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THREE KARSTIC SYSTEMS (ROȘIA, TOPLIȚA DE ROȘIA AND VADUL CRIȘULUI) IN THE PĂDUREA CRAIULUI MOUNTAINS (ROMANIA)

BY

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The paper presents data regarding three karstic aquifers: Roșia, Toplița de Roșia and Vadul Crișului, whose hydrogeological basins were outlined by surveing the subterranean cavities and the tracers experiments. Complete informations are given concerning the experiments with In-EDTA, La-EDTA and Rhodamine B, carried out in Valea Perjii, Birtin and Pintiuca sinkholes. These tracers appeared in Roșia Spring respectively Vadul Crișului. There is also a presentation of the Ciur Ponor cave and a structural characterization of the three karstic systems.

1. GENERAL DATA

Roșia and Toplița de Roșia karstic systems are situated in the southern part of the Pădurea Craiului Mountains, around Roșia village

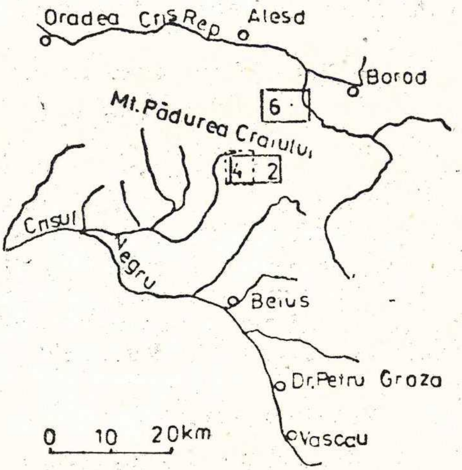

Fig. 1. The position of figures number 2, 4, 6, on the map of Pădurea Craiului Mountains.

and Vadu Crișului in the northern part, near the same named village (Fig. 1).

The Pădurea Craiului Mountains presents the largest karstifiable surface in the North-Western Carpathians with different morphological aspects, the main being the levelling surface.

The karstic pattern is represented by the various forms of the karstic plateau such as : limestone pavement, sink-holes, uvalas, closed depressions, caves, potholes. On the other hand the tributaries to Crişul Negru and Crişul Repede rivers penetrated into this limestone mass, deeping to 200—300 m under the level of the plateaus, generating gorges, in whose cliffs the slope karst is represented by fossil caves and rockslides (e.g. Albioara, Cuţilor and Crişul Repede Valleys).

The limestone pavement are the subcutaneous type and outcrop in the bauxite quarries in the Runcuri area. But the most frequent karstic forms in the limestone plateau are the sinkholes. Their largest number is found in the Jurassic limestones, a fewer of these being in Neocomian-Aptian limestones, while in the Anisian ones they appear sporadically and have smaller dimensions. The connection of more sinkholes brings morphologically closed basins. Some of them are situated at the boundary between the karstifiable and the unkarstifiable formations and are crossed by short rivers, which in their lowest point are going underground, through either a cave or an impenetrable swallow-hole.

In the Pădurea Craiului Mountains more than 850 caves and potholes are known. Among them there is the longest in Romania, the Wind Cave (Peştera Vîntului) and the deepest pothole, Stanu Foncii (— 334 m).

2. GEOLOGICAL DATA

In the area, the Bihor unit and posttectonic cover formations outcrop from the Paleozoic to the Neogen age (Bordea et al., 1986).

There will be presented only the carbonate formations belonging to the Bihor unit and to the posttectonic cover.

2.1. Upper Sinemurian-Lower Callovian

These deposits are formed in the basement by encrinite limestones, which are transgressively disposed over the subjacent ones (Bordea, 1986). They are 3—4 m wide. Above, in continuity of sedimentation, there is a marly sequence, with marly limestones and limestones intercalations, having reduced widths reaching 20 m.

Limestones bearing ferric oolites, having an average width between 5—10 m, are disposed transgressively. The whole block rarely surpasses 50—60 m, and the surfaces on which it outcrops are small and unevetly spread in the area (Bordea, 1986).

2.2. Upper Jurassic

These deposits are disposed in continuity of sedimentation over the earlier ones. As part of these the following terms have been separated: the Vad limestones, the Gălăşeni limestones, Farcu limestones, the Cornet limestones and the Albioara limestones, with a total width of 200 m.

