacul Ochiul Mare (exceptând câteva săptămâni din martie-aprilie), este lipsit de orice aflux de apă termală, făcând astfel posibilă dispariția speciilor pentru ocrotirea cărora a fost înființată rezervația. Abia în luna august 2014, instituția responsabilă de gestionarea apelor geotermale și termominerale: Agenția Natională pentru Resurse Minerale (A.N.R.M.) – la presiunea Custodelui, a Prefecturii Bihor, a Ministerului Mediului și a unei susținute campanii de presă – a comandat executarea unui studiu, cu scopul reabilitării sitului comunitar ROSCI0098 Lacul Pețea precum și o re-evaluare a rezervelor exploatabile de apă termală. La finalizarea acestuia, în noiembrie 2016, concluziile au fost făcute publice doar sub forma unui *Rezumat* (studiul fiind probabil clasificat!), care – în mod logic – conține probabil toate rezultatele semnificative obținute în cei doi ani de cercetare și monitorizare. Aceste rezultate nu sunt nici concludente și nici liniștitoare, ba dimpotrivă: sunt contradictorii, nu sunt în concordanță cu rezultatele cercetărilor anterioare, susțin dependența funcționării izvorului sublacustru de condițiile climatice, dar - ce este mai grav- nu oferă programul de refacere preconizat. Bazați pe datele cercetărilor anterioare, autorii precizează concluziile cele mai discutabile ale acestui studiu, în speranța revizuirii lor de către instituția responsabilă, care – eventual – mai poate atenua deterioarea definitivă a întregului acvifer termal de la Băile Felix-1 Mai.

Abstract. The renowned and unique natural reserve Pârâul Petea located at „1 May" Spa near Oradea, has been deteriorating, then dying since the end of 2011. This reserve has hosted thermophile endemic species since glaciation times, and is the only natural thermal ecosystem of Romania and Europe where a priority habitat 31A0* "Geothermal Waters of Transylvania covered by lotus" naturally exists. It has preserved the most representative species of the local flora, the thermal lotus (*Nymphaea lotus* var. *thermalis*), as well as the termophilic species of the thermal rudd (*Scardinius racovitzai*), snails (*Melanopsis parreyssi*) and a rare species of insect (*Mesovelia thermalis*). First the reduction, and finally the drying of the lake's spring was the cause of the ecosystem's slow disappearance, with a few and sporadic revivals of inreasingly shorter time frames, between 2012 – 2016. Except for a few weeks in March-April, in the last four years, the influx of thermal water into the Lake Ochiul Mare was entirely cut off, therefore now it lacks the species the reservation was founded for. It was only in August 2014 when the National Agency for Mineral Resources (ANRM), the institution responsible for geothermal and thermo-mineral waters, ordered a study for the rehabilitation of the ROSCI0098 Lacul Pețea community site and the re-evaluation of the geothermal resources. The conclusions of this study were made publicly available only as an Executive Summary in November 2016. It was stated that the main conditions for the lake's recharge are dependant on changes in the weather, and no scenarios were provided for the mitigation of this situation. Its results were not satisfactory, moreover, they were contradictory and in disagreement with the conclusions of previous research. Based on their experiment and previous research, the authors of this paper underline the most uncertain conclusions of the ANMR-ordered study, hoping for a revised opinion by the administrative institution that might prevent the total destruction of the Thermal Aquifer „Felix - 1 May" Spas.

Introducere

Emblema vestitelor băi de lângă Oradea, nufărul termal (*Nymphaea lotus* var. *thermalis*), a fost menționat pentru prima dată de renumitul botanist P. Kitaibel

(Viena 1802), a fost descris științific – ca specie – de J. Tuzson (1907), a fost declarat Monument al Naturii (1931) de Academia Română, iar din anul 1932 salba de lacuri cu apă termală care constituiau izvoarele Pârâului Peța devine Arie Protejată (Fig.1). Prin Legea nr. 5 din anul 2000 este definită ca arie protejată, sub denumirea de Rezervația Naturală Pârâul Peța de la Băile 1 Mai, cu o suprafață de 10,8 ha. Lacul Peța (Pețea) a fost desemnat în anul 2007 ca arie naturală protejată pentru conservarea habitatelor naturale -unicul habitat acvatic termal din România- , sit de importanță comunitară ROSCI0098, ca parte integrantă a rețelei ecologice europene Natura 2000.

Pe lângă nufărul termal, în situl Natura 2000 au fost incluse pentru conservare în habitatul lor natural termal gasteropodul *Melanopsis parreyssii* (descris în 1847 de biologul austriac Philippi) și roșioara de apă termală *Scardinius racovitzai* (Müller, 1958), alături de scoica de apă dulce *Unio crassus* sau de gasteropodul terestru *Chilostoma banaticum.*

Exploatarea apelor termale și declinul rezervatiei

Dovezile istorice atestă funcționarea neîntreruptă a pârâului Peța - ce-și avea sorgintea în puternicele izvoare sublacustre din zona din amonte de Ochiul Mare, cu debite ce puneau în mișcare mori și pive, apa neînghețând iarna (fapt pentru care în Evul Mediu alimenta șanțurile cetății Oradea). Primele măsurători de debit pe pârâul Peța (înainte de confluența cu pârâul Hidișel), făcute între 1955-1960, în perioade de secetă, au avut valori cuprinse între 0,35 și 0,45 m^3/s (reprezentând debitul însumat al izvoarelor termale sublacustre, izvoare ce au funcționat probabil o bună parte a cuaternarului, permițând conservarea unor taxoni floristici și faunistici unici pentru teritoriul țării noastre).

Sonda Balint de la Băile Felix, săpată în anul 1885 (debit 196 l/s și 49^0C) a fost prima intervenție antropică asupra zăcământului de apă termală de la Felix-1 Mai, urmată de sonda Izbuc (1886) de la Băile 1 Mai. „La erupția sondei Balint (din ziua de Ajun a Crăciunului 1885) s-a înregistrat scăderea treptată a nivelului apei din salba de lacuri de la Băile 1 Mai. După oprirea erupției, nivelul apei a început să se ridice, revenirea totală a nivelului având loc dupa 3 luni”, notează istoricul Samu Borovszky în lucrarea monografică „Bihar vármegye és Nagyvárad” (Comitatul Bihor și Oradea) publicată la Budapesta în anul 1901.

În perioada 1965-1975 au fost săpate și date în exploatare încă opt sonde, astfel încât debitul total posibil de extras prin sonde a fost de circa 260 l/s (în perioada 1978-1982), fapt ce a permis ca cele două stațiuni să ajungă la o capacitate de 6.900 de locuri în hoteluri și vile (cu bazele de tratament aferente).

Concomitent cu creșterea capacității de extracție a apei termale prin sonde, a scăzut debitul mediu al izvoarelor naturale de la Băile 1 Mai: 140 l/s în perioada 1977-1980, 116 l/s în 1982, 76 l/s în 1983 și 59 l/s în 1984 (până în luna septembrie, când s-a înregistrat efectul închiderii tuturor sondelor din Oradea). Scăderea potențialului de debitare a sondelor de la Băi s-a resimțit începând cu cea de a doua jumătate a anului 1982, an în care acest potențial a scăzut dramatic: de la 255 l/s în februarie, la 186 l/s în august! Efectul s-a resimțit imediat: la Felix sonda 402 Cordău nu a mai debitat artezian, iar la Băile 1 Mai au încetat să debiteze – definitiv - izvoarele sublacustre din amonte de Ochiul Mare (Izvorul dintre Trestii, Ochiul Țiganului și Ochiul Pompei) și a încetat să debiteze artezian sonda Izbuc (care funcționa în regim artezian încă de la finele sec. XIX!). Trebuie precizat că această scădere a avut loc concomitent cu creșterea debitului de apă termală extras la Oradea (de la 35-40 l/s până în 1981, la 106 l/s în 1984). Din cauza exploatării abuzive și necontrolate prin sondele din zona Felix-1 Mai și a creșterii substanțiale a extracției la Oradea, în luna ianuarie 1983 a înghețat apa pe întreaga suprafață a Ochiului Mare, din cauza încetării debitării izvorului sublacustru (ceea ce nu s-a mai întâmplat în timp istoric și nici in timp geologic, lacul generat de izvoarele sublacustre funcționând ca o oază subtropicală pe perioada ultimei glaciațiuni). Remedierea acestor aspecte negative a impus măsuri ferme de reducere a volumelor extrase din cele două perimetre (măsuri propuse de organele locale și dispuse de Ministerul Geologiei în cadrul căruia funcționa atunci Inspecția Geologică, viitoarea Agenție Națională pentru Resurse Minerale!).

