3.6. PARÂNG AND CĂPĂȚÂNII MOUNTAINS

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Introduction

The Parâng Mountains (2519 m maximum elevation - second largest in the Romanian Carpathians) and the Căpăţânii Mountains (a 50 km long, west-east striking mountains ridge) belong to the Southern Carpathians. The boundary between those two mountain bodies follows Olteţ stream, whose valley reaches far up into the mountains, to the pass "Curmătura Olteţului" (1620.2 m elevation).

The very hard rocks that build up those mountains (crystalline schists and granites) favored a good preservation of the erosion surfaces, which occur at distinct elevation levels, namely 700-800 m on the average – the Gornoviţa platform, 1400-1600 m on the average – the Râu Şes platform, and 1800-2200 m on the average – the Borăscu platform. The limestone occurrences in the south-eastern part of Parâng Mountains and in the south-western section of Căpăţânii Mountains resulted in extremely spectacular karst landforms, both at the surface and in the underground.

The stream courses in the area are distributed into two main catchment basins: that of the stream Jiu (represented by its major tributary Gilort) and that of the stream Olt (represented by its major tributaries Olteţ and Luncavăţ). The main tributaries of Gilort are Galbenul and Gilorţelul. The tributaries of Olteţ in the mountains area are Cerna and Tărâia (~Valea Seacă). The streams network density varies as a function of the considered physiographic step: 0.8-0.9 km/km^2 within the mountains, 0.5-0.6 km/km^2 within the hills bordering the mountains (the „Sub-Carpathians) and 0.3-0.5 km/km^2 within the plateau located even further outward.

In the mountains area, an average specific discharge amounting to 40-50 l/s/km^2 is favored by abundant rainfall. Those values progressively diminish from north to the south, as a function of the corresponding reduction in the rainfall amount, increase in the evaporation intensity, less rugged topography, rocks permeability, etc., so that values as low as 10-20 l/s/km^2 are recorded at the boundary of the mountains topographic step (Cârstea and Constantinescu, 1980). The rainfall annual average is 800 mm in the depression area and 1200 mm in the mountains area, while annual average temperatures decrease from the mountains foot to their top, being 17°C at 600 m elevation and -2°C above 2000 m elevation (Harisiad and Brânzan, 1980).

1. Current Status of the Geological and Hydrogeological Investigations

The earliest information concerning the petrography and the structure of the Southern Carpathians was recorded in the works published by B. von. Inkey (1891) and by L. Mrazec (1898, 1902).

Investigations addressing the crystalline schists or the granite bodies have been carried out by G. Munteanu-Murgoci (1905,1912), Ionescu Bujor (1913), G. Manolescu (1937), G. Paliuc(1937), Şt. Ghika Budeşti (1940) and Al. Codarcea (1940).

After the Second World War, a large number of investigators in the field of geology, associated to the University in Bucharest, to the Institute of Geology and Geophysics (I.G.G.), the Enterprise for Geological and Geophysical Prospections (I.P.G.G.), etc have conducted either fundamental research, or geological prospections for iron ores and for non-ferrous ores.

The earliest general image of the sedimentary formations of the Danubian Autochtonous Unit has been provided by G. Manolescu (1932,1937); detailed investigations have been conducted by Al. Semaka (1963), V. Mutihac (1964), Gr. Pop (1965), Al. Codarcea and C. Drăghici (1966), N. Macarovici, Fl. Marinescu and I. Motaş (1966, 1967).

In the years 1967-1968, crews belonging to the Institute of Hydro-technical Studies and Investigations have carried out investigations in the area bounded by the streams Cerna and Gilort, in order to outline the influence exerted by the karst setting on the streams discharge.

In order to establish the groundwater flow directions within the carbonate terrains, tracer tests have been additionally performed (P. Niţă and Al. Bulgăr, 1971, in Bleahu et al., 1976).