At the end of the Jurassic stage, an emersion movement took place, and the raised platform latter underwent an intense erosion (Bordea, 1986).

2.3. Neocomian

The Neocomian is represented by bauxite. In the paleokarst excavations bauxite silts were deposited forming bauxite rocks, which have lens-like forms and variable dimensions (max. 12 m wide, 130 m in diameter, Bordea, 1986).

2.4. Neocomian-Lower Aptian

Transgressively over earlier deposits limestones bearing *Characee* appear, followed by limestones bearing pachyodontes. They are between 35—500 m wide.

2.5. The post-tectonic cover.

The Senonian (Santonian and Lower Campanian) in Codru facies is developing in the Roşia depression in the southern part of the area. It is made up of limestones in plates and limestones bearing rudists, which in the lower part have a gritty sequence, and are covered above by breccias and sandstones.

3. TECTONIC AND STRUCTURAL DATA

Within the Alpine cycle in the North of Western Carparthians there are two over lapped structural units, namely : the Bihor Autochthonous and the system of Codru nappes.

The Autochthonous does not present outstanding structural units (duplicates), only horsts and grabens, where the formations are monoclinal and widely folded. This partitioning is the result of diastrophisms that took place from the Cretaceous to the Pliocene and that affected both the crystalline basement, and the sedimentary cover.

In the Pădurea Craiului Mountains the sedimentary formations generally outline a vast monocline with a daily appearance, in the south-eastern part of the crystalline basement and that north-westwards are overlapped by ever newer formations, up to Cretaceous deposits.

Before the emplacement of the Codru layers, the structural edifice of the Pădurea Craiului Mountains, was to a great extent made up and presented systems of displacements that preferentially have a NE—SW orientation. After the emplacement of the Codru layer (having a layer of shearing nature) appears systems of fractures with a prevailingly NW—SE direction.

Laramic diastrophism stresses the disjunctive tectonics where NW—SE directions are predominant again. In the Neogene, laramic fractures were reactivated, but there are also E—N and N—S orientated secondary fractures.

4. HYDROGEOLOGICAL DATA

Quartz sandstones bearing Werfenian red clay schists make up the impermeable basement for karstic aquifers in the area.

From the Anisian to the Lower Carnian more limestone and dolomite rocks deposits were formed that have a total width up to 900 m representing the *Lower Aquiferous Series* of the Pădurea Craiului Mountains.

From the Hettangian to the Lower Sinemurian the area is marked by a prevailingly gritty sedimentation.The resulted formation is 150 m wide and make up the impermeable foundation for the *Middle Aquiferous Series*.

In the *Middle Aquiferous Series* carbonate rocks prevail about 220 m wide and includes from the Upper Sinemurian to the Cretaceous basis formations.

At the end of the Jurassic, under the effect of a strong emergence, bauxite lenses are developing. Impermeable bauxite rocks and the discordant surface between the Jurassic and the Cretaceous make up the impermeable screen between the Middle Aquiferous Series and the Upper Aquiferous Series. The tightness of this surface is partial, especially due to the discontinuity both of the bauxite rocks and fractures, which allows an intercommunication between the two aquifers, being preferentially directed from the Jurassic to the Cretaceous. The deposits in which the Upper Aquiferous Series lies belong to the Neocomian-Barremian and the Senonian (Santonian-Campanian).

4.1. THE ROSIA KARSTIC SYSTEM

The Roşia spring appears on a NE—SW fracture, which separates the Jurassic formations from the Triasic ones. The minimum registered discharge was 66 l/s (Orăşeanu, 1983). The multi-annual average discharge is 425 l/s (Fig. 2).

The supply area of the Roşia spring extends northwards, the waters going underground through the swallow holes of Barc, Botului, Stanu Foncii, Jurcanilor cave, Orzenişte and Fiului Valley sinkhole (Pietrele Albe). All these points lie in Triasic deposits, and a part of them were checked by tracing experiments (Table 1).

