3.10. MEHEDINȚI MOUNTAINS AND PLATEAU

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Introduction

The Mehedinţi Mountains and Plateau geographically belong to the southwestern extremity of the Southern Carpathians.

The heights of the *Mehedinţi Mountains* do not exceed the altitude of 1466 m in Vf. lui Stan *(Peak of Stan)*, the average height being 1200 m. They stretch along the left bank of the Cerna Valley, between the Motru Valley, to the north, and the Mehedinţi Plateau, to the south and east.

The Mehedinţi Mountains appear as a long summit, ca. 4-5 km wide, with transversal asymmetric profile. The western slope is very steep towards Cerna, while the eastern one, towards the Mehedinţi Plateau, is gentler and more accessible. Limestones outcrop on important areas to the south of Cerna village (Corcoaia Gorges), being present as fragmented bars (between the Corcoaia Gorges and the Arşasca Valley), or as karst summit plateaus up to Băile Herculane.

The Mehedinţi Plateau extends to the east of the Mehedinţi Mountains from the north-east to the south-west, between the Motru River and the Danube (53 km length, 16-23 km width) and has a distinct geological individuality, although it is in fact an organic continuity of the former. Due to the lithologic similarity to the Mehedinţi Mountains (crystalline schists and Mesozoic limestones), the relief (narrow valleys, sometimes as gorges, exo- and endokarst) and the tectonic fragmentation, it is included in the mountains category. The Mehedinţi Plateau can be, at the same time, compared to hilly lands, due to its low altitude and to the peaks, levelled by the erosion platforms. The average altitude does not exceed 500-600 m.

The hydrographic network is represented by the Danube, the Cerna and the Motru and by their direct or indirect affluents. Between the Danube and the Motru, the limestone plateau of Mehedinţi shows a very low density of the hydrographic network, especially in its northern part, where karst phenomena are well developed (0.4 km/km^2), which increases towards the Danube, where it reaches 0.6 km/km^2 (Pascu, 1983).

In the karst area of the Mehedinţi Plateau, there are a few temporary karst lakes (lakes Zăton and Ponoare, near the Ponoarele commune and the Gornoviţa Lake, between Balta and Gornoviţa villages), which, mainly during spring, as a result of the abundant rain, are storing an important water amount. The Balta Lake, located in the middle of the commune with the same name, is a permanent one.

The Mehedinţi Plateau is sheltering also some underground karst lakes, which were formed by the natural damming of cave galleries (in the Topolniţa, Crovu lui Răscraci and Epuran caves).

The climate in this area is temperate-continental with significant sub-Mediterranean influences. Due to the influence of the warmer air, of Mediterranean origin, circulation, the air temperature shows some of the highest values in the country. In Drobeta-Turnu Severin, the annual average of air temperature reaches 11.7°C. This decreases with altitude, thus reaching 8-9°C on the top of hills, while on the mountain peaks it decreases to 6°C and even below 4°C.

The annual rainfall is distributed as follows: less than 500 mm/year on plains, 550-800 mm/year in the hilly area, 800-900 mm/year in the plateau area and 1000-1200 mm/year in the mountain one (Cucu et al., 1980).

1. History of geological and hydrogeological research

The first pieces of information concerning stratigraphy and tectonics of the region are to be found in the works elaborated by Foeterle (1869),

E. Tietze (1872), Koch (1872), Fr. Schafarzik (1890, 1891, 1893, 1895, 1897, 1934), Gh. Murgoci (1905, 1910, 1911), I. P. Voiteşti (1929), A. Streckeisen (1934).

An important moment in the evolution of the knowledge of the geology of the region is represented by the synthesis work on Southern Banat and Mehedinţi Plateau, elaborated by Al. Codarcea in 1940.

After the year 1957, a new period follows, with respect to the research of the geological features of the region. This period is dominated by the works elaborated by I. Focşa (1957,1960), I. Focşa and C. Hurduzeu (1958), S. Năstăseanu (1959, 1967, 1974, 1976), Al. Codarcea, S. Năstăseanu (1964), Al. Codarcea et al. (1961, 1965, 1968), C. Drăghici (1962).

In order to complete the knowledge concerning the Băile Herculane region, geophysical research has also been conducted (magnetometry, electrometry, thermometry and biophysics), papers being signed by M. Visarion et al. (1973), A. Apostol et al. (1974), H. Mitrofan and Ruxandra Slăvoacă (1982).

Researchers from the Institute of Geology and Geophysics (I.G.G.) worked in order to draw geological maps at 1:50,000 scale, the Nadanova and Bâlvăneşti sheets. Among the authors of these maps we mention: I. Stănoiu, S. Năstăseanu, D. Mercus, I. Hîrtopanu, Viorica Iancu, P. Hîrtopanu, T. Berzea., M. Mărunţiu, M. Şeclăman, Fl. Marinescu, M. Conovici, T. Gridan, R. Strusiewicz.

The hydrogeological aspects are included in the works written by D. Slăvoacă and I. Orăşeanu (1970) in the Motru Sec-Baia de Aramă area and I. Lazu (1974) in the Topleţ zone.

Other hydrogeological information was obtained as a result of the hydrocarbons research conducted by D. Slăvoacă, M. Feru, V. Şerbănescu and R. Todea (1963, 1964).

In 1974, G. Simion and Gh. Popa conducted a hydrogeological and hydrochemical study, in order to draft the inventory of the thermal water sources in the areas: Bala, Băile Herculane and Mehedinţi.

2. Geological-structural characterization

The geology of the Mehedinţi Mountains and Plateau comprises metamorphic rocks, sedimentary deposits and igneous rocks, distributed on the Getic Domain, Danubian Domain and the Severin Unit.

Precambrian crystalline formations, which contribute to the structure of the area, belong to the Getic Domain (Sebeş-Lotru Series) and to the Danubian Domain (Drăgşan Series and Lainici-Păiuş Series).

The Palaeozoic from the Danubian area consists in sericite-clorite schists, only locally interbedded with quartzite lenses from the *Ordovician-Silurian* stratigraphic interval and of metapsephytes, metapsamites, sericite-clorite schists, graphite schists, a.s.o., belonging to *Devonian*.

On the same area, the igneous rocks of the Danubian crystalline are represented by granites and granitoids, granodiorites and diorites massifs (the *Cerna granitoid* and the *Tismana granite*).