A fost primul semnal serios de alarmă privind riscul dispariției florei și faunei protejate în Rezervație și a reducerii debitelor în Băile 1 Mai. După anul 1990 această atenționare nu a fost luată în seamă de entitățile care aveau – prin lege – obligația de a veghea asupra corectei exploatări a zăcământului de ape termale: cei ce aveau licențe de exploatare nu urmăreau și nu raportau volumele extrase și nici nu asigurau o judicioasă utilizare a apei termale, iar cei puși să controleze buna, corecta și completa gospodărire a resursei geologice, nu impuneau ferm respectarea reglementărilor din domeniu, ba chiar avizau săparea de noi sonde într-un perimetru în care extracția depășise deja rata alimentării naturale. În plus, cei responsabili cu protejarea mediului înconjurător au uitat total că este vorba de o posibilă dispariție a unei rezervații naturale într-un sit de interes comunitar, inclus în rețeaua europeană Natura 2000.

Dezvoltarea explozivă a turismului balnear termal, materializată prin zecile de vile, pensiuni, hoteluri, acvaparcuri sau locuințe de lux, apărute în peisajul celor două stațiuni precum și a localităților limitrofe, după 1990, a crescut exponențial cererea de apă termală (nu doar pentru tratament sau balneație, ci și pentru

Figura 1. Nufărul termal (*Nymphaea lotus* var. *thermalis*) înainte de secarea lacului termal.

încălzire și apă caldă menajeră). Marea lor majoritate au săpat foraje având ca scop declarat alimentarea cu apă potabilă (care nu necesita obținerea licenței de la Agenția pentru Resurse Minerale, ci doar aprobarea Direcției Ape Crișuri Oradea și avizul Agenției pentru Protecția Mediului Bihor), dar adevăratul obiectiv era apa termală (care va fi găsită relativ ușor și la adâncimi mici, apoi exploatată fără nici un control și fără a plăti nimic Statului, proprietarul resursei!). Și sunt zeci de asemenea foraje ilegale în Sânmartin și în Haieu, Rontău, Cordău, precum și în cele două stațiuni, fără să mai punem la socoteală forajele executate fără nici o avizare.

Atenționările repetate, făcute începând cu anul 2011 de custodele Rezervației și de specialiști, nu au putut învinge setea de înavuțire a celor care – profitând atât de unele lacune legislative, cât, mai ales, de o condamnabilă lipsă de fermitate a organelor de avizare și control – au generat actuala stare de fapt: „azi” moare Rezervația, iar „mâine” vor muri stațiunile balneare Băile Felix și Băile 1 Mai!

În data de 13 decembrie 2011, Muzeul Țării Crișurilor, în calitate de custode, atenționează toți factorii responsabili de gestionarea zăcământului asupra opririi debitării izvorului natural sublacustru din Ochiul Mare (scafandrii înregistrând la nivelul izvorului o temperatură de doar patru grade Celsius!), ceea ce periclitează grav habitatul termal pentru care au fost create cele două arii naturale protejate și în primul rând supraviețuirea speciilor endemice de floră și faună, și solicită ANRM să ia „măsuri urgente pentru a reglementa exploatarea zăcământului geotermal din arealul Băilor 1 Mai".

Deși lacul îngheață din nou, în februarie 2012, iar pe pârâul Peța – aval de Ochiul Mare - nu mai curge apă termală (decât ceea ce se deversează din bazele de tratament ale celor două hoteluri și a Spitalului de recuperare pentru copii), organele locale se mulțumesc cu măsuri paleative (întâlniri, analize, planuri de măsuri și constituiri de comisii), în schimb Agenția Națională pentru Resurse Minerale, care are responsabilitatea legală a exploatării corecte a acviferului termal de la Băile Felix-1 Mai (de modul în care este gestionată resursa depinzând existența unicului habitat acvatic termal protejat din Europa), a acordat în anul 2013 două noi licențe de explorare – exploatare (în Felix, în zona Aquapark President și în 1 Mai, la hotel Flora), forajele săpate intrând imediat în exploatare (cu debite ce depășeau 10 l/s) și de atunci debitează! Referitor la protejarea Rezervației și a sitului Natura 2000 ROSCI0098, ANRM nu a întreprins nici o acțiune concretă, mulțumindu-se să justifice la toate întâlnirile oficiale că secarea izvoarelor de la 1 Mai și scăderea nivelului apei în Ochiul Mare (inclusiv înghețarea acestuia) se datorează „schimbărilor climatice și secetei"!

S-a ajuns astfel, în ultimii șase ani, la o situație limită, în care chiar și puternicul izvor sublacustru din Rezervația de la Băile 1 Mai (care, acum 37 de ani, avea un debit minim de 136 l/s) să-și înceteze debitarea - la început temporar, iar în ultimii doi ani permanent - la fel ca izvoarele sublacustre din amonte (secate acum mai bine de 30 de ani). În plus, toate sondele din zona Felix-1 Mai nu mai produc artezian (exceptând unele perioade foarte scurte, când – la câteva sonde – nivelul piezometric ajunge la suprafață), ele fiind exploatate de ani buni în regim de pompaj. Astfel s-a ajuns la situatia redată pe Fig. 2. și Fig. 3.

Observatii privind studiul ANRM

Abia în luna august 2014 ANRM – la presiunea Custodelui, a Prefecturii Bihor, a Ministerului Mediului și a unei susținute campanii de presă – anunță autoritățile implicate că „a demararat procedurile de realizare a unui studiu denumit *Sistemul geotermal Oradea-Băile Felix-1 Mai și interdependența cu situl comunitar Natura 2000 ROSCI 0098 Lacul Pețea"*, contractat – prin încredințare directă – cu Facultatea de Geologie a Universității București și cu Asociația Hidro-

Figura 2. Lacul rezervației in trecut

Figura 3. Lacul rezervației in prezent

geologilor din România.

După contractarea *Studiului* și demararea lucrărilor, A.N.R.M. organizează în februarie 2015 o conferință de presă pentru prezentarea lui, dar – surpriză – acesta are titlul schimbat: *„Studiul hidrogeologic privind situația actuală a resurselor sistemului hidrogeotermal Oradea-Băile Felix- 1 Mai și posibilitatea de protejare a sitului Comunitar ROSCI 0098, Lacul Pețа”*. Se remarcă înlocuirea cuvântului *„interdependența”*, cu sintagma *„posibilitatea de protejare”*. Această schimbare de titlu s-a produs într-o perioadă în care – din cauza încetării debitării izvorului sublacustru – speciile de floră și faună protejată din Rezervație au dispărut odată cu dispariția habitatului lor termal, iar media lunară a nivelului apei din Ochiul Mare a scăzut de la -47 cm (în iulie 2014) la -184 cm (febr. 2015), lacul devenind o mică băltoacă cu un diametru de 8-10 m în care se pompa – pe un furtun de pompieri – apă termală de la un foraj din apropiere, al S.C.T. Felix (în perioadele în care folosințele acestuia – un hotel și un sanatoriu de copii – o permiteau). A devenit clar pentru orice persoană cât de cât avizată că *„interdependența*”, ca și *„posibilitatea de protejare”* erau termeni ce nu puteau fi aplicați unui obiectiv ce nu mai exista, întrucât Ochiul Mare (Lacul cu Nuferi) a dispărut – prin secarea izvorului sublacustru – la fel ca și Pârâul Pețа (dispărut și el în zona 1 Mai de mai bine de cinci ani!).

Activitatea din cadrul studiului a fost prezentată sub forma mai multor rapoarte intermediare (preliminare, de etapă și de monitorizare) și un raport final, prezentat în rezumat, toate publicate pe web-siteul Asociației Hidrogeologilor (AHGR), acolo unde s-a prevăzut dezbaterea publică a Programului de refacere a Rezervației și a sitului comunitar de la Băile 1 Mai, pentru a conștientiza la nivelul comunitații locale semnificația măsurilor propuse privind regimul de exploatare durabilă a resurselor hidrostructurii Oradea - Felix - 1Mai și legătura dintre regimul de exploatare a apelor geotermale și starea sitului comunitar ROSCI 0098, Lacul Pețа. Studiul, având ca obiectiv principal reabilitarea sitului comunitar, nu a fost supus dezbaterii publice, nici măcar prin afișarea lui pe situl Asociației. Din acest motiv cei care în trecut au participat la cercetarea acestor probleme (și au fost invitați inițial de președintele Asociației să conlucreze la elaborarea studiului, dar ulterior au fost „uitați”), se simt obligați să-și formuleze observațiile referitoare doar la un *Rezumat al studiului*. Presupunând că autorii au cuprins în acest rezumat cele mai importante concluzii ale cercetării, sperăm totuși să putem contribui la elucidarea și eliminarea unor greșeli, confuzii și interpretări eronate, care apar în acest material, după cum urmează :

- pag. 2: *„În zona Băile Felix - 1 Mai apele termale sunt exploatate din depozitele cretacic inferioare (acviferul cretacic) în timp ce la Oradea din calcarele și dolomitele triasic inferioare (acviferul triasic), depozite atribuite structural Unității de Bihor.”*

Acviferul termal de la Oradea este cantonat în roci de vârstă triasic mediu.