On the 28-th of August 1985 a tracing experiment with In-EDTA was made in the Perjii Valley sinkhole. The Topliţa de Vida, Topliţa de Roşia and the Roşia springs were established as main points of waiting the tracer. The tracer was pointed out only in the Roşia spring. On the basis of measured values the variation curve of the tracer concentration was drawn according to the time, shown in Fig. 3. Analyzing the C(t) curve, we can say that the tracer probably appeared between 4 and 5 of September 1985, because the value of the maximum concentration was obtained for the sample taken on the 5-th of September 1985, namely 8 days after the injection day.

The test was made in a low discharge period. Immediately after the injection date, several rains fell that determined an increase of the Roşia spring discharge. This water supply caused quicker flowing of the tracer towards the spring.

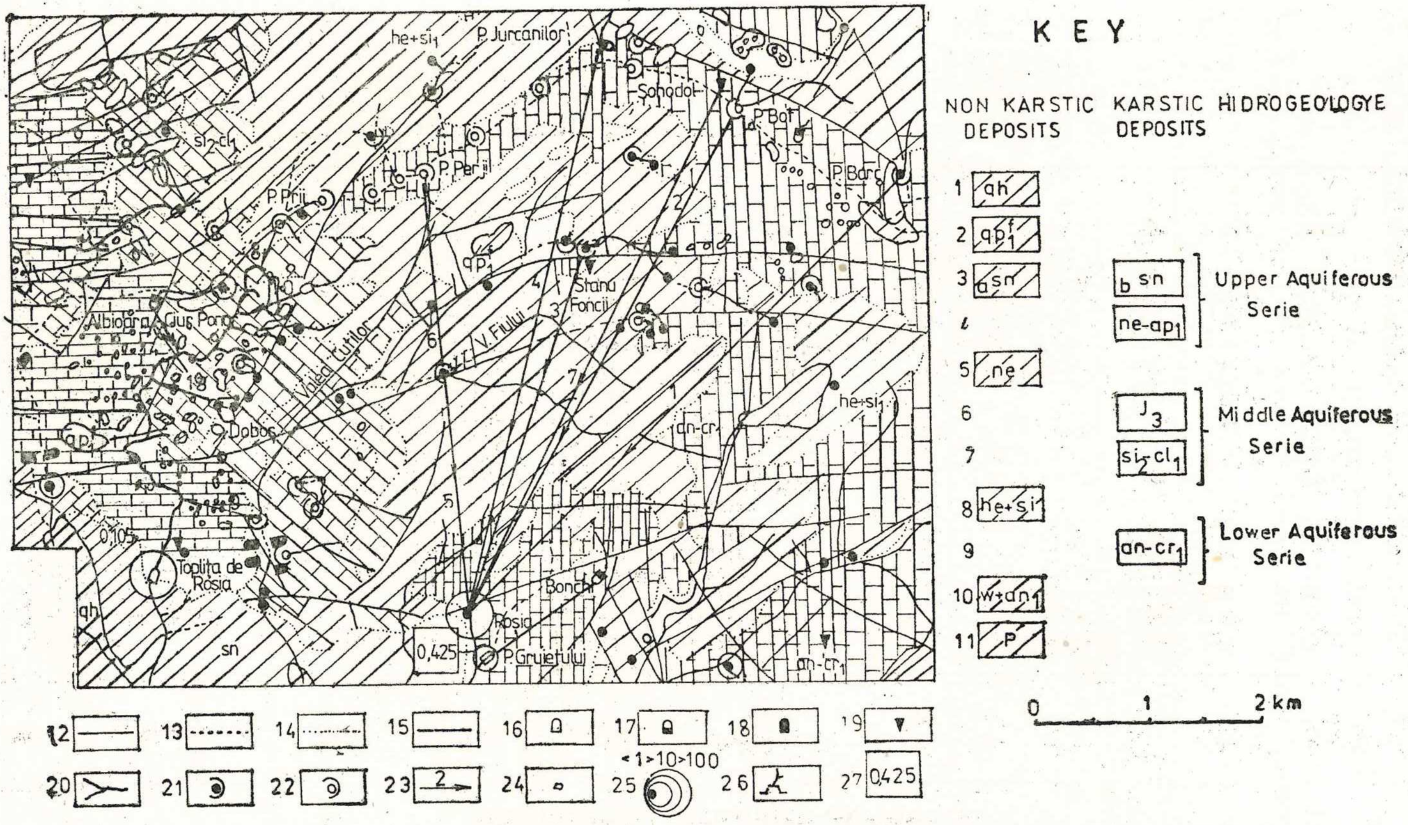

Fig. 2. Hydrogeological map of the Roșia area : 1. Quaternary ; alluvial deposits ; 2. Quaternary ; old colluvial deposits ; 3.a. Senonian ; sandstones and conglomerates, b. Senonian ; limestones in plates ; 4. Neocomian-Lower Aptian ; limestones with Characee ; 5. Neocomian ; bauxites ; 6. Upper Jurassic ; Farcu and Albioara limestones ; 7. Upper Sinemurian-Lower Callovian ; sandy and marly limestones ; 8. Hettangian-Sinemurian ; quartzitic sandstones ; 9. Anisian-Lower Carnian ; Wetterstein limestones ; 10. Werfenian-Lower Anisian ; quartzitic sandstones and schists ; 11. Permian ; schists and sandstones ; 12. Geological limit ; 13. Lithological limit ; 14. Discordance limit ; 15. Fault ; 16. Outlet cave ; 17. Inlet cave ; 18. Fossil cave ; 19. Pothole ; 20. Cave passages ; 21. Shallow hole ; 22. Temporary shallow hole ; 23. Direction of groundwater flow ; 2 – number of experiments from the Table 1 ; 24. Sinkhole ; 25. Spring ; discharge in l/s ; 26. Mine gallery ; 27. Multi-annual average discharge in m/s.