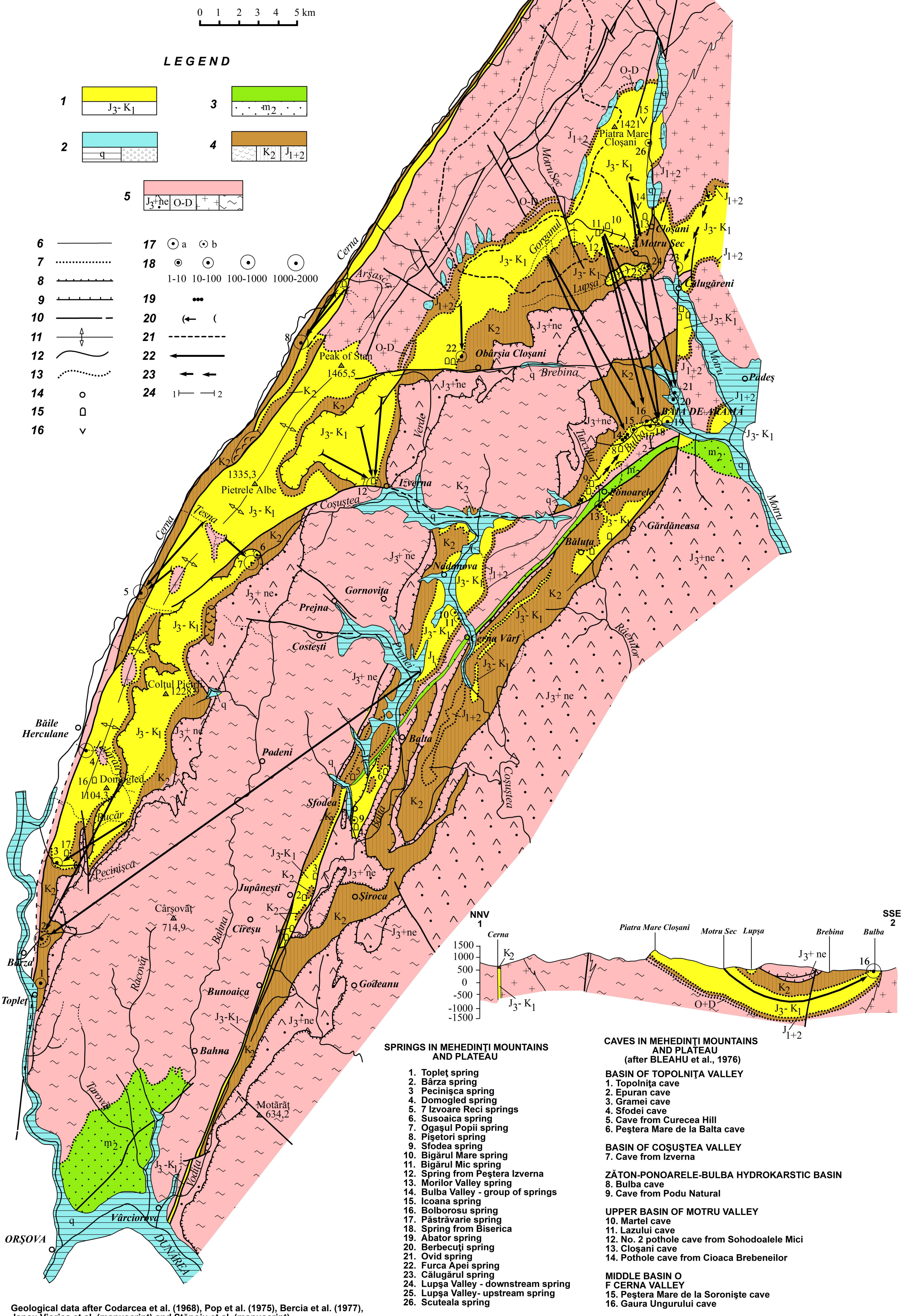
The Jurassic sediments discordantly overlay the Palaeozoic or the crystalline basement; the

Figure 1. Hydrogeological map of the Mehedinți Mountains and of the Mehedinți Plateau

Legend: 1. Mesozoic carbonate series, fractured and karstified, characterised by an intensive groundwater flow. Numerous karst systems with important water resources. Springs with flow rate up to 2000 l/s; Mesozoic limestones (J_3-K_1); 2. Quaternary detritic deposits with reduced thickness and extension, hosting groundwater pores-flow. Local importance aquifers; Alluvial deposits (q) and screes; 3. Detritic deposits with permeability of fissures and pores with reduced thikness and extension. Discontinous water accumulations in the more permeable terms. Miocene sands, gravels and clays (m_2); 4. Deposits incuding rock-complexes of variable permeability, hosting occasionally groundwater accumulations. Holocene lanslides; Cretaceous marly-limestones, sandstones and clays (K_2); Jurassic clays and sandstones (J_{1+2}); 5. Mesozoic ophiolites (J_3+ne), Palaeozoic shists (O-D), Precambrian and Palaeozoic granites and shists with large thickness and extension. The permeability of fissures has a discontinous distribution and intensity; 6 - Geological boundary; 7 - Unconformity boundary; 8 - Overthrust plane; 9 - Wedge; 10 - Fault; 11 - Anticline; 12 - Perennial surface course; 13 - Temporary surface course; 14 - Locality; 15 - Cave; 16 - Pothole; 17 - Perennial spring (a); temporary spring (b); 18 - Sources discharge (l/s); 19 - Group of springs; 20 - Ponor; 21 - Limit of the hydrographic basin checked by hydrometric gauging sections; 22 - Underground flow direction established by tracer experiments; 23 - Presumptive underground flow direction; 24 - Hydrogeological cross-section line.

Figure 1

HYDROGEOLOGICAL MAP OF THE MEHEDINŢI MOUNTAINS AND OF THE MEHEDINŢI PLATEAU



SPRINGS IN MEHEDINŢI MOUNTAINS AND PLATEAU

1. Topleţ spring
2. Bârza spring
3. Pecinişca spring
4. Domogled spring
5. 7 Izvoare Reci springs
6. Susoaica spring
7. Ogaşul Popii spring
8. Pişetori spring
9. Sfodea spring
10. Bigărul Mare spring
11. Bigărul Mic spring
12. Spring from Peştera Izverna
13. Morilor Valley spring
14. Bulba Valley - group of springs
15. Icoana spring
16. Bolborosu spring
17. Păstrăvarie spring
18. Spring from Biserica
19. Abator spring
20. Berbecuţi spring
21. Ovid spring
22. Furca Apei spring
23. Călugărul spring
24. Lupşa Valley - downstream spring
25. Lupşa Valley- upstream spring
26. Scuteala spring

CAVES IN MEHEDINŢI MOUNTAINS AND PLATEAU (after BLEAHU et al., 1976)

BASIN OF TOPOLNIŢA VALLEY
1. Topolniţa cave
2. Epuran cave
3. Gramei cave
4. Sfodei cave
5. Cave from Curecea Hill
6. Peştera Mare de la Balta cave

BASIN OF COŞUŞTEA VALLEY
7. Cave from Izverna

ZĂTON-PONOARELE-BULBA HYDROKARSTIC BASIN
8. Bulba cave
9. Cave from Podu Natural

UPPER BASIN OF MOTRU VALLEY
10. Martel cave
11. Lazului cave
12. No. 2 pothole cave from Sohodoalele Mici
13. Cloşani cave
14. Pothole cave from Cioaca Brebeneilor

MIDDLE BASIN O F CERNA VALLEY
15. Peştera Mare de la Soronişte cave
16. Gaura Ungurului cave

Geological data after Codarcea et al. (1968), Pop et al. (1975), Bercia et al. (1977), Iancu Viorica et al. (manuscript) and Stănoiu et al. (manuscript)

Lower Cretaceous outcrops in depositional continuity, while the Upper Cretaceous is transgressive.

The *Lower Jurassic-Middle Jurassic* interval is predominantly silty-clayey, reaching a thickness between 300-500 m in the Coşuştea Valley.

The Middle Jurassic (Bajocian-Callovian) is featured by the calcareous-clastic aspect, on most of the Danubian Domain extent.

In the area of the Cerna, Coşuştea and Motru valleys, the Upper Jurassic-Cretaceous interval also shows a calcareous, reef-like aspect. The following intervals have been distinguished: *Upper Jurassic-Neocomian*, consisting in pelletal and intraclastic limestones, often dolomitized, with cherts; *Upper Jurassic-Aptian*, represented by micritic, breccious or marly limestones which emerge in the area of the localities Ponoarele, Cerna-Vârf and Sfodea; *Barremian-Aptian*, placed on top of the carbonate layers of the Upper Jurassic, consists in limestones pertaining to Urgonian facies.

In the Lower Cretaceous-Upper Cretaceous interval sandy beds (*Albian-Senonian*), marly and marly-calcareous deposits appear, belonging to the Nadanova Formation (*Cenomanian-Middle Turonian*) and deposits with a pronounced flysch character (*Upper Turonian-Senonian* and *Senonian*).