- pag. 2: *„În ultima perioadă, în zona Livada (sud-vest Oradea) au fost puse în evidență și zone productive din cadrul colectorului cretacic (sonda 1720*).”

Sonda 1720 este la Sântandrei, la limita vestică a perimetrului geotermal Oradea, sondă care, din cauza dificultăților tehnice din timpul forajului, nu are finalizate probele, deci nu s-a putut preciza formațiunea colectoare.

- pag. 4: *„Față de gradul de cunoaștere anterior, monitorizarea sistemului Aleșd – Oradea - Băile Felix - 1 Mai efectuată de către AHGR în perioada septembrie 2014 - noiembrie 2016 pune în discuție o componentă nouă, importantă, prin care se presupune alimentarea sistemului de-a lungul unei falii (sau sistem de falii) cu caracter regional, cunoscut sub numele de falia Galbenei (Orășeanu 2015, 2016). Conform acestei ipoteze, sistemul de falii canalizează pierderile de debit întâlnite pe limita vestică a Munților Apuseni de Nord și le directionează spre colectorul cretacic din zona Băile Felix-1Mai și în continuare către colectorul cretacic din zona Oradea."*

Această nouă componentă „presupune" o altă direcție de realimentare, în timp ce ipoteza anterioară a fost GRYHGLWă de rezultatele complexelor cercetări geologice, hidrogeologice, chimice și izotopice, a urmăririi exploatării multianuale a sistemului, precum și de un test de interferență special, de 28 zile. Unul din autorii *Studiului* care a fundamentat prin cercetările sale – desfășurate pe aproape 40 de ani – ipoteza anterioară, optează acum pentru o nouă direcție de alimentare, fără ca elemente noi, semnificative să fi apărut față de cele pe care le-a avut în vedere anterior, inclusiv la elaborarea articolului din anul 2010.

Noua ipoteză de realimentare poate părea interesantă (dacă nu chiar spectaculoasă), dar este nefundamentată geologic, geofizic sau hidrogeologic. Această variantă de realimentare nu are antecedente – nici măcar la nivelul unor presupuneri – în publicațiile și documentațiile celor care au lucrat în zonă. Este o noutate, aparută cu ocazia acestui studiu. Din *Rezumat* nu reiese în ce măsură a contribuit monitorizarea la formularea ipotezei. Verosimilitatea ipotezei nu a fost însă verificată în cadrul studiului, nici măcar prin câteva analize chimice sau izotopice. Se pare că reprezintă o tentativă de satisfacere a cerințelor ANRM-ului (care refuză să vadă ceea ce este evident: supra-exploatarea este cauza declinului hidrodinamic din zona Băilor și a sfârșitului Rezervației și a sitului comunitar ROSCI 0098 Lacul Pețea).

Precizăm că pierderile de debit despre care se face referire, au avut, sau au loc, nu pe limita vestică a Apusenilor de Nord, ci, eventual, în interiorul lor. În plus, cum pot fi omise rezultatele forajelor săpate în estul zonei Felix-1 Mai, toate fără aflux de apă termală și cu un flux geotermic normal? Sau cum va putea fi justificată „prelungirea" forțată a sistemului de falii Galbena ca „să ajungă" până la Băile Felix și Băile 1 Mai (și, de acolo, la Oradea și chiar Sântandrei)? Sau cum acest gigantic „dren" a funcționat în partea finală a Cuaternarului fără să lase urme, sau care este relația acestuia cu perimetrul hidrogeotermal Beiuș, în care – de o bună bucată de timp se extrag anual, din zăcământ, peste jumătate de milion de metri cubi de apă geotermală? Sperăm că forajul structural de cercetare geologică 4008 Cotiglet, săpat în anul 1967 (și care nu a avut ca obiectiv o investigație hidrogeologică) nu va fi adus ca argument în justificarea prelungirii – pe hârtie – a faliei Galbena!

- pag. 4: *„Rețeaua de monitorizare instalată în zonele Oradea și Băile Felix - 1Mai în perioada septembrie 2014 - noiembrie 2016 a inclus:”*

Atât tematica *Studiului*, cât și scopul monitorizării se referea la sistemul Oradea - Băile Felix-1Mai (în rezumat mai apare și formularea „sistemul Aleșd - Oradea - Băile Felix - 1 Mai). In ciuda acestui fapt doar o singură sondă din Oradea – și aceasta incomplet probată și nepusă niciodată în producție – a fost monitorizată, deci nu se cunoaște evoluția nivelelor acestui acvifer. Chiar și această singură sondă (1730 Cihei) este problematică din cauza dificultăților tehnice întâmpinate la săparea și probarea ei și a faptului că nu se cunoaște exact nici formațiunea productivă. Întrucât sondele din Băi funcționează practic permanent (după cum subliniază și rezumatul), senzorii instalați în sursele din Băi – cu o singură excepție – nu au putut înregistra decât nivelul dinamic. Monitorizarea sistemului Oradea – Băile Felix - 1 Mai era deci unilaterală, insuficientă și inexactă pentru formularea unor decizii hotărâtoare pentru soarta Rezervației.

În Raportul de etapa din 30 martie 2015, la pag. 12 remarcăm următoarea observație care confirmă ineficiența/inutilitatea monitorizării în stabilirea nivelului hidrostatic general al zonei Băilor: *„Vă rugăm de asemenea să analizați posibilitatea opririi pentru 1-3 zile a tuturor forajelor din zona Felix-1Mai pentru identificarea unui nivel pe cât posibil hidrostatic, care să poată fi considerat de referință în interpretarea viitoare a datelor în cadrul studiului aflat în derulare”.* Trebuie subliniat că oprirea tuturor forajelor nu a avut loc și deci modelările făcute nu dispuneau de nivelul static actual al acviferului cretacic. În privința ariei din Bazinul Borodului (zona Aleșd) nu s-au făcut nici monitorizări de nivel, nici analize chimice sau izotopice.

- pag. 4: *„Înregistrarile efectuate în forajele Afrodita și FP3 (Ștrandul cu valuri), sunt foarte sugestive pentru ilustrarea dinamicii suprafeței piezometrice a acviferului. În perioada de observații, octombrie 2014 - noiembrie 2016, suprafața piezometrică a acviferului termal a prezentat o evoluție verticală ondulatorie, cu o amplitudine maximă de cca 2,5 m. În general, cotele maxime apar în perioadele mai - iunie, iar cele minime în decembrie - ianuarie, poziția lor fiind însă regizată de extinderea ciclurilor hidrologice (Figura 4).”*

Nivelul măsurat în forajul Afrodita (nota bene: forajul FP3 nu apare pe diagramă) reflectă variațiile suprafeței piezometrice a acviferului în regim dinamic.

În acest fel poziția minimelor - maximelor nu este rezultatul ciclurilor hidrologice, ci reflectă, în mod direct, doar debitul și durata extragerii din diverse alte surse. Minimele observate în perioada noiembrie/decembrie - ianuarie/februarie sunt consecințele exploatării masive a sondelor clandestine din zona Sânmartin - Felix - 1 Mai, precum și a celor din Oradea, utilizate la încălzirea locuințelor.

Este foarte ilustrativ în acest sens fig. 4 din „Raportul de etapă 30 sept. 2015”, precum și fig. 8 a rezumatului (care cuprinde întreaga perioadă a monitorizării). Aceste diagrame prezintă oscilațiile nivelului piezometric din zona izvorului sublacustru, în comparație cu debitul total de apă termală extras din ambele acvifere. Evoluția antagonistă a nivelului piezometric din sonda neutilizată Afrodita și a debitului cumulat extras este un indiciu al unității hidraulice dintre cele două acvifere. Menționăm că la valoarile debitelor cumulate există diferențe între cele doua diagrame, în perioada 15.03.2015 - 30.05.2015 (diagramele fiind destul de greu interpretabile).

În cap. 5 al *Raportului* este descrisă metodica practicată pentru urmărirea efectului exploatării sondelor din Oradea asupra acviferului de la Băi: *„Pentru a ține cont de modul în care exploatarea sondelor Transgex (Oradea) influențează comportamentul hidrodinamic din zona Felix - 1Mai, evoluția debitelor extrase din aceste sonde a fost decalată cu un interval de 30 zile conform cu rezultatele testului de interferență din 1985”.* Atragem atenția asupra faptului că această decalare cu 30 zile nu este corectă, deoarece în cadrul testului efectuat între 27 aug. - 24 sept. 1984 (și nu 1985!) efectul redeschiderii sondelor din Oradea s-a resimtit la Băi aproape instantaneu (evident în special în zona izvoarelor de la 1 Mai și a sondei 402 Cordău), iar efectul sistării extracției de la Oradea s-a resimțit mult mai lent, abia dupa 20-25 zile, cum era de așteptat, pentru umplerea rețelei de fisuri.