Table nr. 1

THE RESULTES OF TRACTING EXPERIENCES

Nr.	Injection point	Alt.	Q l/s	Data	Author	Appearance point	Alt m	Q l/s	Dist. km	Dis-lev m	Transit time	Speed m/h	Tracer type
1	Barc	615	0,8	1983	I. Orășeanu	Roșia	290	105	6,38	325	624	10,2	In
2	Boiului valley	525	—	1966	T. Rusu	Roșia	290	—	5,10	235	146	35	F
3	Iezere valley	550	—	1967	T. Rusu	Roșia	290	100	2,40	260	350	68	F
4	Jurcanilor cave	545	1,5	1983	I. Orășeanu	Roșia	290	100	5,10	255	—	—	R
5	Pietrele Albe valley	515	—	1970	T. Rusu	Roșia	290	—	2,10	255	300	7,0	F
6	Perjii valey	486	0,1	1985	G. Ponta	Roșia	290	250	4,40	196	168	26,1	In
7	Sohodol II pothole	—	—	—	CSA Cluj	Roșia	290	—	—	—	—	—	F
8	Prii valley	415	4,2	1986	T. Rusu	Toplița Roșia	275	52	—	140	—	33,0	F
9	Cuților valley	360	5,0	1970	T. Rusu	Toplița Roșia	275	22	1,0	85	13,3	59,0	F
	Cuților valley	360	—	1981	I. Orășeanu	Toplița Roșia	275	—	1,0	—	—	27,5	R
10	Tinoasa valley	535	—	1968	T. Rusu	Toplița Roșia	275	—	3,0	260	78,0	38,0	F
11	Ciur Panor cave	480	—	1968	T. Rusu	Toplița Roșia	275	—	2,4	205	93,0	26,0	F
12	Ciur Izbuc cave	515	—	1968	T. Rusu	Toplița Roșia	275	—	2,8	240	70,0	40,0	F
13	Dobos cave	485	0,5	1981	I. Orășeanu	Toplița Roșia	275	50	1,6	210	22,0	72,0	R
14	Albioara	420	0,7	1968	T. Rusu	Toplița Roșia	275	22	2,5	145	89,0	29,0	F
15	Bătrînului cave	574	0,3	1966	T. Rusu	Vadu Crișului	305	102	4,2	269	89,0	47,0	F
16	Pintiuca	604	0,1	1986	G. Ponta	Vadu Crișului	305	—	4,4	299	—	20,3	In
17	Pintiuca	604	0,1	1986	G. Ponta	Vadu Crișului	305	—	—	—	—	—	R
	Birtin	550	0,1	1986	G. Ponta	Vadu Crișului	305	—	4,5	245	270,0	59,0	In
18	Tomnatic school	640	0,1	1986	G. Ponta	—	—	—	—	—	—	—	La

F = Fluoresceine ; R = Rodamine ; In = Indium ; La = Lanthanum

The test allowed the tracing of the watershed between the Toplița de Roșia and Roșia basins.