The Severin Unit (*Upper Jurassic-Neocomian)* is situated between the Getic Domain and the Danubian Domain and shows the most important area developed between Motru and Danube. Tectonically, it overlays the Upper Cretaceous layers of the Danubian Domain and underlays the Getic Domain.

In the structure of the Severin Unit, two distinct formations can be detected: basic and ultrabasic rocks and sedimentary rocks, represented mostly by flysch.

In the Mehedinţi Plateau, the post-tectonic layers are attributed to Neozoic. These show a maximum development in the Orşova-Bahna area and in the Balta-Baia de Aramă passage. The *Badenian-Meotian* interval is dominated by clays, sands, gravels, marls and reef-like limestones.

The Quaternary is represented by terrace deposits, alluvial deposits, landslides and scree deposits.

According to Stănoiu (1997), the lithostratigraphic entities of the Mehedinţi Mountains and Plateau belong to six tectonic units: the Cerna-Ilova Nappe (a basement nappe); Coşuştea Nappe (Laramide cover); Obârşia Nappe (Austrian and Laramide nappe); Severin Nappe; Borăscu Nappe (Austrian basement nappe) and Godeanu Nappe (Austrian basement nappe).

The Southern Carpathians sector, where the studied area is situated, is characterised by a complex tectonics, reflected in the major plicative and disjunctive structures, result of the Precambrian, Palaeozoic and Mesozoic movements. One of their essential features is the presence of large overthrusts.

As a result of the geotectonic evolution, to the east of the Cerna Valley and in the Mehedinţi Plateau, on top of the Danubian Domain, the formations of the Severin Unit are situated, underlaying the Getic crystalline patch of Bahna.

In the Cerna Valley area, the main tectonic elements are: the Getic Nappe, the Cerna Nappe, the Cerna Graben, the Vf. lui Stan-Domogled Anticline.

Concerning the Cerna Graben, this has been activated in the Miocene or Pliocene, between two profound fractures oriented NNE-SSW, along which a 1000 m level shift took place.

Along the major tectonic elements, many secondary, longitudinal or transversal faults appear in the area.

In order to draw the hydrogeological map, the geological maps (scale 1:50,000) issued by I.G.G.: Tismana (1975), Obârşia Cloşani (1977), Bâlvăneşti (manuscript) and Nadanova (manuscript) were used.

3. Hydrogeological features of carbonate deposits

The entire carbonate pile may be divided into two categories: limestones with various degrees of crystallinity, occupying relatively limited areas, and limestones in Urgonian facies, placed on an extended area (Figure 1).

The existence of systems of fractures and the high degree of cracking have favoured the development of karst forms, a fact which led to the creation of important underground drainages.

While in the Mehedinţi Mountains the plateau and slope karst are predominant, in the plateau area the lowered limestone bars karst is typical.

In the area of the Mehedinţi Plateau, the strip of limestones outcropping between Baia de Aramă and Cireşu, with a thickness varying between 200 and 300 m, has generated numerous and varied karst forms. Many of the brooks coming from the east, from non-karst formations are catched underground, at the contact with the limestone bar. Downstream from the catching point, the valleys remain dry, forming in time antithetic steps, such as the ones of the Topolniţa and Ponorel brook, etc. In plateau limestones, underground cavities with horizontal development are predominant, respectively 231 caves (11 with development between 1-20 km) and only 76 potholes (Goran, 1982). The most important underground karst networks are the caves Topolniţa, Epuran, Bulba, the one in Isverna and those on the Motru Sec and Motru (Martel Cave, Lazului Cave, Mare Cave in Cloşani).

In the hydrographic basin of Cerna three important hydrostructures have been identified: the Cerna Syncline developed in the Cerna right slope, the Cerna Graben and the limestone plateau of the Mehedinţi Mountains, developed in the Cerna River left slope. In certain sectors, these can be found interconnected.

Hereinafter, starting from the karst systems and hydrographic basins for which researches and hydrometric surveys have been performed, we shall present the hydrogeology of the Mehedinţi Mountains and Mehedinţi Plateau karst, morphological units which form a complex hydrogeological structure.

3.1. Western Part of the Mehedinți Mountains

The Cerna left slope, consisting in limestones aged Barremian-Aptian, has a steep, calcareous, aspect, with high vertical walls up to 500 m and which are continued with higher and higher peaks, one of these being the Domogled Peak (1104.9 m)

Structurally, the limestone plateau of the Mehedinţi Mountains presents an anticline arching between the Vf. lui Stan, to the north, and the Domogled Peak, to the south. This arching constitutes a hydrogeological watershed along which the karst aquifer complex is divided into two major sectors: the western sector included between the anticline axis and the Cerna Graben and the eastern sector as a synclinorium, situated to the east of the axis. Between the sectors, there are possibilities of hydraulic connections, favoured by the flattening areas of the anticline (areas where the non-karst basement is lower).

The western sector of the Mehedinţi Mountains (average altitude ca. 1200 m) is supplied directly from rainfall and can be characterised as a poorly organised karst system, drained by springs

Source no.	Source	Qmax. l/s	Qmax. l/s	Qmax/ Qmin	Qmean l/s	α	Vol. din. m³	M.E. days	T.F	R.T. days
2	Bârza	3174	1362	2,3	1755	0.0030	47300	39	0.08	38
3	Pecinişca	443	42	10.5	107	0.0084	1240	32	0.170	26
4	Domogled[1]	29.9	4.2	10.37	7.12	0.0227	2160	84	0.036	85
5	Şapte Izvoare Reci[2]	336	110	3.05	198.3	0.0044	33500	31	0.088	36
8	Pişetorile[3]	124.8	19.2	6.5	47.9					
12	Isverna	2255	38	59.3	301	0.0161	376	8	0.152	9
13	Spring on the Morilor Valley	340	10	34	35	0.0165	157	8	0.148	16
19	Abator	140	24	5.8	75	0.0151	425	29	0.116	25
20	Bridge Springs + Berbecuţi	842	92	9.1	177	0.0060	1750	8	0.228	11
21	Ovid	1187	47	24.5	167	0.0056	2730	10	0.208	9
22	Furca Apei	1086	53	20.5	173	0.0103	611	7	0.204	4
23	Călugărul	1749	23	75.4	111	0.0208	218	4	0.208	4
24	Lupşa Spring - downstream	41.8	4.8	8.7	15.7	0.0071	219	25	0.144	24
25	Lupşa Spring - upstream	71	1.4	50.7	9.7	0.0180	41.8	3	0.264	

Table 1. Hydrodynamic parameters of sources in the Mehedinți Mountains and Plateau, monitored in the period 01.10.1997 - 30.09.1998

α - discharge coefficient; M.E. - memory effect; T.F. - truncation frequency; R.T. - regulation time

[1] 1.10.1998 - 30.09.1990

[2] 17.03.1966 - 16.02.1967 (ISPIF Bucharest)

[3] 08.04.2005 - 17.03.2006 (data obtained by I. Orășeanu, unpublished)

situated at the foot of the slope or even in the thalweg of the Cerna Valley. Valleys in this sector are dry, except for the Ţesna brook, Ogaşul lui Roşeţ and the Pecinişca brook.

The results obtained after processing the data resulting from the on-site measurements made on the most important sources in the area (period 01.10.1997-30.09.1998), are presented in Table 1.

The most significant sources in this sector, from the south to the north, are: *Pecinişca Springs* (source no. 3), *Domogled Spring* (source no. 4), the springs line called *Şapte Izvoare Reci* (source no. 5) and the *Pişetorile Springs* (source no. 8).