Dacă modificăm în acest sens fig. 4 din *Raportul de etapă* și fig. 8, a rezumatului, este și mai evidentă influența exploatării din Oradea.

Este semnificativ că în același raport de etapă, 30 sept. 2015, se subliniază următoarele: *„Considerăm că această scădere a nivelului apei din lac nu poate fi explicată decât printr-o intensificare a exploatării debitelor exclusiv din forajele fără licență chiar dacă debitele de exploatare din zona Felix - 1Mai au depășit cu circa 25 l/s debitele recomandate, deoarece depășirea menționată a fost în mare parte compensată de scăderea de debit din zona Oradea pe perioada sezonului cald.”* Adică doar cu un an înainte de finalizarea studiului autorii subliniau și menționau mai multe indicații (nivel, debit, izotopi) ale legăturii hidraulice dintre cele două acvifere termale, ca – la final – să se dezică, fără nici o argumentare plauzibilă.

Deși este prezentată această diagramă comparativă din fig. 8, nici măcar nu s-a încercat o interpretare a evoluției parametrilor prezentați, a legăturii dintre debitele exploatate și oscilațiile nivelului piezometric. Având acces la debitele extrase, atât la Oradea, cât și la Felix, se putea efectua o analiză și mai detaliată a legăturilor hidraulice dintre cele doua acvifere, fapt care – în schimb – ar fi scos în evidență supra-exploatarea prin depășirea cantităților exploatabile – motiv pentru care a fost omisă!

- pag. 4: *„Pentru refacerea habitatului natural din Rezervația RO-SCI 0098 Lacul Pețа este necesar ca nivelul apei din lac să fie în permanență mai mare (sau egal) decât cota de 156 mMN."*

Cota recomandată de 156 mMN reprezintă nivelul obișnuit al apei din lac înainte de declanșarea perturbațiilor. Nu este însă necesară pentru repornirea izvorului, al cărui debit este cu atât mai scăzut, cu cât este mai mare înălțimea coloanei de apă de deasupra. De fapt cota de 156 mMN este înălțimea impusă de stăvilarul de pe pârâul Pețа (când acesta curgea!) și nu are nici o legătură cu funcționarea izvorului. Trebuie subliniat că acest nivel nu a fost atins în cele 790 de zile cât a durat realizarea studiului (cu excepția perioadei 22-26 febr.2016, când – datorită topirii zăpezii – nivelul apei în lac a crescut cu 20 cm peste cota de 156 mMN, apa având temperatura de doar 10 grade!).

- pag. 6: *„Oscilațiile nivelului apei lacului Ochiul Mare, reflectă în mare oscilațiile nivelului acviferului termal la care este conectat printr-o fisură/gol carstic continuată spre suprafață cu o discontinuitate a depozitelor pliocen-cuaternare colmatată cu detritus permeabil."*

Încă nu s-au executat cercetări speciale în vederea precizării structurii și morfologiei izvorului sublacustru, a legăturii hidraulice dintre izvor și acvifer, deci întreaga frază este o variantă presupusă.

- pag. 7: „Figura 5. Evoluția de ansamblu a NP în perioada septembrie 2014 – noiembrie 2016."

Diagrama, care ar trebui să vizualizeze rezultatele celor 2 ani de monitorizare, este practic neinterpretabilă, din cauza dimensiunii și slabei rezoluții. Este păcat că *Rezumatul* destinat publicului prezintă rezultatul măsurătorilor executate timp de peste doi ani într-o asemenea manieră.

- pag. 7: *„Conform cu datele izotopice, apele actualmente înmagazinate în colectorul cretacic inferior (K1) provin din precipitații căzute la altitudini nu prea înalte, pe durata întregului an, în timp ce apele din colectorul triasic (T2) par a fi formate la altitudine mai mare și într-un sezon mai rece al anului. Această observație pare să susțină ipoteza realimentarii din zone diferite a celor două acvifere."*

În *Raportul de etapă* 30 sept. 2015 (accesibil pe website-ul AHGR) se pot citi următoarele detalii: *„Interconexiunea hidrodinamică dintre acviferele ter-*

male Oradea și Băile Felix &1 Mai dovedită prin testele de interferență efectuate în 1979 și 1984, au demonstrat că acestea, deși sunt cantonate în formațiuni de vârste diferite (Triasic și respectiv Cretacic inferior) și sunt situate la complet alte intervale de adâncimi (2.300-3.000 m și respectiv 50-300 m) formează un sistem hidrodinamic unic, iar 3H și 14C au dovedit că sistemul este deschis, existând chiar o componentă de realimentare recentă a acviferului K1. Conform elementelor prezentate mai sus (piezometrice, izotopice și hidrochimice) credem că ar putea fi luată în considerație – cel puțin pentru blocul tectonic pe care-l reprezintă scufundarea Giriș-Oradea – ipoteza unei direcții de curgere NW-SE prin acviferul triasic. În acestă viziune, direcția de curgere E-W și zona de alimentare din M-ții Pădurea Craiului ramâne probabil componenta principală a blocului Felix - 1Mai. Ambele acvifere se intercondiționează hidrodinamic și își descarcă apele prin zona Băilor Felix - 1 Mai.”

Afirmația citată din *Rezumat* este în contradicție inexplicabilă cu această formulare clară din 2015.

Rezumatul (probabil și studiul) rămâne dator cu explicarea neglijării determinărilor de vârstă absolută a apelor din cele două acvifere. De asemenea lipsesc referirile la posibilitățile de fracționare izotopică pe parcursul îndelungat de realimentare și influențele trecerii într-un regim termic ridicat, precum și posibilitățile și efectul probabil al unor amestecuri în subteran a apelor din diverse colectoare.

- pag. 7: *„Prezența radioizotopului tritiu s-a decelat local numai în acviferul K1 (zona Băile Felix - 1 Mai), în zona Oradea (acviferul T2) lipsind total. Aceasta demonstrează faptul ca apele din K1 au legaturi de realimentare cu apa recentă.”*

Afirmația nu este fundamentată de rezultatele concrete ale măsurătorilor de tritiu, și nu este precizată nici măcar calitativ măsura (slabă, moderată, acccentuată) legăturii cu apele recente. O asemenea afirmație ar trebui susținută de un număr suficient de mare de determinări cel putin de tritiu, atât din ape termale, cât și din precipitațiile recente. Concluzia finală și cea mai importantă din *Rezumat*, formulată pe pag. 12 (*„În situația actuală a perimetrului Băile Felix-1Mai variațiile climatice reprezintă factorul cel mai important care intervine în reglarea debitelor de exploatare astfel încât să se asigure nivelul apei în lacul Ochiul Mare la cota de deversare.”)* nu poate fi acceptată fără o urmărire îndelungată a evoluției conținutului în tritiu.

- pag. 7: *„Datele izotopice și hidrochimice au permis elaborarea unei variante noi de model conceptual care va fi integrat în modelul hidrodinamic și geotermic aflat în faza de construcție dar care nu poate fi finalizat fără repetarea testului de interferență dintre cele două perimetre.”*

Care este esența acestui nou model conceptual, și – având în vedere scopul comandării studiului (salvarea urgentă a Rezervației) – de ce nu s-a finalizat modelul în 2 ani? Testul de interferență executat în anul 1984 nu poate fi „repetat" din următoarele motive:

a. Utilizarea apelor termale în Oradea, ca agent termic pentru încălzire și preparare ACM a devenit atât de extinsă încât sondele din Oradea nu mai pot fi închise timp de 28 de zile.

b. În urma supraexploatării multianuale – atât la Oradea, cât și la Băi – condițiile hidraulice s-au schimbat atât de radical, încât rezultatele unui nou test nu vor fi comparabile cu cele din trecut.

- pag. 10: *„În acest moment rezerva exploatabilă în zona Băile Felix – 1 Mai, în condițiile unei funcționări continue a izvorului submers din cadrul sitului Natura 2000, este strict dependentă de condițiile climatice respectiv de nivelul precipitațiilor din anii anteriori (probabil 1-3 ani) și din anul în curs. Durata redusă a perioadei de monitorizare nu permite încă o extrapolare coerentă a acestor observații pe termen mediu și lung."*

Considerăm că această afirmație nu are nici un suport, în schimb va avea efecte grave asupra posibilităților de reabilitare a habitatelor naturale.