4.2. THE TOPLIȚA DE ROȘIA KARSTIC SYSTEM

The Toplița de Roșia spring lies in the basin of the Roșia valley and constitutes the main outlet of the Runcuri karstic plateau, which is

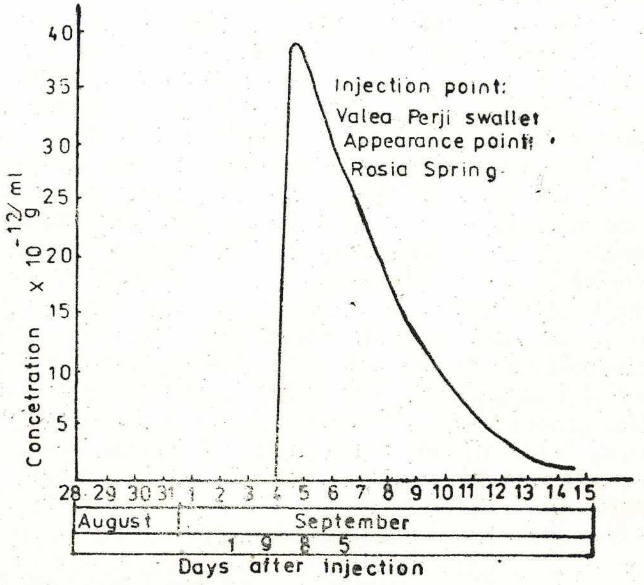

Fig. 3. The transfer curve of the In-EDTA concentration detected in the Rosia spring.

situated in Neocomian-Barremian limestones. The registered minimum discharge was 11 l/s (Orășeanu, 1983), while the multi-annual average discharge is 105 l/s. During long periods without rains the main spring that appears through the entrance of the cave runs completely dry, and only the downstream one remains active.

The supply of the system is assured by the Albioara swallow-hole, the Ciur Ponor cave, the Tinoasa cave, the Runcuri swallow-hole, the Prii valley swallow-hole, the loss in the Cuților valley, that is completely drained only during periods of low flow rates (Fig. 4).

The swallow-holes belonging to the supply area of the Toplița de Roșia spring were checked by 7 tracing experiments (Table 1). The results of these experiments allowed the outlining of the hydrogeological basin of the spring.

The main collector of the Toplița de Roșia spring is given by the Ciur Ponor cave.

4.2.1. Description of the Ciur Ponor — Toplița de Roșia cave

The entrance of the Ciur Ponor cave is 5 × 5 m, lying at the absolute altitude of 483 m. The downstream entrance, Toplița de Roșia is 6 × 5 m and lies at an absolute altitude of 280 m.

The cave starts with a entrance chamber, 10 m in diameter, where the river bed is covered by gravel and a clay beach. At the end of it a narrow passage opens, which is 0.8—1.5 m wide, with waterfall-like slope breaches, the highest being 10 m. At its basis there is a relatively round chamber 5 m in diameter, that divides the cave in two distinct sections, the downstream system and the upstream system.

The downstream system begins with a narrow passage similar to the entrance one which does not change its shape up to the duck-under named by the cavers ,,Sifonul lui Peşte''. After this restriction the gallery enlarges step by step reaching 2.5 × 2.5 m at the point of confluence with the first side tributary.

The first left side tributary is 1460 m long and the end of it is at + 30 m from the jonction point. The passages are disposed on two levels, an active one and a fossil one. In the middle part of the side gallery, the two levels are present and form a labyrinthic maze.