As far as karst phenomena are concerned, the area owes its reputation both to the Olteţ gorge and Polovragi cave, and to the Galbenul gorge and Muierii cave at Baia de Fier. The earliest information about certain caves are due to Joannes (1868), Al. Ştefulescu (1894), Gh. Munteanu-Murgoci (1898), R. Jeannel and E. Racoviţă (1929), Chappuis şi Winkler (1951), Silvia Iancu et al.(1961). Detailed speleological investigations have been carried out by: Margareta Dumitrescu et al.(1952), I. Viehmann (1954), M. Bleahu (1956), I. Ilie şi Silvia Lupu (1962), G. Diaconu et al. (1971-1974). The exploration and the current survey of Polovragi cave have been mainly carried out by Focul Viu - Bucharest caving club.

2. Geological – Structural Setting

In the south-eastern section of Parâng Mountains and the south-western section of Căpăţânii Mountains there occur formations belonging to the Getic Domain (the Sebeş-Lotru series), a tectonic mixture strip consisting of the Tărâia Unit, and formations belonging to the Danubian Domain (the Schela Unit and the Lainici Unit). The hydrogeological map of the area (Fig.1) made use of a geological background compiled from the geological maps of Trifulescu et al., 1974, Apostoloiu et al., 1984, 1989 and Hann et al., 1988, modified.

1. **The Getic Domain** consists of the *Sebeş-Lotru series* (pgnms), which includes mesometamorphic formations, mainly of mudstone origin, in part migmatized, outcropping in the eastern part of the area.
2. **Tărâia Unit** (Berza et al., 1986, in Apostoloiu et al., 1989) consists of a carbonate grey-blackish milonitic stack, subject to intense shearing, which outcrops between the valleys of Olteţ and Valea Seacă and which corresponds approximately to the Severin Unit.
3. **The Danubian Domain**. Metamorphic formations outcropping in the area belong to the alpine units of Schela and Lainici. Each one of these units includes both basement formations (*the Lainici-Păiuş series* -pgn) and sedimentary cover formations, intruded by the *Suşiţa granitoides* (γ^S), and by the *Olteţ granitoides* (γ^O) respectively.

Figure 1 includes only sedimentary cover formations belonging to the Lainici Unit.

The Alpine sedimentary cover includes the Lunca Olteţului sandstone formation, the Oslea-Polovragi limestone formation, the Nadanova formation and the Cernădia flysch formation.