The tracing operations performed in the '70s and '80s by specialists of S.C. Prospecţiuni S.A., Institute of Nuclear Physics and Engineering (I.F.I.N.) and the Institute of Speleology Emil Racoviţă (I.S.E.R.), separately or in cooperation, have proved that the water of the Bârza Spring is also originating in the discharge of the aquifer located in the western side of the Mehedinţi Mountains limestone plateau (Table 2).

3.1.1. Bârza-Topleț Hydrokarst System

This system is located in the synclinorium delineated to the west by the Vf. lui Stan-Domogled anticline and to the east by the tectonic passage Baia de Aramă-Balta. The northern limit of this structure, proven by tracing, is the Prejna Valley, while the southern is joining the Bârza and Topleţ springs. Possibly, the structure stretches to the north up to the Isverna - Ponoarele line.

The tracing operations have shown the existence of a karst aquifer which stretches both to the level of the Mehedinţi Mountains and the Mehedinţi Plateau.

The tracing performed with ^{131}I by I.S.E.R. in cooperation with I.F.I.N, in the sinkholes of the Jelerău Valley, left side affluent of the Cerna Valley, had as result the appearance of the isotope in the water of the *Bârza Spring* (Table 2), thus demonstrating the direction of the water drainage in the southern area of the Mehedinţi Mountains.

On the 19th/08/1998, S.C. Prospecţiuni S.A. performed a tracing operation using fluorescein in the immergence area identified in the Gornoviţa Meadow (Prejna Brook). The tracer appeared in the water of the Bârza Spring, 19 days after the injection (Table 2). The transfer function, characterised by only one apex, shows a well-organized drainage, on only one transit way. The map distance between the immergence and the emergence points being of 22 km, a transit speed of 1.15 km/day results (Bandrabur et al., 1998-1999).

The Bârza-Topleţ hydrokarst system includes area with diffuse flow and areas with well-organised flow, in hydraulic contact. In this context the following aspects can be stressed:

- the areas with diffuse flow, including most of the limestones, may store a considerable water amount and are characterized by low transmissibility and low flow speeds;
- the areas with well-organised flow are developed on the main drainage directions, the flow takes place with high speed through karst cavities, in a free flow regime at start, followed by flow under pressure;
- during rainfall, the flow speed of the groundwater increases rapidly (approx. 1 km/day), in the areas with well-organised flow, determining the increase of the discharge at the Bârza Spring (fast reaction to rain);
- at the same time, the diffuse flow area is supplied, either directly by rainfall, or by the drainage of the cover layers, or by the drainage of adjacent well-organised flow areas;
- when rainfall stops, the well-organised karst areas are supplied by the areas where the flow is diffuse.

Another important spring in the area is the *Topleţ Source* (source no. 1). In the period 01.10.1997-31.09.1998, the minimal flow of the source reached up to 18 l/s, while the maximal up to 55 l/s.

The structural-geological position of the source, as well as its mesothermal character (18°C), show that it represents a shallow component of the aquifer, which is drained by the two springs, Bârza and Topleţ. Compared to Bârza, the Topleţ Source has a deeper and a slower circulation.

3.1.2. Șapte Izvoare Reci Hydrokarst System

One of the most interesting groups of karst springs from the east of the Mehedinţi Mountains, nowadays situated under the level of the Prisaca water storage, is located at ca. 8 km upstream from Băile Herculane, in the base of the Cerna left slope, on a 200 m front (Figure 2).

The geology of the Cerna left slope is dominated by the crystalline-granite ridge Vf. lui Stan

- Domogled, which emerges in the middle part of the Ţăsna (800-850 m) and in Poiana Balta Cerbului (950 m), as well as by the special extension of the J_3-K_1 limestones. These latter are dipping to the east under the Severin Para-autochthonous and the Bahna Patch, in a large syncline structure, the eastern side of which emerges in the Mehedinţi Plateau. They are also inclined towards west, moulding the bed, and are divided and vertically shifted along the fault, parallel with the major Cerna Fault. More than 60% of the limestones outcrop on the eastern part of the summit plateau, belonging to the autochthonous, or are tectonically linked to the Cerna Duplicature. On the western part of the plateau and on most of the slope outcrop only autochthonous limestones. The only sector where the slope limestones are in direct relation with the ones at the Cerna level, and thereby, with the graben ones, is the one around the emergences of the *Şapte Izvoare Reci* area.

The morphology is dominated by the surface of the high plateau, where we remark the *Balta Cerbului Depression*, the sinkhole plateaus *Ploştina Bălţii* and *Lacu Ursului*, the Cerna steep slope and the relief steps tectonically generated towards the Cerna. The entire area of the plateau has an endoreic character.

The surface flow shows many discontinuity elements. Ţăsna flows into Cerna during the year, excepting the dry season. Cociu (Ogaşul lui Roşeţ), although with a permanent flow, loses by diffusion a few litres per second in the area of the steep slope. The bed of the Balta Cerbului Depression, totally developed on granites, collects all the discharge from the limestones placed in superior altimetric position, into a permanent brook, *Foeroaga Bălţii,* which flows into a sinkhole, above the steep slope. Some of the springs, even with weak flows, can sustain a surface flow on lengths of tens of metres in the Sandilor Valley, Năvlău Valley and the Între Plaiuri Valley.

An important requisite of the existence of losses in the Cerna and of a longitudinal circulation through the graben southwards is represented by the system of longitudinal and transversal faults which delimit tectonically fallen blocks, some located at 150-200 m away from the others. The 300-400 m thickness of the Urgonian limestones

	Imergence	Tracer	H m	Emergence	H m	L km	ΔH m	V km/d	Year	Reference
1	Prejna stream	F	470	Bârza Spring	240	22.0	230	1.15	1998	Bandrabur et al, 1998-1999
2	Poiana Muşuroaie	I	870	Bîrza Spring	240	7.2	630	1.03	1979	Povară, 1980
3	Ogaşul Ştiubeiului	In	750	Jelerău Spring	650	1.9	100	?	1988	Povară, 1980
4	Balta Cerbului	I	950	Şapte Izvoare Reci	175	1.85	775	6.3	1975	Povară, 1980
5	Balta Cerbului	F	950	Şapte Izvoare Reci	175	1.85	775	1.46	1977	
6	Balta Cerbului	F	950		175	1.85	775	1.10	1978	
7	Valea Ţăsna	F	590	Vânturătoarea	250	1.75	340	0.9	1979	
8	Ogaşul Bobotului	F	560	Pişetori Springs	350	2.60	210	0.16	2005	unpublished
9	Ogaşul Ţiganului	F	560		350	1.25	210	0.27	2005	unpublished
10	Izvorul lui Trop	R	680		350	0.85	330	0.05	2005	unpublished
11	Valea Vlazilor I	F	770	Cârlige Spring	580	1.24	190	0.25	1979	Povară, 1980
12	Valea Vlazilor II	R	750	Geanţul Hărmanului	414	0.42	336	0.60	1979	Povară, 1980
13	Cave in Glameia creek	R	580	"La Schit" Springs	455	1.15	125	0.28	1979	unpublished
14	Gorganu creek	I	495	Bolboros Spring	280	8.65	215	2.16	1970	Slăvoacă et al.,1985
15	Losses of Motru Sec	In	350	Bolboros Spring	280	7.4	70	1.48	1983	Slăvoacă et al.,1985
16	Ponorul Izvorele	In	580	Bolboros Spring	280	8.83	300	0.63	1989	Diaconu, 1989 (ISER Report)
				Baia Catchment	275	9.32	305	0.61	1989	
				Brebina Springs	280	8.24	300	0.60	1989	
17	Valea Jghiabului	F	700	Furca Apei Spring	500	1.85	200	0.31	1996	Povară et al, 1996
18	Ogaşul Mohilii	F	980	Isverna Cave	450	2.55	600	0.39	1979	Povară, 1980
19	Ogaşul Giurgiani	F	850		450	4.60	440	1.58	1979	

Table 2. Water tracing in the Mehedinți Mountains and Mehedinți Plateau.