Downstream the jonction point, the cave gallery has large dimensions (2 × 5 m). On the right side it is running in the water of the third tributary. At 1300 m from the entrance there are two chambers that are morphologically linked, known under the name of ,,Sala Taţilor de Familie''. 100 m later, the fourth left side river appears, with a total length of 1 km. A new chamber follows on the the main gallery, that has a clay beach on the right side, crossed by a water course. From this point the gallery gets a winding aspect due to meanders and flowing levels. The gallery forks into an active field and a subfossil one, the ,,Marmitelor Gallery'' becoming one again after 50 m. In the mentioned active field affluent 5 bis inlets. At the terminal point, named BH the water is lost in a sump, that can be overtaken, through a short dry field comunicating with the river through a 4 m shaft-pit. The gallery of the active field suddenly enlarges in the biggest chamber of the cave named ,,Paragina Chamber''. The area has a chaotic aspect of fallen blocks coming up to more than 25 m high, through which the river penetrates with difficulty to ,,The Meanders Passage'' It is a wide gallery (4—6 m) with flowing levels on walls, quite well decorated. Its terminal point is a lake, 18 m in diameter, that being the first sump, of the cave.

A succession of three short sumps follows, disposed on 100 m, beyond which a gallery with the same shape like Meanders Passage begins having a length of 1540 m. In the central part of this passage, two left side tributaries are coming in. At the jonction point a chamber with a large collapse of blocks is present.

The section between 4 to 8 number sumps is 140 m long, the 8-th sump being in the entrance of the Topliţa de Roşia Cave.

The Upstream system

It has a total length of more than 3000 m. The main gallery is about 1000 m long, with a stream to a greatest extent. Here, the widths of the galleries are smaller the height are 20 m, having a general aspect of diaclases. On the walls, flowing levels are present. The end presents a labyrinthic maze, where the dry and streamy passages alternates. The river appears in the cave at — 0.5 m relative altitude from the entrance. It represents the northern part of the cave, where the river is coming in diffusely from narrow passages, through blocks of stone.

Three inlets on the left side were descovered, being supplied probably by the Ciur Izbuc stream. The stream from the northern end of the cave are supplied by diffused losses at the contact between limestone and the impermeable rocks (the main swallow hall is the Prii valley), the main ground course being formed at the joining point of four water penetrations.

We can see that the entrance gallery and the upstream system of the cave present a different morphology from the downstream one. In the first case the narrow galleries prevail, and have a diaclases aspect, in whose walls flowing levels appear. The downstream system is characterized by wide high galleries and large chambers.

This differenciation is caused by the lithology of the deposits crossed by the ground river. The upstream system is generally situated in a gritty, marly oolitic carbonate rocks belonging from the Lower Sinemurian to the Callovian, while the downstream one is developped in Tithonian and Neocomian-Barremian limestones.

On the geological section in Fig. 4 the direction of the main stream of the area is shown. The caves survey and the tracing experiments clarify the ground drainages disposed on a 200–300 m difference of level and are helpful for calculating the water dynamic reserve.

The information of the static reserve of the carbonate deposits, disposed on other 400 m wide are less known and will be completed by hydrochemical studies, environment isotopes and hydrogeological drillings.

4.2.2. *Structural characterization*

The area is part of the tectonic compartment situated in the southern and eastern part of the Pădurea Craiului Mountains, named the area of antithetic steps.

The structural assemblage is generally orientated east-westwards, strata falling to the south and south-west, bordered to the north by the raising of the Jofi compartment.

The major tectonic accidents (faults) in the area are mainly orientated NE–SW, secondly NW–SE and the third one is E–W orientated (the Jofi an Ţarina fault) (Fig. 4).

The microtectonic measurements pointed out the following main systems of fissures in the area:

— the microtectonic profile made near the entrance of the Ciur Ponor cave presents a main system NE–SW orientated, with bendings oscillating around 90° and a NW–SE orientated system with bendings close to the vertical line.

— the microtectonic profile made next to the main shallow-hole of the Albioara valley pointed out the presence of a NE–SW orientated fissure system, with bendings close to the vertical line and a NW–SE fissure system.

The orientation of the development directions of the galleries in the Ciur Ponor cave presents a main maximum point on the NW–SW direction and a secondary one NW–SE.

Fracturing statistic study

The rectilinear parts of the faults, characterized by length and azimuth were separated on the geological map 1 : 50000, by means of a compass, then numerically treated by a programme that supplies the unitary and cumulated lenghts of the faults on angular sections of 10°.