Dacă ar fi așa, temperatura, chimismul și compoziția izotopică (tritiu) ar trebui să oscileze haotic, în funcție de precipitații. Faptul că in primăvara anului 2016, dupa câteva ploi intense, izvorul a repornit pentru o scurtă perioadă nu se datora precipitațiilor, ci reducerii/terminării sezonului de încălzire. Tot așa a repornit izvorul și în 2015, fără să fie precipitații, dar acest fenomen de fapt se întâmplă cu regularitate anuală. Perioadele secetoase nu puteau și nu pot cauza secarea izvoarelor termale (și cele ploioase nu pot determina revenirea lor), pentru că au fost suficient de multe secete și în deceniile și secolele trecute, dar ecosistemul a rămas intact, lacul Ochiul Mare nu a rămas nicicând fără apă termală din lipsa precipitațiilor. Numai în timpul ce s-a scurs de la înfiintarea Rezervației în 1932 au fost 9 perioade de secetă extremă, totuși prima secare a izvoarelor Rezervației a apărut după ce debitul cumulat extras la Felix-1 Mai și la Oradea a trecut peste o anumită limită.

- pag. 11: În cadrul recomandărilor: *„Micșorarea diferenței dintre valorile de debit din perioadele de maxim și minim, păstrând însă nivelul mediu de exploatare impus."*

Licențele de exploatare emise pe baza documentației din 1985 au prescris că sondele din Oradea nu pot fi exploatate decit cu maxim 90 l/s în regim eruptiv, fără reinjectare. De o vreme această cifră a început să fie interpretată greșit, ca debitul mediu anual exploatabil. La fel de greșit se interpretează și se impune de către A.N.R.M. și debitul exploatabil din sondele de la Băi: nu 207 l/s debit maxim, ci mediu anual! Autorii *Studiului* probabil au avut acces la documentațiile care au stat la baza stabilirii acestei valori limită a debitelor exploatabile fără aplicarea reinjectării. Totusi, în *Rezumat* nu se atrage atenția asupra consecințelor nefaste ale acestei interpretări greșite, și se prezintă valorile medii anuale exploatate de Transgex la Oradea și de SCT Felix și licențiații particulari la Băi, recomandând doar reducerea valorilor – ceea ce va continua să accentueze declinul acviferului termal de la Băi.

Concluzii

De câțiva ani Lacul Ochiul Mare și Pârâul Peța sunt lipsite de speciile endemice pentru ocrotirea cărora a fost înființată Rezervația (care a devenit apoi și sit Natura 2000), prin încetarea debitării izvoarelor sublacustre. Ne mai existând habitatul acvatic termal care le-a protejat, aceste specii au fost „exilate” în acvarii din țară și din străinătate, dar – din păcate – menținerea în viață și reproducerea melcului termal *(Melanopsis pareyssi)* a eșuat, specia dispărând definitiv. Nu se știe cât timp vor rezista, în exil, celelalte două rarități – nufărul termal și roșioara lui Racoviță – pentru a căror salvare se fac eforturi disperate, dar nici în urma *Studiului* (de la a cărui încheiere a trecut deja un an!) și nici în urma măsurilor luate de A.N.R.M. nu sunt speranțe pentru refacerea habitatului. Practic, Rezervația se dorește a fi desființată – ceea ce ar putea avea consecințe nedorite și din partea Uniunii Europene. Continuarea exploatării necontrolate a resurselor de apă termală din zona Băilor Felix și 1 Mai, precum și întârzierea generalizării reinjecției pe Oradea vor duce – mai devreme sau mai târziu – la dispariția stațiunilor termale Băile Felix și Băile 1 Mai, așa cum – din păcate - a dispărut și Rezervația cu situl său comunitar cu tot!

Faptul că *Studiul*, care avea ca obiectiv *„posibilitățile de protejare a sitului comunitar...”* nu menționează nicăieri că izvorul sublacustru nu a funcționat în mare parte din perioada elaborării lui (iar când a debitat nu a putut asigura nivelul de apă necesar supraviețuirii speciilor protejate) și faptul că principala concluzie este că: *„rezerva exploatabilă…este strict dependentă de condițiile climatice, respectiv de nivelul precipitațiilor din anii anteriori (probabil 1-3 ani) și din anul în curs”*, repetată și în fraza de încheiere a lucrării („În situația actuală a perimetrului Băile Felix-1 Mai variațiile climatice reprezintă factorul cel mai important care intervine în reglarea debitelor de exploatare astfel încât să se asigure nivelul apei în lacul Ochiul Mare la cota de deversare”), ne întărește convingerea că acest studiu, finanțat din bani de la bugetul de stat, a avut menirea să se constitue într-o „umbrelă” care să exonereze ANRM-ul de vina de a fi „groparul” Rezervației, studiul putând fi considerat un Recviem la slujba de înmormântare a lotusului termal și a celorlalte specii endemice.

Bibliografie

Asociația Hidrogeologilor din România, 2014. - raport preliminar privind stadiul lucrarilor la 24 Octombrie 2014. *Web-sit-ul Asociației Hidrogeologilor din România*

Asociația Hidrogeologilor din România, 2014. - Raport Preliminar privind stadiul lucrarilor la data de 20 Decembrie 2014. *Web-sit-ul Asociației Hidrogeologilor din România*

Asociația Hidrogeologilor din România, 2015. - Raport Preliminar privind stadiul lucrarilor la data de 31 Martie 2015. *Web-sit-ul Asociației Hidrogeologilor din România*

Asociația Hidrogeologilor din România, 2015. - Raport de etapa 30 Septembrie 2015. *Web-sit-ul Asociației Hidrogeologilor din România*

Asociația Hidrogeologilor din România, 2016. - Raport asupra monitorizarii dinamicii acviferului termal din zona lacului Ochiul Mare (zona Felix-1 Mai) perioada septembrie 2014 - februarie 2016. *Web-sit-ul Asociației Hidrogeologilor din România*

Asociația Hidrogeologilor din România, 2017. - Studiu hidrogeologic privind situația actuală a resurselor sistemului geotermal Oradea – Băile Felix-1 Mai și posibilitățile de protejare a sitului comunitar ROSCI 0098, Lacul Pețа, RAPORT FINAL Rezumat). *Web-sit-ul Asociației Hidrogeologilor din România*

Asociația Hidrogeologilor din România, 2017. - Raport Preliminar privind stadiul lucrarilor la data de 31 Martie 2016. *Web-sit-ul Asociației Hidrogeologilor din România*

Cohut, I., Paál, G. (1985) - Studiul legăturilor hidrodinamice dintre ariile geotermale Oradea si Felix*. Arhiva Intreprinderii de Foraj și Lucrări Geologice Speciale I.F.L.G.S.,* București 81p.

Cohut, I., Paál, G., Plăviță, R. 1986. - Studiul privind posibilitatile de exploatare industriala a perimetrului hidrogeotermal Oradea, cu calculul rezervelor de caldura la data de 1 ian. 1986. - Raport. Arhiva Institutului de Geologie si Geofizica Bucuresti.

Orăşeanu, I. 2015. - Groundwater dynamics of Beiuş Basin basement and its surrounding mountain areas. *Nymphaea*, **42**: 5-18.

Țenu, A. 1975. - Cercetari hidrogeologice complexe asupra apelor termale din zona Băilor Felix si 1 Mai. - *Studii de hidrogeologie-I.M.H.*75-133, Bucuresti.

Țenu, A. 1981. - Zacaminte de ape hipertermale din nord-vestul Romaniei. Editura Academiei, Bucuresti, 208 p.

Țenu, A., Diaconu, M. 2010. - Thermal Aquifers in Mesozoic Karstified Limestones from Oradea-Băile Felix & 1 Mai Area, Western Romania*. Karst Hydrogeology of Romania,* 444 p.

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In Memoriam Tiberiu Jurcsák (1926-1992)

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Abstract. The Romanian paleontologist Tiberiu Jurcsák had a primary interest in vertebrate paleontology. He worked for the Țării Crișurilor Museum, Oradea, Romania, for almost four decades, being the founder of the museum's Department of Natural Sciences. His outstanding knowledge of osteology led Jurcsák into a variety of groups of fossil vertebrates, including Plio-Pleistocene mammals, Cretaceous dinosaurs and pterosaurs or Triassic marine vertebrates. Tiberiu Jurcsák dedicated his life to vertebrate paleontology, but he also did a great job in museology and nature conservation. He passed away 25 years ago, leaving behind a huge number of vertebrate specimens in the collections of the Natural Sciences Department of Țării Crișurilor Museum, Oradea, which still are subject of work for many paleontologists from Romania and abroad.