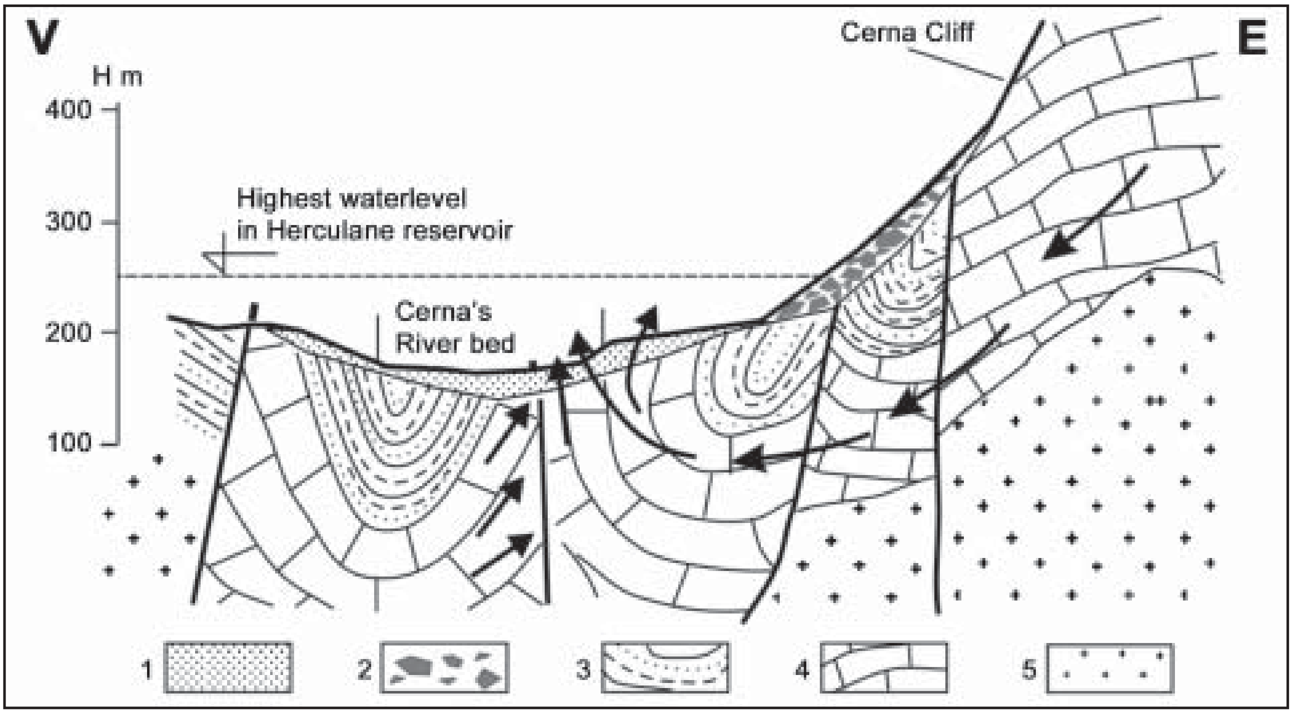


Figure 2. Hydrogeological features of the appearance of the emergence group "Şapte Izvoare Reci". Due to the presence of the Prisaca (Herculane) water storage, the emergences are located at 40-50 m below the level of the lake.

1. Alluvia; 2. Glacis scree; 3. Upper Cretaceous (flysch-like deposits); 4. Limestones J_3-K_1; 5. Cerna Granite.

may assure their longitudinal continuity, from one compartment to another.

3.1.3. Pișetorile Hydrokarst System

The *Pişetorile* group of springs is situated 22 km north of Băile Herculane, in the Cerna left slope, at 15-25 m relative height (Figure 3). From a geological point of view, the area belongs to the Danubian Domain, at the border between the sedimentary areas Presacina (with thicker and coarser deposits) and Cerna, with deep sea depositional aspect (Codarcea 1940, Năstăseanu 1979).

Taking into account the Jurassic and Cretaceous sediments aspects, this sector is integrated within the Cerna sedimentary area (Codarcea 1940). As opposed to the „classical", Cerna area, the Liassic (Lower Jurassic) layers, consisting in siliceous or lithic sandstones, are very reduced (ca. 1-2 m thickness) or missing, thus above the Arşasca Granite, where limestones can be directly, transgressively encountered. Similarly, the sparitic or dolomitic Dogger calcareous sandstones, overlaid by a thick Upper Jurassic siliciferous limestone sequence, and especially by massive limestones of Barremian-Aptian age, in Urgonian facies. In the supply area of the Pişetori Aquifer, the Nadanova Layers appear absent, and the Upper Cretaceous is represented by heterogeneous deposits with wildflysch aspect.

The general geological structure is characterised by the shrivelling of older and harder rocks, together with newer and more plastic rocks from the wildflysch. The hard rocks adapted to stress by bed fractures and vertical subdivisions (shortening of bed with space narrowing), and the plastic ones by shrivelling and intense crushing, forming oblong synforms between the anticline climaxes.

The morphology is dominated by Urgonian limestone crests, parallel to the Cerna River (which they dominate by 250-300 m), where the affluents of the latter form short gorges with 20-25% slopes where diffuse water infiltration take place. Tracings with fluorescent tracers (fluorescein and rhodamine), performed by I. Povară and I. Orăşeanu in 2005 on Ogaşul Bobotului, Ogaşul Ţiganului, Ogaşul cu Bolovani and downstream of the Trop Spring, have shown the drainage link between these losses and the Pişetori sources. The theoretical average velocities obtained varied between 0.05 and 0.27 km/day.

The six resurgences appear diffusely from under a calcareous detrital deposit on a front of 240 m, reaching an annual average flow of 47.9 l/s

(Table 1). The temperature of the sources water varies (8.9 and 9.5°C), and the annual variation does not exceed ±0.2°C. Downstream of the emergence areas, recent calcareous tuffs have been deposited, on a 3 m thickness.

3.2. Topolnița Valley

This river is formed by two brooks, originating in crystalline rocks, in the proximity of the villages Prejna and Coşuştea, at an altitude of ca. 600 m. Downstream, Topolniţa forms two lakes, one temporary at Gornoviţa, the other permanent in the Balta village.

The karst phenomena are present only in the area of the upper stream of the river, between the localities Prejna and Bunoaica, becoming especially important to the south of Balta.

In its upper part, the Topolniţa basin is rather asymmetric, the important affluents coming from the right side. They cross the limestone wall, mostly through underground ways, the surface courses being rather short. Thus the Valley of the Ponorel, after a quite short route, completely loses its water at the contact with the limestones (Q_{mean} = 10 l/s). The same process is witnessed in the Ponorăţ and Topolniţa Valleys.

The most evolved karst phenomena are seen in the Topolniţa-Epuran complex.

The Topolniţa-Epuran Area. *The Topolniţa Cave*, carved in limestones of Upper Jurassic-Aptian age, is a gigantic, ramified, sub-horizontal cave, developed on a system of diaclases and fractures, generally striking NNE-SSW. The galleries network (ca. 16000 m) is situated on four levels, of which one is active, carved by three brooks, namely: Topolniţa, Peţimea and Ponorăţ.

The Epuran Cave is a large cave (3604 m length), with galleries placed on two levels, an upper, fossil, one and a lower, active, one. It is actually the northernmost part of the Topolniţa Cave. It was created by the combined action of the waters of the Ponorăţ and Topolniţa brooks, which merge underground (Bleahu et al., 1976).