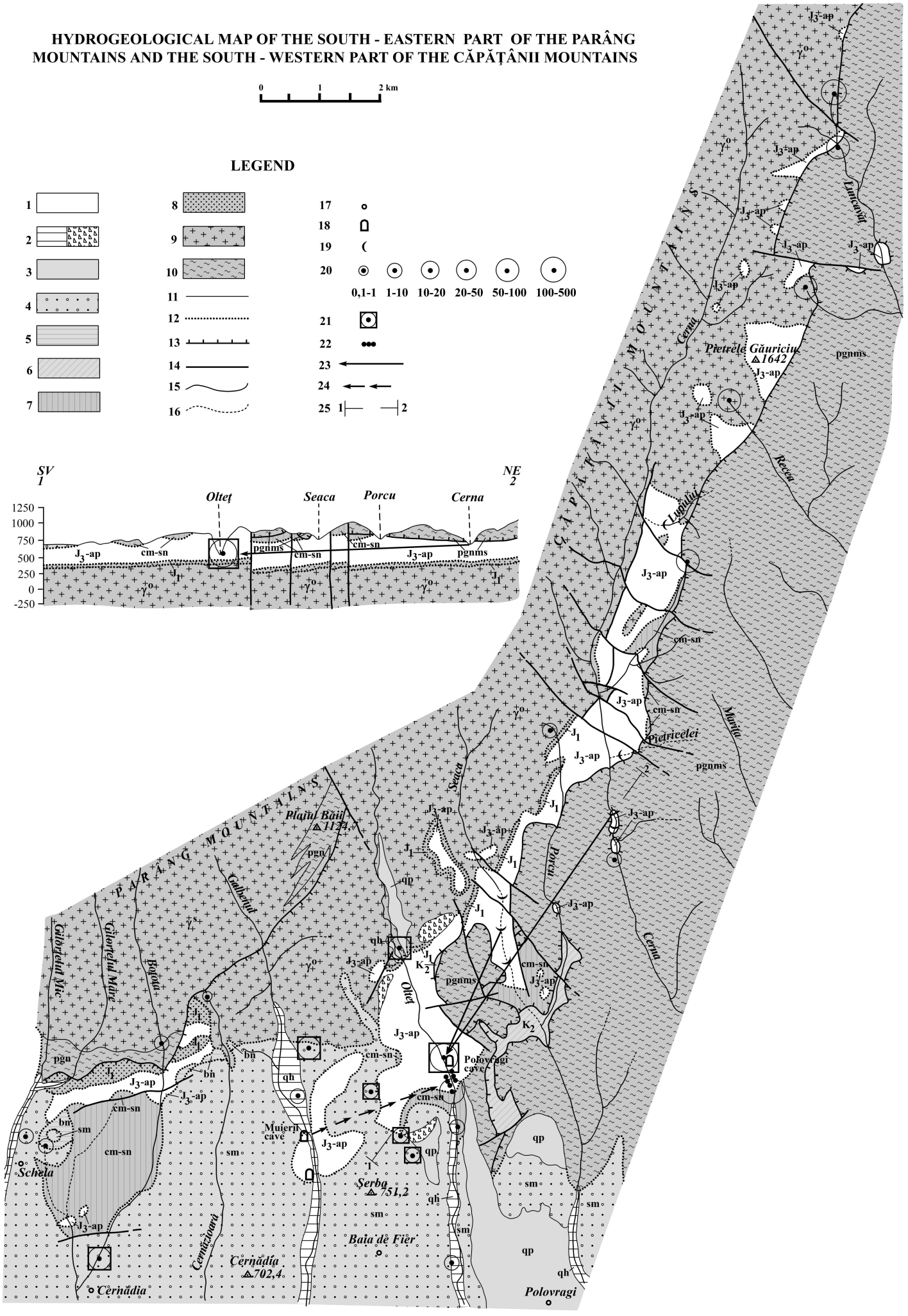
- *Lunca Olteţului sandstone* (J_1) outcrops in the valleys of Boţota, Olteţ and Valea Seacă;
- *The Oslea-Polovragi limestone formation* (J_3-ap) consists of white-grey or white limestone, which in certain places occurs as a schistous marble, while in other instances it occurs as a compact mass; it forms an almost continuous outcrop extending as a stack of variable thickness (20-300 m);

Figure 1. Hydrogeological map of the South-Estern part of the Parâng Mountains and the South-Western part of the Căpățânii Mountains.

Legend:

1 - Mesozoic limestones (J_3-ap);
2 - Alluvial deposits, colluvial deposits (qh);
3 - Boulders, gravels, sands (qp);
4 - Sands, gravels, marls (sm);
5 - Marls, limestones, sandstones, greenish breccias (bn);
6 - Carbonatic mylonites (K_2 - Tărâia Unit);
7 - Clays, arenites - Cernădia Formation and marly limestones, clays - Nadanova Formation (cm-sn);
8 - Sandstones (J_1);
9 - Granites (γ^O -Olteț granitoids; γ^S - Susița granitoids);
10 - Paragneisses, gneisses, micashists (pgn - Lainici-Păiuș series; pgnms - Sebeș-Lotru Series);
11 - Geological boundary;
12 - Unconformity boundary;
13 - Overthrust plane;
14 - Fault;
15 - Perennial surface course;
16 - Temporary surface course;
17 - Locality;
18 - Cave;
19 - Ponor;
20 - Spring discharge (l/s);
21 - Catchment;
22 - Group of springs;
23 - Underground flow direction established by tracer experiments;
24 - Presumptive underground flow direction;
25 - Hydrogeological cross-section line.

HYDROGEOLOGICAL MAP OF THE SOUTH - EASTERN PART OF THE PARÂNG MOUNTAINS AND THE SOUTH - WESTERN PART OF THE CĂPĂŢÂNII MOUNTAINS



- *The Nadanova Formation* (Cenomanian-Turonian) consists of alternating limestone or carbonate milonites, grey-blackish carbonate shales;
- *The Cernădia flysch formation* (Senonian) includes sandstones, ranging from coarse to fine, siltstones and shales.