Introduction

Tiberiu Jurcsák was a Romanian paleontologist, with a primary interest in vertebrate paleontology, who worked for the Țării Crișurilor Museum for almost four decades. I first met him in 1978, when my aunt, Emilia Tallódi, took me to the museum with some strange bones in her pocket, which have been found by two miners in the bauxite Lens 204-Cornet, Bihor County. Tiberiu Jurcsák knew at first glance the importance of the discovery, dinosaur bones in bauxite being really uncommon. Since then, I had the chance to visit the museum's collections and to follow his work as a student and latter as a geologist. The more I got closer, the more I discovered his restless efforts in collecting, preparing and identifying vertebrates from Triassic to Pleistocene deposits of North Western Romania. His passion for fossils and collections determined my professional life, as I had the chance to continue Jurcsák's work in the field of Mesozoic vertebrates at the museum in Oradea.

In the following biographical notes I used the museum's archive, especially Jurcsák's fieldbooks, containing interesting unpublished information and data.

Abbreviation: MTCO – Ţării Crişurilor Museum, Oradea.

Biography

Vertebrate paleontology

There are only a few papers dealing with T. Jurcsák's biography (Dumitrascu & Paina 1986, Paina 1996), and the most extensive is the one written by F. Wanek (2013) in Hungarian, however Jurcsák's work is poorly known today.

Born on 29th December 1926 in Olcea, Bihor County, Romania, Jurcsák attended elementary school first in Oradea, then in Bucharest and graduated highschool at Emanuil Gojdu College Oradea in 1947 (Paina 1996).

Finding work at the museum in Oradea in 1951, Tiberiu Jurcsák rapidly developed an interest in vertebrate paleontology (Fig. 1). His first job was to organize the paleontological and the ornithological collections, managing to set up in 1952 the Department of Natural Sciences of the Ţării Crişurilor Museum (Wanek 2013).

Surprisingly Jurcsák's initial studies had nothing to do with fossil vertebrates, thus in order to get skills in paleontology he graduated the Faculty of Biology and Geography – University Babes-Bolyai Cluj in 1957.

The first decade of his work was oriented on the research of Quaternary vertebrate paleontology (Fig. 2), especially the study of Quaternary mammals from Betfia, in collaboration with Elena Terzea from the "Institute of Speleology Emil Racoviță" București. He was involved in ornithological researches as well, helping ornithologists in their field activity, especially ringing birds. He prepared comparative osteological materials of mammals and birds, increasing the museum's osteological collection.

Jurcsák's interest in vertebrate paleontology led him to a joint project with the museums' archaeologists Ivan Ordentlich and Doina Ignat, collecting bones from archaeological sites. According to Jurcsák's fieldbooks, starting with 1968, he participated in the paleontological and archaeological researches of the caves

Figure 1. Tiberiu Jurcsák at work in the Paleolab of Țării Crișurilor Museum

of Crișului Gorge at Vadu Crișului, which were coordinated by Doina Ignat. They regularly organized field campaigns there (1972, 1976, 1977), which resulted in a high number of vertebrate specimens of Pleistocene mammals, especially *Ursus spelaeus*, *Crocuta spelaea* and other cave mammals. An extensive excavation was held in 1976 in the Bear's Cave at Chișcău, where T. Jurcsák worked with Elisabeta Popa on the inventory of in situ skeletal remains and hibernation dens of *Ursus spelaeus*, and he also identified almost 40 mammal taxa during the excavation campaign.

During the years 1972-1975 he excavated and studied proboscidean remains from the late Miocene and Pliocene deposits at Huta, Derșida, Dijir and Pleistocene deposits from Oradea. The most important excavation for proboscidean fossils was the one held in 1972 in Oradea, at the Beer Factory. Jurcsák extracted an almost entire skeleton of *Mammuthus primigenius*, using remarkable field techniques for that time (Fig. 3).

Figure 2. Excavations at the Beer Factory in Oradea (1972) led by Tiberiu Jurcsák.

T. Jurcsák begun an ambitious project on the study of Triassic marine vertebrate assemblages from Peștiș (October 1969) and Lugașu de Sus (1974), from where he described two new species: a Nothosaurid from Peștiș, namely *Nothosaurus transsylvanicus* Jurcsak, 1976, based on a skull fragment (MTCO 7653), formerly identified by Jurcsák as *Nothosaurus* cf. *procerus,* and *Tanystropheus biharicus* Jurcsak, 1975 from Lugasu de Sus, based on a cervical vertebra (MTCO 8988).

Jurcsák met Ruppert Wild, the famous German paleontologist who worked on Triassic vertebrate fauna. They developed a professional bond, which endured several years. R. Wild visited the Triassic collections in the Țării Crișurilor Museum Oradea and participated with T. Jurcsák to the fieldworks at Lugasu de Sus in 1977. T. Jurcsák continued his research on the Triassic fauna until 1978, when a new fossil site has been discovered in the Lower Cretaceous bauxite Lens 204-Cornet.

The last decade of his work was focused on the Early Cretaceous fauna from the bauxite Lens 204-Cornet. T. Jurcsák and Elisabeta Popa extracted tons of bauxite with bone fragments, working in extremely difficult conditions, assisted by

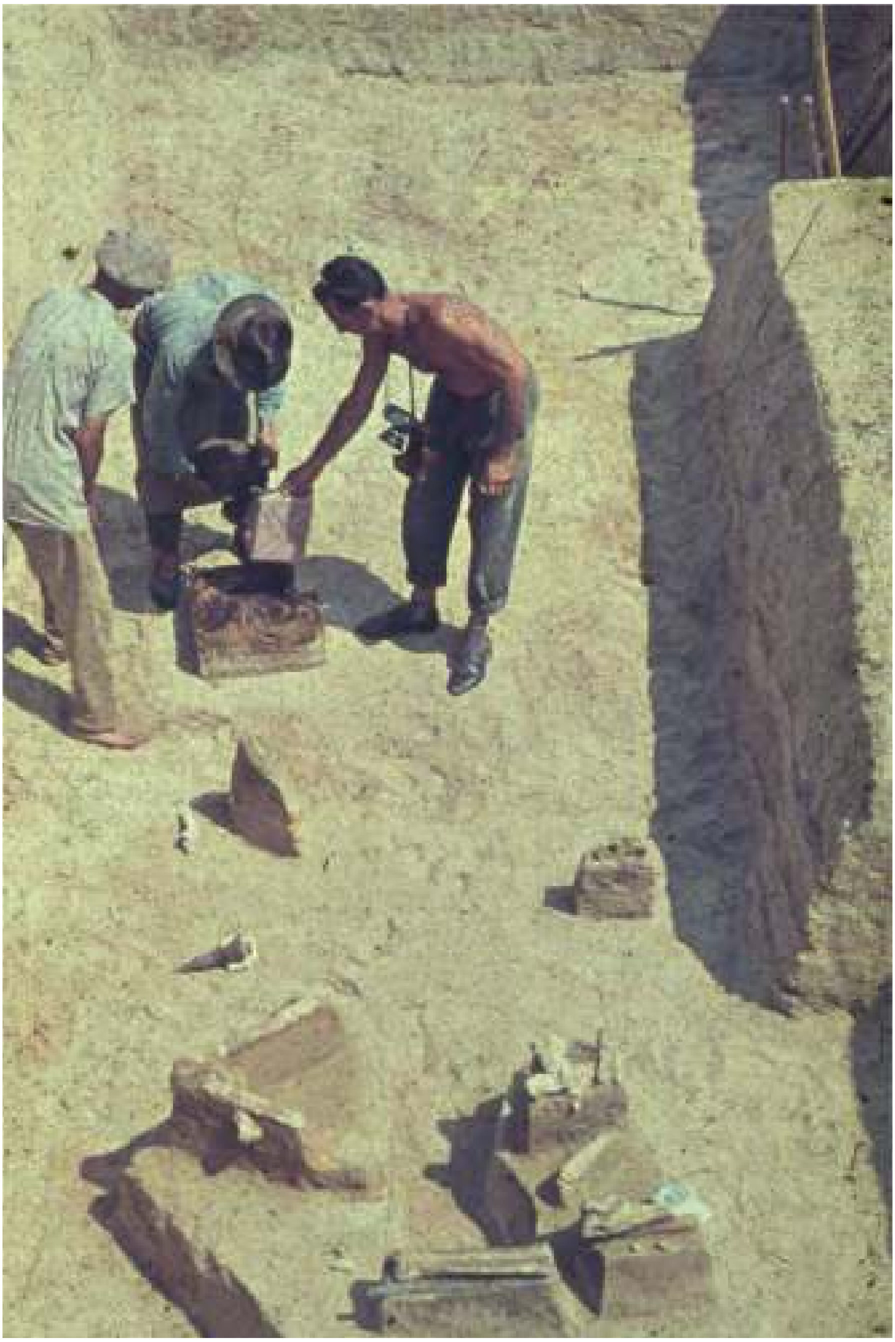

Figure 2. Excavations at the Beer Factory in Oradea (1972) led by Tiberiu Jurcsák.

miners. Preparation of vertebrate fossils was done by E. Popa, who was Jurcsák's main assistant. Jurcsák dedicated his last years to the study of the vertebrate fauna from Cornet, consisting of dinosaurs, pterosaurs and birds. He studied the Early Cretaceous bird fauna in collaboration with Eugen Kessler, with whom he has led several common paleo-ornithological researches over the previous years.