The Gramei Cave. This cave is developed on a system of diaclases and horizontal layers, with fossil and sub-fossil galleries, 390 m long. The cave was carved by the water of a valley situated right to its north, which soon ends in some sinkholes.

The Sfodea-Balta Area. To the north, the limestones situated between the localities Balta (NE) and Sfodea (SW) occupy an area of ca. 2 km^2. The limestones of Upper Jurassic-Aptian age appearing in the area are dipping to the southeast. As most important endokarst phenomena we indicate: *the Sfodei Cave* (640 m) and *Peştera Mare de la Balta* (600 m).

An important karst source for this sector is *the Sfodea Spring* - source no. 9 (Q = 3-5 l/s; T = 9.7-9.9°C), found right upstream from the homonymous cave with its supply area, from the limestone plateau extending to the north-east.

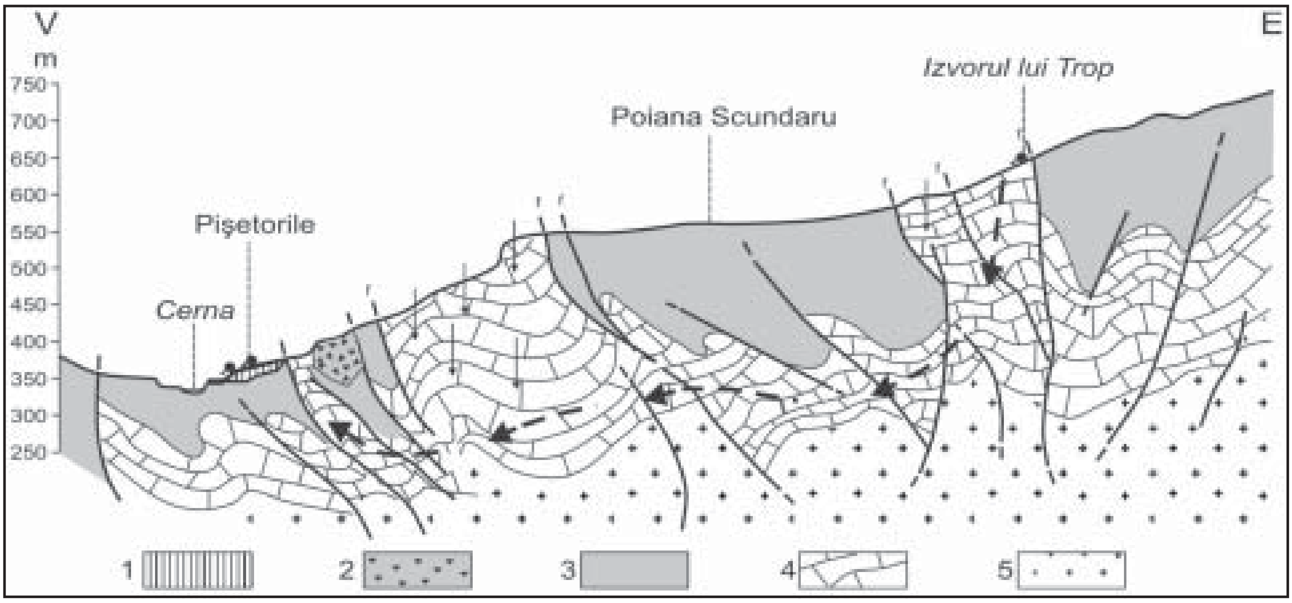


Figure 3. Hydrogeological profile in the emergence area of the Pişetori karst sources. (M. Conovici, I. Povară, previously unpublished material)

1. Travertine; 2. Clays with limestone blocks - K_2; 3. Flysch deposits - K_2; 4. Limestones - J_3-K_1; 5. Cerna Granite.

3.3. Eastern area of the Mehedinţi Mountains

From the east of the Vf. lui Stan-Domogled Anticline, between Vf. lui Stan to the north and Vf. Colţul Pietrii to the south, mainly outcrop Barremian-Aptian limestones. The general drainage of groundwater in the northern zone of this sector is west-east, while in the southern zone the discharge takes place towards the hydrographic basin of the Cerna, downstream from Băile Herculane.

In 1979, I. Povară (I.S.E.R.) was able to prove, using dye tracers, that the plateau sector developed to the east of the mentioned anticline and situated between Vf. lui Stan to the north and the Ţesna Brook to the south, is mostly discharged into the hydrographic basin of the Coşuştea Brook.

The main sources from this area are the springs of the Coşuştea Valley and the Isverna source.

The supply of the Coşuştea Brook (at the origin) is done by the *Susoaică Spring* - source no. 6 (Q = 15 l/s; T = 7°C) and *Ogaşul Popii* - source no. 7 (Q = 4 l/s; T = 10°C), these springs emerging, just like in the case of the Isverna Cave Source, from the Lower Cretaceous limestones of the Cerna Duplicature.

Isverna Cave. This is a cave developed on 4200 m, through which an underground stream flows on a distance of 2700 m, of which 1438 metres represent galleries situated below the piezometric level (siphons)[1]. The flow of the stream as it leaves the cave varies depending on the rainfall (Table 1). The cave is supplied from the limestones of the Cerna Duplicature situated to the north and north-east, through numerous sinkholes and diffuse infiltration points located on Ogaşul Surdului, Ogaşul Zgăului, Ogaşul Mohilii, etc.

3.4. Coşuştea Valley

The carbonate sector of the Coşuştea Valley stretches from the north of Nadanova up to the south of the Cerna-Vârf. After entering the limestones, during the dry season, the brook diffusely infiltrates in its bed, the waters resurging near the locality Cerna-Vârf.

The few caves in this area have non-significant dimensions.

The only identified springs, *Bigărul Mare* - source no. 10 (Q = 0-10 l/s and T = 11.2°C) and *Bigărul Mic* - source no. 11 (Q = 0-5 l/s and T = 10.4°C) are temporary. According to Bleahu et al. (1976) these springs might originate from the partial drainage of the waters of the neighbouring hydrographic basin (Prejna Valley - Area of the Gornoviţa Meadow).

3.5. Northern Sector of the Mehedinţi Mountains

This sector is situated between the Brebina Valley to the south and the Motru Valley to the north and east. Middle Jurassic-Cretaceous Limestones are an extension of those from the southern and central part of the Mehedinţi Mountains, forming a 15 km long and 1.4 km wide strip.

Brebina-Obârşia Valley. The most important karst source of the area is the *Furca Apei Spring* - source no. 22 (Table 1), a spring situated in the westernmost part of the locality Obârşia Cloşani. The geological structure of the area is of a faulted monoclinal type, striking SW-NE and dipping SE. The faults, of small extent, are considered fractures associated to the large horizontal fracture developed along the Brebina Valley (Povară et al., 1996).

During one of the tracing operation performed in order to outline the supply basin of this source, the tracer (fluorescein) launched in the loss area of the thalweg of the Jghiabului Valley, a valley situated ca. 2 km north of the spring, appeared at the Furca Apei Spring, 6 days later, the result being a theoretic average velocity of ca. 13 m/h (Povară et al., 1996).

The Motru Sec-Baia de Aramă hydrokarst system. The karst area of the Motru Sec Valley corresponds to a strip of limestones, 3.5 km wide, which is cut by the water of this brook, between the Gorganului Brook and the Motru Sec village. During prolonged dry seasons, the water of the Motru Sec Brook is entirely catched, upstream of the locality Motru Sec. Most of the rainfall infiltrates through the beds of the valleys, which become dry, and also through sinkholes. The springs are missing.