The last two formations occur with small thicknesses and in an alternating manner between Valea Seacă (to the east) and Gilorţel stream (to the west); on the geological map (Fig.1) they have been represented as a single entity (cm-sn).

The Neogene sedimentary formations include two distinct entities: one of *Badenian* age (bn, greenish sedimentary breccia, fossiliferous marls, grey, arenitic reef limestone) and the other of *Sarmatian* age (sm, violet, thinly bedded marls, frequently with a shaly, dissodilic appearance, sands and gravel).

The Quaternary includes terrace deposits (Pleistocene-qp), the alluvia of the main streams in the area, alluvial fans and scree deposits (Holocene-qh).

The main tectonic feature of the area is the Getic Unit over-thrust over the Danubian Unit, the outcrop of the NE-SW striking thrust plane being located to the west of Olteţ valley.

3. The Mesozoic Carbonate Deposits Hydrogeology

The main reservoir formation in the area consists of Late Jurassic - Aptian carbonate rocks (*The Oslea-Polovragi limestone formation*). In the south-eastern section of Parâng Mountains and in the south-western section of Căpăţânii Mountains, between Gilorţelul Mic stream (to the south-west) and Luncavăţ stream (to the north-east), over a length of about 87 km, there occurs a continuous or broken strip of Late Jurassic - Aptian limestone (9.23 km^2). Its maximum width, 1-1.5 km, is recorded in the section bounded by the streams Galbenul (to the west) and Cerna (to the east).

Surface karst landforms are rather poorly developed, yet worth to be mentioned are the occurrences of grikes, natural bridges and porches, limestone escarpments, seasonal flow valleys, swallets and springs. Gorges are the most illustrative surface karst landforms in the area (ex.: the gorge sections of Valea Seacă and those of the streams Galbenul, Olteţ, and Cerna).

The most important underground karst phenomena are *Polovragi Cave* (9171 m length) in the Olteţ Gorge, and *Muierii Cave* (3566 m length) in the Galbenul Gorge.

The systematic catalogue of the caves in Romania (Goran, 1982) indicates the existence of 74 cavities characterized by various genetic and topographic features, occurring mainly clustered in the gorge sections or in their close proximity (Table 1).

By considering from a regional perspective the geographic distribution of the karst cavities, it results that the highest percentage (61%) are located within the Olteţ catchment area, with Galbenul catchment area coming next (35%). While within Galbenul catchment area caves of less than 20 m length prevalently occur, most caves within the Olteţ catchment area are in the 20-50 m length range. Most caves, i.e. 72 (or 97%) – have no permanent stream flow.

In the south-eastern section of Parâng Mountains and in the south-western section of Căpăţânii

Catchment	No. of cavities	Side of the valley		Length of cave passages (m)				Elevation range over which the cave passages extend (m)				Hydrologic regime of cavity	
		left	right	<20	20-50	50-100	>100	<5	5-10	10-20	>20	Stream -caves	Dry caves
Cernăzioara	1	-	1	1	-	-	-	1	-	-	-	-	1
Galbenul	26	13	13	13	6	3	4	17	5	2	2	-	26
Olteţ	45	23	22	13	22	3	7	37	3	4	1	2	43
Cerna	2	-	2	2	-	-	-	1	1	-	-	-	2
Total	**74**	**36**	**38**	**29**	**28**	**6**	**11**	**56**	**9**	**6**	**3**	**2**	**72**

Table 1. Geographic location and morphometric data of the cavities of the south-eastern Parâng Mountains and the south-western Căpăţânii Mountains.

Mountains, there have been identified 29 springs discharging from limestone deposits. Among those springs, 15 have flow rates that range between 1 and about 230 l/s.

In terms of groundwater hydrology, the most important area is that bounded by the streams Lupului (to the north) and Galbenul (to the south), where carbonate deposits exhibit their largest extent and occur as a continuous mass. The fractured-karst aquifer that occupies the Late Jurassic – Aptian carbonate rocks discharges by the multitude of springs occurring in the Olteţ Gorge. For the carbonate terrains located to the west of Olteţ stream, groundwater flow from Galbenul stream is only hypothetized, yet for the eastern area, underground flow from the streams in Valea Seacă and in the Cerna valley has been proven by means of tracer tests.