Museology

T. Jurcsák dedicated his life to the museum in Oradea, organizing its collections since 1951. He was the head of the Natural Science Department since 1952 until his retirement in 1988. The size and importance of the paleontological collections are linked to Jurcsák's name, due to his efforts in collecting paleontological material. He also had a key role between 1972-1975 in organizing the department's collections and storages (Jurcsák 1972).

He had a major contribution in the design and concept of the department's permanent exhibitions, first in 1973, when the official opening of the exhibitions in the Baroque Palace was held on 23rd June 1973. The second permanent exhibition was realized in 1983 also under the guidance of T. Jurcsák (Dumitrașcu & Paina 1986).

Nature conservation

T. Jurcsák had an important role in the conservation of protected areas in North-Western Romania. As member of the Comission of Nature's Monuments, Jurcsák proposed several paleontological sites and caves on the list of protected areas in 1975 and 1981. He was involved in educational as well as conservational actions in order to promote nature conservation or cave and wildlife protection.

Like many others of his generation in communist Romania, Tiberiu Jurcsák had to face the lack of information, the lack of communication with foreign scientists and the interdictions to leave the country in order to study paleontological collections. Even so, paleontologists from all over the world managed to send him publications and books. In the archive of the Țării Crișurilor Museum in Oradea all Jurcsák's correspondence is kept, which he carefully preserved. All the letters were typed and a copy was filed, attesting his gratitude and great respect for other paleontologists and their work. In the 80's he managed to travel to Tübingen and Mondbelliard, but at the previous international symposia he could not participate.

He passed away on 23rd January 1992, leaving behind a huge number of vertebrate specimens in the collections of the Natural Sciences Department - Țării Crișurilor Museum Oradea, which were subject of work for many paleontologists from Romania and abroad.

T. Jurcsák remains a remarkable figure in the history of Romanian natural sciences. In order to preserve his memory, a hall received his name in the former permanent exhibition of the Department of Natural Sciences of the Ţării Crişurilor Museum Oradea. In his honour a street in Oradea was named Jurcsák Tibor in 2010.

List of Jurcsák's publications in chronological order:

1. Terzea, Elena, Jurcsák, T. 1967 – Asupra unui nou punct fosilifer descoperit la Betfia. *Lucrările Institutului de Speologie "Emil Racoviţă"*, Bucureşti, VI, pp. 193–209.

2. Macarovici, N., Jurcsák, T. 1968 – Asupra unui *Hipparion* din Pliocenul de la Derşida (S Blaj). *Analele Stiintifice ale Universității „Al. I. Cuza", Iaşi*, (Sectiunea 11, b), Geologie-Geografie, 14: 101–104.

3. Terzea, Elena, Jurcsák, T. 1968 – Bemerkungen über die mittelpleistozänen Faunen von Betfia. *Ber.Geol.Ges.*DDR, 13, 3, pp. 381-391.

4. Jurcsák, T. 1969 – Contribuţii la cunoaşterea faunei malacologice de la Răbăgani (jud. Bihor). *Sesiunea de Comunicări Ştiinţifice a Muzeelor*, 1964, *Ştiinţele Naturii*, Bucureşti, pp. 37–39.

5. Jurcsák, T. 1969 – Minunea de la Izbuc (Booklet), Oradea.

6. Béczy, T., Poliș, Rozalia, Jurcsák, T. 1969 – Contribuții la cunoașterea avifaunei izvoarelor termale de la Băile 1 Mai și Pîrîul Pețea. *Sesiunea de Comunicări Științifice ale muzeelor, Științele naturii,* 1964 București, pp. 177–187.

7. Poliș, Rozalia, Béczy, T., Jurcsák T. 1969 – Fauna ornitologică a bălților de la Otomani. *Sesiunea de Comunicări Științifice ale Muzeelor*, Științele naturii, 1964. București, 155–161, 1 tab.

8. Terzea, Elena Jurcsák, T. 1969 – Contribuţii la cunoaşterea faunelor pleistocene medii de la Betfia (România). *Lucrările Institutului de Speologie "Emil Racoviţă"*, Bucureşti, VIII, pp. 201–214.

9. Jurcsák, T. 1970 – Date paleontologice privind vârsta teraselor şi a locurilor fosilifere din împrejurimile oraşului Oradea, Muzeul Ţării Crişurilor. *Caiet de comunicări*, 8, 10–41.

10. Fuhn, I.E., Jurcsák, T. 1972 – O ţestoasă nouă pentru fauna paleoherpetologică a României: *Testudo kalksburgensis,* Toula*,* 1896 (Dealul Viilor – Oradea). *Centenarul Muzeal Orădean*, Oradea, pp. 667–672.

11. Jurcsák, T. 1972 – Douăzeci de ani de activitate a secţiei de Ştiinţe Naturale din Muzeul Orădean. *Centenarul Muzeal Orădean*, Oradea, pp. 95–99.

12. Jurcsák, T. 1973. – Scheletul de mamut descoperit la Oradea. Comunicare la a *X-a Sesiune Ştiinţifică Jubiliară a Institutului Pedagogic din Oradea* Unpublished manuscript.

13. Jurcsák, T. 1973. – Date noi asupra reptilelor fosile de vârstă mezozoică din Transilvania. *Nymphaea*, I, Oradea, pp. 245–261.

14. Jurcsák, T. 1973. – *Deinotherium giganteum* Kaup din zăcămintele de bitum de la Derna (Bihor). *Nymphaea*, I, Oradea, pp. 301–311.

15. Jurcsák, T. 1973. – Răspândirea mastodonţilor la vest de Munţii Apuseni. *Nymphaea*, I, Oradea, pp. 313–341.

16. Jurcsák T., Kessler, E. 1973 – Cercetări paleornitologice din România. *Nymphaea*, I, Oradea, 263–300.

17. Dumitraşcu, S., Faur, V.I, Godea, I., Grigorescu, E., Hîrcă, R., Ignat-Sava, D., Jurcsák, T., Marinescu, I., Marossy, A., Mozes, T., Ordentlich, I., Poaina, Ion, Poliş, R., Sasu, E., Toth, S., Zintz, M, 1974 – *Repertoriul monumentelor din Judeţul Bihor*. – Oradea, 320–399.

18. Jurcsák, T. 1974 – Prezenţa lui *Gyps fulvus* Habl. în Cuaternarul României. *Nymphaea*, II, Oradea, pp. 169–184.

19. Jurcsák, T. 1974 – Deformaţii patologice pe un humerus de *Ursus spelaeus* Rosenm. Et Heinr. din Peştera Muierilor (Baia de Fier) în Oltenia. *Studii şi Comunicări*, Craiova, pp.11–15.

20. Jurcsák T., Godea, I. 1974 – Teascurile de struguri de la Carastelec. *Biharea*, Oradea, pp. 307–316.

21. Jurcsák, T., 1975. – *Tanystropheus biharicus* n.sp. (Reptilia, Squamata) o nouă specie pentru fauna triasică a României. *Nymphaea*, III, Oradea, pp. 45–52.

22. Jurcsák, T. 1975 – Reptile fosile din împrejurimile oraşului Aleşd, I, Oradea, (text dactilografiat). Unpublished manuscript, 98 pages

23. Terzea, Elena, Jurcsák, T. 1975 – Données nouvelles sur le *Machairodus* de Betfia - XIII (Bihor, Roumanie) et son age Géologique. *Trav. Inst. Speol. Emil Racoviţă*, Bucureşti, LXV, pp. 175–185.

24. Jurcsák, T. 1975 – *Capra ibex carpathorum* Koch, 1891 în colecția Muzeului Banatului. *Tibiscus*, *Seria Șt. Nat*., Timișoara, pp. 243–254.

25. Jurcsák, T., 1976. – Noi descoperiri de reptile în Triasicul de la Aleşd. *Nymphaea*, IV, Oradea, pp. 67–105.

26. Terzea, Elena, Jurcsák, T. 1976 – Faune de Mammiféres de Betfia-XIII (Bihor, Roumanie) et son âge géologique. *Trav. Inst. Speol. Emil Racoviţă*, XV, pp. 175–185.