The rainfall runoff, gathering from the right slope of the Motru Sec Valley, from the outcrop-

[1] *Information received from M. Baciu, Speleology and Underwater Explorations Group - Bucharest.*

ping area of the low permeability deposits of the Cretaceous flysch, is disappearing through the beds of the valleys, as soon as they enter the limestones. The caves are dry and become active only in seasons with abundant rainfall.

In the Motru Sec Basin 26 potholes and 33 caves have been discovered so far, of which the Martel Cave and the Lazului Cave together account for nearly 8 km galleries (Goran, 1982).

The discharge of the water catched in the area of the Motru Sec Valley (carbonate zone) takes place through the springs of the thalweg of the Brebina and Bulba valleys, near the locality Baia de Aramă.

Their character of karst resurgences has been proved in time by tracings with tracers made by the specialists of the I.N.M.H. (National Institute of Meteorology and Hydrology), I.S.E.R. or S.C. Prospecţiuni S.A. Thus, on the occasion of one of these tracings performed by Slăvoacă and Orăşeanu (1970), on one of the affluents of the Gorganului Valley, which loses its water at the entrance in the limestones, the tracer (^{131}I) appeared 96 hours after the injection, nearly simultaneously in the emergences of the Berilă Brook - Bolborosu Spring (source no. 16) and the springs of the left slope of the Bulba Valley (group of sources no. 14).

The continuity of the limestones of the Danubian Domain from the Motru Sec towards Baia de Aramă, underneath the wildflysch layers has also been proved by another tracing performed by the above named specialists. The tracer (In-EDTA) inserted into the Motru Sec Brook (upstream of the Motru Sec village) was detected 120 hours later in the Berbecuţi (source no. 20) and Bolborosu springs (source no. 16).

The fluorescein inserted in the sinkhole of the Izvorele Valley, a left side affluent of the Motru Sec in its lower course, the northernmost point where a tracer had been injected, was detected in the Baia de Aramă Springs (Diaconu, 1989).

In the bed of the Brebina Valley, upstream of the confluence with the Bulba Brook, three important sources have been identified, namely: *Bridge Springs*, *Berbecuţi Spring* (source no. 20) and the *Ovid Spring* (source no. 21). In the left slope of the Bulba brook or in its bed, right upstream of Baia de Aramă, on a distance of ca. 300 m, a *line of springs* appears (grouped in the source no. 14) with flows comprised between 0-25 l/s. During prolonged dry seasons, many of the mentioned sources turn from springs into sinkholes through which the water of the Bulba Brook is catched. Due to the rarity of this mechanism in the Romanian karst we present its scheme in Figure 4.

Icoană Spring, situated at the downstream extremity of the group (source no. 15) operates as a permanent spring. In 1992, I. Povară, showed by

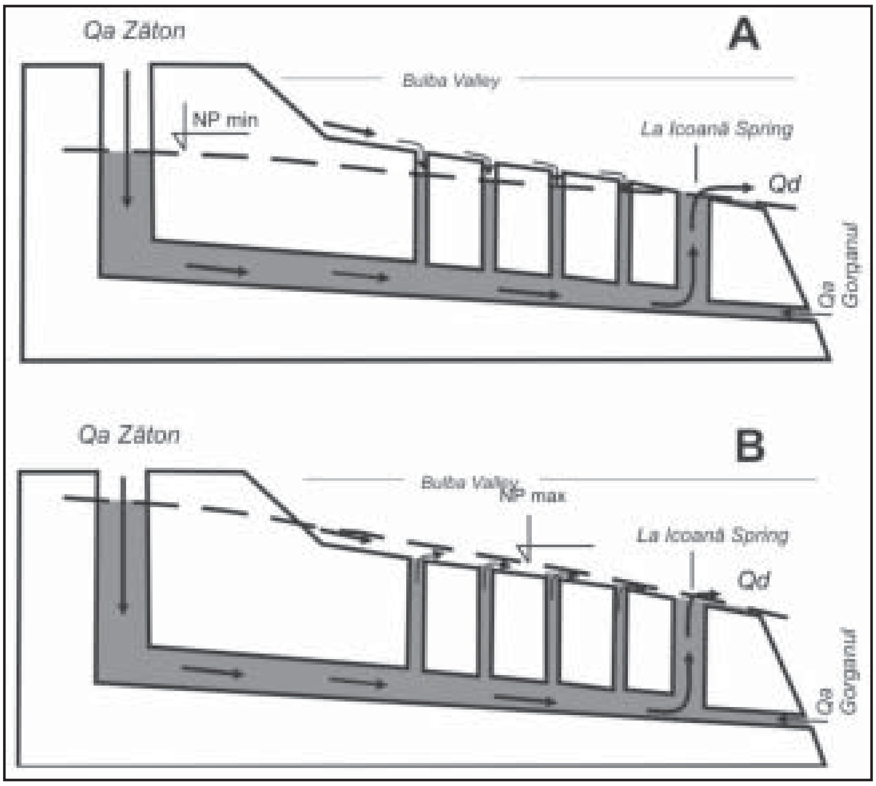


Figure 4. Hydrodynamic mechanism of the *sinkhole-spring type (estavella)*.
A - At the minor bed, when the rate flow (Q_a) is lower than the discharge possibilities (Q_d), the Bulba Brook supplies the karst aquifer through sinkholes.
B - In periods with abundant rainfall, the supply of the aquifer exceeds the discharge possibilities, and the sinkholes become springs (Povară, 2006).

tracing with fluorescein that there is a hydrodynamic link between one of the sources/sinkholes situated on the Bulba Valley, upstream, and the Icoană Spring. The tracer appeared some 52 hours from the launch, the travel distance being ca. 300 m.

Other important sources in the area are: *Bolborosu Spring* (source no. 16), with a flow rate of ca. 30 l/s, *Păstrăvărie Spring* (source no. 17), with a flow rate of ca. 40 l/s, *Spring from Biserică* (source no. 18) with a flow rate of ca. 3 l/s and the *Abator Spring* (source no. 19) with specifications rendered in Table 1.

The Motru Valley. The Motru River or Motru Mare, up to the junction with the Brebina Valley crosses two areas with carbonate deposits.

The first zone, situated north of the locality Cloşani, represents the eastern end of the Mehedinţi Mountains. In this sector, Piatra Mare a Cloşanilor (1420 m) represents a massif with a very narrow crest, with nearly vertical walls on the north slope. Eastwards, towards the Motru Valley, an area where there are many karst voids (caves and potholes), the slope is cut by steep and dry valleys.

Scuteală Spring - source no. 26 (Q = 8 l/s; T = 8.8°C) is situated at the entrance of the Motru in the gorge sector, upstream of the Cloşani village, in the right slope, the minor bed. The supply area is represented by limestones forming the Piatra Mare a Cloşanilor.

West of the Cloşani village, at 433 m absolute altitude and 73 m above the river Motru (right slope), is situated one of the best known caves from Romania, the *Cloşani Cave*. This is a fossil cave consisting in two galleries, 1100 m long. As of its genesis, researchers from I.S.E.R. show that one of the galleries (the northern one) was carved by the waters of the Motru Mare Valley, and the other one (western one), by the waters of the Motru Sec Valley (Bleahu et al., 1976).

The second carbonate zone, crossed by the Motru Valley, is located on the territory of the locality Călugăreni.

Călugărul Spring (source no. 23) situated in the thalweg of the Călugărul Valley (N of the locality Călugăreni) is the most important karst spring in the basin of the Motru Mare. The water is ascendant, emerging at the base of a limestone steep slope of ca. 15 m height. The supply area coincides with the karst plateau situated immediately to the northeast (western end of the Vâlcan Mountains).