Galbenul stream

There haven't been identified any springs along the 700 m long carbonate rocks section of Galbenul stream. Yet the underground karst phenomena abundance in the Galbenul Gorge area indicates that in the past, a rather intense hydrologic activity must have occurred there.

Erosion levels are traced by cave entrances occurring on both sides of the valley. The most important cavity is *Muierii Cave* at Baia de Fier. It is a large cave (3566 m long) excavated in Late Jurassic – Aptian limestone and developed on four floors, none of which is subject to perennial stream-flow. The overall passage system strikes NNW-SSE, similarly to the fracture line on which it was developed and which additionally concerned the right side of Galbenul Gorge. The passages are a result of limestone dissolution by water infiltrated from Galbenul stream through underground flow paths along the fracture line, and they have evolved in parallel with the gorge incision that was completed by the main course of the stream (Bleahu et al., 1976).

Along the gorge section of Galbenul stream there haven't been noticed any visible sinking points of the water that runs through the valley. Alternatively, by means of flow rate gauging performed in August 2004 along the stream course, upstream and downstream the gorge, there has been recorded a 74 l/s loss (12 % of the overall flow rate).

The instance that the elevation ranges of the carbonate sections of the streams Rudii (805-850 m) and Boţota (695-735 m) are positioned higher than the carbonate section of Galbenul stream (590-600 m), authorizes the inference that an underground circulation occurs within the carbonate deposits, from the stream Galbenul toward the stream Olteţ (570-620 m).

Olteţ stream

Before reaching the depression located in front of the Carpathians (the «Oltenia section of the Subcarpathian Depression»), Olteţ stream cuts through the E-W striking limestone bar a gorge whose depth is in excess of 100 m, while its length exceeds 1 km.

In spite of being located just 5 km east of Galbenul gorge, the Olteţ gorge displays a completely different appearance. The opposite walls of the valley occur very close to one another: the distance between them varies from 4-5 m next to the streambed, to 10-20 m in the upper part. Several erosion levels can be traced within the walls, more prominent being the levels highlighted by the cave-entrances lineaments occurring at 25 m and at 60 m above the streambed. The most important cavity is *Polovragi Cave* (9171 m long), a former underground meander of Olteţ stream; the cave entrance is located 20 m above the streambed and some 200 m upstream the place where the stream leaves the gorge.

At the present time, the stream Olteţ exerts a subterranean piracy tendency which concerns the streams which run in its proximity. As a result, the

Date	Upstream losses (l/s, and % from total)	Downstrem exceses	
		(l/s, and % from total)	Polovragi Cave only (l/s)
August 2004	255 (59%)	442 (52%)	234
September 2004	283 (75%)	445 (69%)	114

Table 2. Olteț streamflow gauging.

stream Olteţ behaves as the main drain of the water which flows across the limestone strip.

Streamflow gauging of Olteţ has been performed within the carbonate rocks area in the year 2004. The results are indicated in Table 2.

During the draught period of a year, the flow running through the valley sinks as a general rule completely, immediately after entering the gorge. About 1 km further downstream, a large number of springs located on both sides of the gorge rebuild the surface stream discharge, yet doubled or tripled as compared to the one which sinks at the upstream end of the gorge.

We presume that part of the water of the springs located on the right side of the gorge (in its final section) originates in the water sunk from Olteţ stream at the gorge entrance, while another fraction includes the losses from Galbenul stream (which is located immediately to the east). The discharge of the springs located on the left side of the gorge (in its final section) originates in the water sunk in the carbonate sections of the streams Cerna and Valea Seacă, both of which are located to the east of Olteţ valley, and also in some additional inflows derived from rainfall and smaller streams.

The last section of the underground flow-path followed by the stream which comes from Cerna valley is accessible within the cave Polovragi and in Peştera cu Apă din Cheile Olteţului. The investigations conducted in the year 2004 have identified 19 outlets with flow rates in the 0.2-240 l/s range, located along the final section of Olteţ gorge, at the stream water level or above it . Additional springs may occur at streambed level. In the months of August and September 2004, there cave have been conducted two operations which consisted in simultaneously gauging the discharge of Olteţ stream upstream and downstream the outlet located in the proximity of Polovragi cave. There have resulted excess flow rates of 234 l/s and 114 l/s respectively (Table 2).