Out of comparing the lengths of cumulated faults on angular sections of 10°, on the one hand, and the number of fissures on the other, the following coefficients of correlation resulted;

— for the interval between 0° and 100°; r = 0.55 with the equation of the regression right line

$$y = 3.91 + 0.28 \times \text{(Fig. 5)}$$

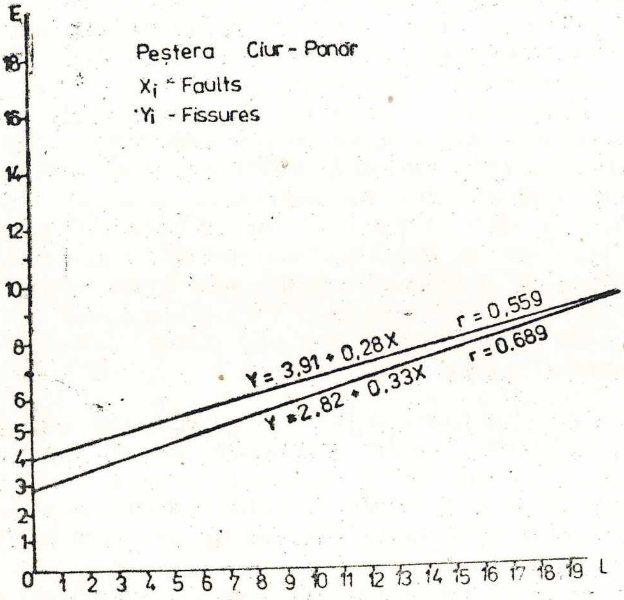

Fig. 5. The relation between the lengths of cumulated faults on angular sections of 10° and the number of fissures in Ciur Ponor cave area.

— for the interval between 91° and 180°; r = 0.689; and the equation of the regression right line is

$$y = 2.82 + 0.33\,x$$

— for the interval between 101° and 130°; r = 0.839
— for the interval between 11°—40°, r = 0.750
the other intervals of correlation being insignificant.

The comparison between the lengths of the faults and the rectilinear parts of the galleries in the Ciur Ponor cave on angular fields of 10° gives the following coefficients of correlation;

— for the interval 0°—180,°, r = 0,14
— for the interval 31°—60°, r = 0.788
— for the interval 61°—90°, r = 0.998
— for the interval 90°—120°, r = 0.990
— for the interval 121°—150°, r = 0.986

For the other intervals the correlations are very weak. Out of the statistic analysis it results that the orientation of the faults, fissures and rectilinear parts of the galleries in the Ciur Ponor cave develop on two main NE—SW and NW—SE orientated directions.

4.3. THE VADU CRIŞULUI CAVE KARSTIC SYSTEM

The Vadu Crişului cave resurgence is situated on the left side of Crişului Repede valley. The multi-annual average discharge is 186 l/s.

The first experiment with tracers in the area was carried out by Theodor Rusu, who proved the underground connection between the Bătrînului cave inlet and the Vadu Crişului cave outlet. (Fig. 6). On the June the 4-th 1986, 3 testing experiences were made in the same time, as follows: In-EDTA (20 g) in the Bătrînului swallow hole, La-EDTA (40 g) in the Tomnatic swallow hole and 3,5 kg B Rhodamine in the Pintiuca swallow hole.

The tracers were waited for in six springs disposed along the left side of Crişul Repede river, but it appeared only In-EDTA in the Vadu Crişului spring. The transfer curve presented in Fig. 7, shows that the