Lupşa Valley. The basin of this valley is mainly formed on flysch type deposits (siltstones), but before the junction with the Motru Sec River, the Lupşa Brook crosses on ca. 2.4 km a patch of limestones, outcropping on an area of 0.875 km^2. The entire zone is affected by numerous fractures, and the limestones are very karstified.

The position of this patch of limestones is uncertain. While researchers from the I.G.G. (Pop et al., 1975) consider it to be an olistolith, the I.S.E.R. researchers (Povară et al., 1996) consider its position as tectonic superposition on siltstones.

On the sector where Lupşa crosses the carbonate layers, partial or total water losses have been identified (during dry seasons). Also, on the affluents of the valley, diffuse water losses (for the left side affluents) or total water losses, at the contact with limestones (for the right side affluents) have been noted.

In the Lupşa Valley left slope, ca. 200 m upstream from the confluence with the Motru Sec Valley, at bed level, two springs emerge (sources no. 24 and 25 – Table 1). During dry periods, when the main valley remains without water, small springs appear upstream, in the bed.

Tracing operations performed within the basin have shown some drainage directions. Thus, the tracer inserted in immergences of the right side affluents of the Lupşa Brook (at the entrance in the carbonate sector), was detected in the emergence downstream (source no. 24) and in those from the river bed (Povară et al., 1996).

3.6. Northern Sector of the Mehedinți Plateau

The northern sector of the Mehedinţi Plateau is framed between the Brebina Valley to the north and the Isverna-Ponoarele fracture to the south.

The Zăton-Ponoarele-Bulba hydrokarst system. At the northern limit of the Mehedinţi plateau, on the territory of the Ponoarele commune, one of the most complex hydrokarst systems of Romania can be found. This system looks like a file of closed hollows, without surface communication, but united by a common underground drainage.

The Zăton Hollow (2 km^2), situated to the south-west of the locality Ponoarele, consists in two branches, a northern and a southern one, each of these being crossed by a water stream. In seasons with abundant rainfall or after the melting of snow, the water volume brought about by the brooks is higher than the one which the sinkholes from the eastern part of the hollow are able to drain. The water excess accumulates in a temporary lake - Zăton Lake, with an area of a few hectares.

Ponoarele Hollow (0.8 km^2) is nearly entirely developed on limestones and is crossed by the Turcului Brook to the north and by the Ponorului Spring Brook (Morilor Valley) to the south, a brook which loses its water in the Podul Natural Sinkhole. Here also a lake is formed (Ponoarele Lake) in periods with abundant rainfall.

The Podul Natural Cave, situated in the area of the Ponoarele locality, is a sub-horizontal cave, consisting in a network of fossil, sub-fossil and active galleries. The two upper levels represent the old drainage ways of water from Zăton to Ponoarele Lake. In periods of water level rise in the Zăton Lake, the sub-fossil gallery is flooded through two wells operating as overflow mechanisms (Goran, 1978).

The water of this karst system gathers underground in the *Bulba Cave* and resurfaces in the cave resurgence.

Gărdăneasa-Băluţa Zone. This karst area with a height of 550-600 m, occupying ca. 4 km^2, is fragmented by a hydrographic network oriented NW-SE. The Gărdăneasa-Băluţa karst plateau lacks a permanent flow of surface waters. The water draining non-karst formations is catched by sinkholes, at the contact with the carbonate zone, excepting Răeni Valley in the rainy seasons.

The Băluţa Cave, the largest accessible karst cavity in the area, is a temporary emergence, situated near the thalweg of the Răeni Valley (left slope). The water is discharged by some resurgences situated at the lowest elevations, on both sides of the limestone pile.

Among the most important sources we mention the one in the Morilor Valley, source no. 13, by which a part of the water accumulated in the western part of the zone is discharged (Table 1).

4. Hydrogeological balance – Motru Sec Valley basin

The rainfall in the area of the Motru Sec Valley, obtained on a basis of daily measurements, performed during the hydrologic year 01.10.1997-30.09.1998 at various pluviometric stations, indicate close values, namely: 1020.5 mm at Baia de Aramă (altitude 280 m), 1091.1 mm at Motru Sec (altitude 350 m) and 1359 mm at Cloşani (altitude 350 m).

The appraisal of water losses by evapotranspiration at the ground surface in the interest area was made based on data resulted from direct measurements performed at the mini-platform installed in the locality Cloşani. The values of evapotranspiration on grassy land were lower than the ones of the lysimeter with shrub (657.1 mm compared to 607.3 mm). Conversely, infiltration was more intense on grassy land compared to the shrub covered land (270 mm compared to 209.7 mm).

The mean annual discharge in the basin of the Motru Sec Valley - upper stream (up to the karst entrance) was of 832.46 l/s, this resulting in an average specific discharge of 16.57 l/s/km^2.

The basin of the Motru Sec Valley - middle and lower stream consists up to 80% in carbonate deposits. For this sector, an average annual specific flow of 12.3 l/s/km^2 was obtained.

The hydrogeological balance drafted for the hydrologic year taken into account indicated that from the value of the yearly average flow of 1339.22 l/s, some 737.75 l/s (55%) infiltrates. This value can be found back in the flows of the Baia de Aramă sources, for which the total yearly average flow amounted to ca. 810 l/s. To the losses in the Motru Sec Valley one might add the possible losses from the Motru Valley or the infiltration taking place on the limestone plateau north of Obârşia Cloşani.

5. Hydrochemical considerations

In order to understand the water-rock interactions along the surface and underground water streams, samples of rainwater, of surface water and of spring water were taken for chemical analysis.

Simulations using PHREEQE soft have shown that most waters are sub-saturated considering carbonate minerals (calcite and aragonite), being able do dissolve $CaCO_3$, either on their surface course (e.g. Motru Sec Valley), or on their underground course (*e.g.*: immergence in the Lupşa Valley with Lupşa emergence - downstream and immergence in the Prejna Valley with emergence at Bârza).

For the basin of the Lupşa Valley the result is a dissolving capacity (underground) of 36 mg/l, to $CaCO_3$ (characteristic value at the time of sampling).

The results obtained (by hydrochemical modelling) in the case of analysis made using immerging water from the Prejna Valley (Mehedinţi Plateau) and the Bârza emergence (Mehedinţi Mountains, Cerna basin) have shown the following aspects:

- the water of the *Bârza Spring* is modified compared to the immerging water in the Prejna Valley, due to an addition of magnesium resulted from the contact water-magnesium minerals (phyllosilicates: talc, sea foam and chrysotile);
- the mineralizing of the Bârza water takes place mostly due to the dissolution of $CaCO_3$, which brings 45 mg/l Ca^{2+} (for the monitored period).

The water of the springs in the Mehedinţi Plateau and Mountains is differentiated qualitatively only by the presence and variation of the magnesium contents (present in concentrations much lower than those of calcium), the general chemical character being bi-carbonated calcic.

Chemical simulations indicate two chemical water types:

- a type of water with chemical character resulting only by the dissolution of limestone (*e.g.*: Icoană Spring, similar to the spring in the Lupşa Valley - downstream);
- a type of water with chemical character resulting from the mixture between the first type of water and the water crossing other lithologic layers, from where they take over a relatively small, variable quantity (less than 10 mg/l), of magnesium (*e.g.*: Spring from Biserică and Păstrăvărie Spring, similar to the Bârza Spring); the origin of the magnesium consists in the relatively small quantities of dolomite and filosilicates (talc, sea foam and chrysotile); the latest minerals show a longer contact between water, crystalline schists and basic rocks.

The general chemical character of the investigated sources is, as mentioned above, bi-carbonated calcic, with total mineralization varying between 150-450 mg/l.

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