In order to establish the origin of the spring water (the recharge area), as well as the underground flow directions and velocities in the area, a series of fluorescein tracer tests have been conducted in the year 2004, the recorded parameters being indicated in Table 3.

The different velocities recorded in the case of the two experiments is due both to the manner in which the water reaches the underground, and to the underground flow paths characteristics. While in the first case water sank in a punctual manner and underground flow was rather fast, occurring along distinct flow-paths, the second experiment was conducted subject to difficult water sinking conditions, due to the small flow rate and to the geological constitution of the streambed, while underground circulation took place along a poorly organized channel network.

Cerna stream

Along its course, Cerna stream crosses three distinct carbonate areas. The northern one is the largest, extending over 800 m of the stream length. The next two have much smaller extents, namely 220 m (measured along the stream length) in the case of the median section, and 120 m respectively in the case of the southern section.

There are few karst cavities identified so far within the Cerna catchment area. Nonetheless, the tracer tests results (Table 3) and the stream flow rate gauging (Table 4) suggest that a major network of karst cavities exists, although they are not accessible. Moreover, during periods of less abundant rainfall, even certain tributaries of Cerna diffusely sink when entering the carbonate terrains (ex: Lupului stream, Pietricelei stream).

No.	Sinking point (Q, l/s)	Resurgence	L (m)	H (m)	T (hours)	V (m/hour)	Date of tracer injection
1	Cerna brook (3)	Polovragi Cave source	4050	160	70	57.86	19.08.2004
2	Valea Seaca (0.1)	Polovragi Cave source	2200	210	110	20	16.09.2004

Table 3. Results of tracing operations in the Cerna - Olteț karst area.
L = Horizontal distance between sinking points and resurgences
H = Elevation drop from sinking points to resurgences
T = Time of the tracer first arrival
V = Velocity

Date	Losses (l/s, and % from total)	
	Northern sector	Median and southern sectors
August 2004	36 (27%)	31 (34%)
September 2004	35 (40%)	31 (46%)

Table 4. Cerna stream flow gauging.

4. Hydrochemistry Issues

There is a rather small variation range of the chemical composition of the water of the outlets which discharge from carbonate deposits. The main chemical feature of these waters is their low content of Na^+ (2.33-3.69 mg/l), K^+ (1.06-1.59 mg/l), Cl^- (7.1-21.3 mg/l) and SO_4^{2-} (0 mg/l). Similar values are also recorded in terms of their Mg^{2+} content (1.83-2.27 mg/l).

The water is of calcium bicarbonate type, with total mineralization in the 181.90-192.00 mg/l range.

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The karst of this area is not outstandingly impressive and its areal extension is rather small, but in spite of that, commercial tourist activities have been developed in *Muierii Cave* and in *Polovragi Cave*, while part of the discharge of the outlet located next to Polovragi cave has been taped for the water supply of Alimpeşti village. At the same time, by taking also into account the tracer tests results, a special attention must be devoted to the environment protection, especially in the above mentioned outlet recharge area.

References

Bleahu M., Decu V., Negrea Şt., Pleşca C., Povară I., Viehmann I. (1976) Peşteri din România, Editura ştiinţifică şi enciclopedică, Bucureşti, pp. 357-360.

Cîrstea Gh., Constantinescu D. (1980) Judeţul Vâlcea, Ed. Sport-Turism, Bucureşti, pp.12-29.

Goran C. (1982) Catalogul sistematic al peşterilor din România,1981, Ed. C.N.E.F.S., Bucureşti, pp. 77-81.

Hann H.P., Ricman C., Pană I.P., Săbău G., Bindea G., Tatu M. (1988) Structural and petrographic study of the Getic Nappe metamorphics in the Căpăţâna Mountains (South Carpathians), D.S. Inst. Geol. Geofiz., vol. 72-73/5 (1985; 1986), Bucureşti, pp. 131-143.

Harisiad Elena, Brînzan N., Mocioi I. (1980) Judeţul Gorj, Ed. Sport-Turism, Bucureşti, pp. 11-25.