27. Jurcsák,T., 1977 – Contribuţii noi privind placodontele şi sauropterygienii din Triasicul de la Aleşd (Bihor, Romania). *Nymphaea*, V, Oradea, pp. 5–30.

28. Jurcsák,T., 1977 – Asupra unui craniu de Capră (Ibex) *Ibex carpathorum* Koch, 1821 din Valea Carașului. *Tibiscus, Ştiinţe Naturale,* Timişoara, pp. 243–254.

29. Jurcsák,T. Popa, Elisabeta 1977 – *Anancus arvernensis* Croiz et Joob din Pliocenul de la Huta (Bihor, Romania). *Nymphaea*, V, Oradea, pp. 71–93.

30. Jurcsák, T., Popa, Elisabeta 1977 – Săpătura de salvare de la Huta (jud. Bihor). *Muzeul și educația socialistă*, Ed. Muzeul de Istorie al RSR, 1, 78–85, București.

31. Jurcsák, T. 1978. – Rezultate noi în studiul saurienilor fosili de la Aleşd. *Nymphaea*, VI., Oradea, pp. 15–60.

32. Jurcsák, T. Popa, E. 1978 – Resturi de dinozaurieni în bauxitele de la Cornet (Bihor). *Nymphaea*, VI, 61–64.

33. Terzea, Elena, Jurcsák, T. 1978 – Faunes des Mammifères de Betfia (Bihor, Roumanie). *Trav. Inst. Speol. Emil Racoviţă*, Bucureşti, LXIV, pp. 131–136.

34. Ignat, Doina, Jurcsák, T. 1979 – Cercetări arheologice şi paleontologice în Defileul Crişului Repede. *Crisia*, IX, Oradea, pp. 61–76.

35. Jurcsák, T. Popa E., 1979 – Dinozaurieni ornitopozi din bauxitele de la Cornet (Munții Pădurea Craiului). *Nymphaea*, VII, 37–75.

36. Jurcsák, T. 1980 – Reptile fosile din împrejurimile oraşului Aleşd, II, Oradea. Unpublished manuscript, 195 pages.

37. Jurcsák,T.,Poliş, Rozalia, Ignat, Doina, Şerban, M. Popa, Elisabeta 1980 – 1981 Date privind fauna fosilă a Peşterii Urşilor (Munţii Bihor). *Nymphaea*, VIII-IX, 161–257.

38. Jurcsák, T. Popa E., 1981 – Conservarea vestigiilor paleontologice în Peştera Urşilor de la Chişcău. *Cercetări de conservare şi restaurare a patrimoniului muzeal,* Naţionale de Istorie, Bucureşti, I, pp 201–204.

39. Jurcsák, T. 1982 – Occurences nouvelles des Sauriens Mesozoiques de Roumanie. *Vertebrata Hungarica*, 21, Budapest, pp. 175–184.

40. Jurcsák T Kessler, E. 1982 – La 150 de ani de la moartea marelui paleontolog Georges Cuvier. *Nymphaea*, X, 297–298.

41. Jurcsák, T., Rădulescu, C., Samson, P. 1982-1983 – Les mammifères du Wurm de la Dealul Burzău I. Rodentia. *Nymphaea,* X, Oradea, 151–170.

42. Jurcsák, T., 1983 – Răspândirea Proboscidienilor în Nord-vestul României. *Nymphaea*, X, Oradea, pp. 65–85.

43. Jurcsák, T., 1983 – *Archidiscodon meridionalis* (Nesti) din Villafranchianul de la Oradea. *Nymphaea*, X, Oradea, pp. 87–142.

44. Jurcsák, T. Moisi, N., 1983 – Conservarea şi restaurarea scheletului de mamut descoperit la Oradea. *Nymphaea*, X, 143–150.

45. Jurcsák, T. Popa E., 1983 – Reptile zburatoare în bauxitele de la Cornet, nota preliminara. *Nymphaea*, X, 7–15.

46. Jurcsák, T. Popa E., 1983 – La faune de dinosauriens du Bihor (Roumanie). In Buffetaut, E, Mazin, J.-M. and Salmon, E. (eds.), *Actes du Symposium paléontologique G. Cuvier, Montbéliard*. Ville de Montbéliard, Paris, 325-388.

47. Kessler, E., Jurcsák, T. 1984 – Fossil bird remains in the bauxite from Cornet (Pădurea Craiului Mountains - Romania). *75 Years Laboratory of Paleontology Special Volume. University of Bucharest*, 129–134.

48. Kessler, E., Jurcsák, T. 1984 – Fossil bird remains in the bauxite from Cornet (Romania, Bihor county). *Travaux du Muséum d'Histoire Naturelle Grigore Antipa*, 25, 393–401.

49. Jurcsák, T., 1984 – Obiecte de podoabă de origine sudică în aşezările de epoca bronzului de la Derşida (jud. Sălaj). *Acta Musei Porolissensis, Zalău, VIII,* 111-119, 7 fig.

50. Jurcsák, T., Popa, E., 1984 – Pterosaurians from the Cretaceous of Cornet, Roumania. In Reif, W.-E. and Westphal, F. (eds.), *Third symposium on Mesozoic terrestrial ecosystems, short papers*. Attempto, Tübingen, 117–118.

51. Jurcsák, T., Rădulescu, C., Samson, P. 1984 – Les mammiferes du Wurm de la Dealul Burzău II. Rodentia. *Nymphaea* extras din *Crisia,* XIV, Oradea, pp 534–538.

52. Jurcsák T., Kessler, E. 1985 – La paleofaune de Cornet – implications phylogénetique et ecologiques. *Evolution et Adaptation II (Cluj Napoca)*, 137–145.

53. Kessler, E., Jurcsák, T. 1986 – New contributions to the knowledge of Lower Cretaceous bird remains from Cornet (Romania). *Travaux du Muséum d'Histoire Naturelle Grigore Antipa*, 28, 289–295.

54. Jurcsák, T., Kessler, E. 1986 – Evolutia avifaunei pe teritorul României. I. *Nymphaea*, XVI, (extras din *Crisia*), pp. 577–615.

55. Jurcsák, T., Poliș, Rozalia. 1986 – O nouă expoziție de bază la Muzeul Țării Crișurilor, Revista muzeelor și monumentelor, VI. 23, 5–28, București.

56. Czier, Z, Jurcsák T., 1987 – Un craniu de elan (*Alces alces L.)* descoperit în Avenul lui Avrămuţ din Cheile Someşului Cald. *Nymphaea,* XVII, 611–625.

57. Huza R., Jurcsák T., Tallodi E., 1987 – Fauna de reptile triasice din Bihor. *Crisia*, XVII, 571–578, Oradea.

58. Jurcsák, T. 1987 – Triassic reptilian fauna from Bihor, Romania, *In* Currie, P. M. and Coster, E. H. (eds.). *Fourth Symposium on Mesozoic Terrestrial Ecosystems, Drumheller: Short Papers: Occasional Papers of the Royal Tyrell Museum of Palaeontology*., v. 3, pp. 125–128.

59. Jurcsák, T., Kessler, E. 1987 – Evolutia avifaunei pe territorul României. II. Morfologia speciilor fosile. *Nymphaea*, XVII, (extras din Crisia), pp. 583–609.

60. Jurcsák, T., Kessler, E. 1988 – Evolutia avifaunei pe territorul României. III. Filogenie și sistematică. *Nymphaea*, XVIII, (extras din Crisia), pp. 647–688.

61. Jurcsák, T., Lipai, G. 1988 – Aspecte din natura Judeţului Bihor. Aspects of the Nature Bihor county, C.C.E.S., Complexul muzeal judeţean Bihor (ghid).

62. Huza R., Jurcsák T.,1988 – Un dinte de placodont din Triasicul superior, descoperit din zona Finiş (Munţii Codru, judeţul Bihor), *Nymphaea*, extras din Crisia, XVII, 639-–646, Oradea.

63. Jurcsák, T., Kessler, E. 1991 – The Lower Cretaceous paleofauna from Cornet, Bihor County, Romania. *Nymphaea*, XXI, 5–32.

References

Dumitrașcu, S., Paina, M. 1986 – Jurcsák Tiberiu, *Crisia* XVI: 681–685.

Jurcsák, T. 1972 – Douăzeci de ani de activitate a secţiei de Ştiinţe Naturale din Muzeul Orădean, în *Centenarul Muzeal Orădean*, Oradea, pp. 95–99.

Paina, M. 1996 – Jurcsák Tibor Iván, *Nymphaea Folia naturae Bihariae*, XXII (1992): 151–153.

Wanek, F. 2013 – Jurcsák Tibor tudományos hagyatéka, *Historia Scientarium,* pp. 37–45.