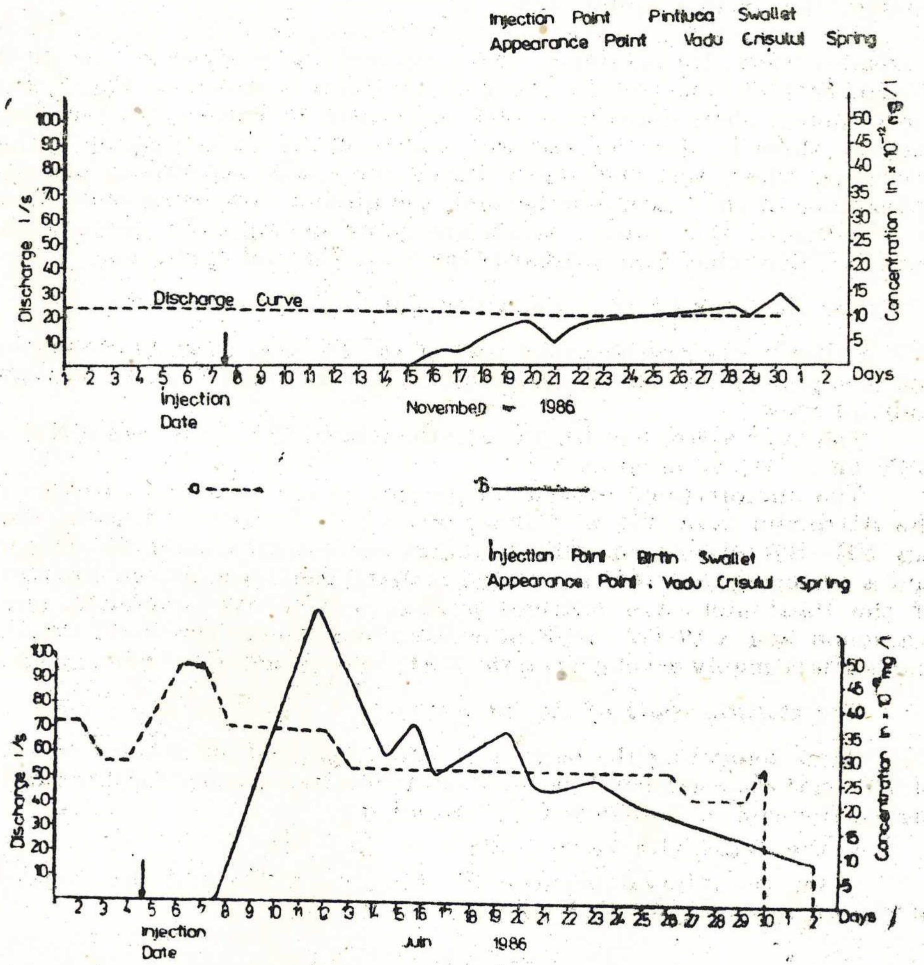

Fig. 7. The transfer curve of In-EDTA concentration detected in Vadu Crişului spring; a. spring discharge curve; b. In-EDTA curve.

transit time of the tracer through the spring exceeded 25 days. The average transit time calculated for this situation is 270 hours. In fact the curve can be extrapolated, being likely to extend to at least 7 more days. As a result of this, the dynamic volume, V, must be higher than the value : V (m) = 30 Q
volume Q is the discharge of the Vadu Crişului spring in $m^3/24$ hours. On the same diagram the discharge curve was shown too. It can be noticed on this that the quick appearance of In-EDTA was helped by the high flood produced during the experiment. The tests carried out with the other two tracers led to no results because the Rhodamine B experiment carried out in Pintiuca sinkhole resulted negative.

In November 1986 the test was remade in the Pintiuca swallow hole, this time the In-EDTA was used, water samples systematically taken from six springs pointed out the direction of ground flow only through the Vadu Crişului cave.

The first appearance of the tracer was signaled out on the 16-th November 1986. Its maximum concentration was reached on the 30-th November 1986. The transfer curve of the tracer is shown on Fig. 7, and the technical characteristics of the experiment in Table 1. On the same diagram there is also the variation curve of the Vadu Crişului spring discharge, which was unchanged during the whole experiment and the appearance of the tracer was belated, the ground flow being quite slow. It is supposed that waters which are going underground through the Surdului cave inlet, drains towards the Vadu Crişului spring too.

The Bătrînului cave — Vadu Crişului Cave hydrostructure

It lies in the north-eastern part of the Pădurea Craiului Mountains and it is part of the Zece Hotare tectonic compartment from a structural point of view.

The main systems of fractures in the area are NE—SW and WNW — ESE up to E—W orientated.

The microtectonic measurements carried out near the entrance of the Bătrînului cave (Fig. 6) pointed out a main system of fissures, that are NE—SW orientated with bendings oscillating around 90° (Fig. 6) and a secondary NE—SE orientated system. The development directions of the Bătrînului cave passages present a NE—SW orientated main maximum and a WNW—ESE orientated maximum. The Vadu Crişului endokarst is mainly developed on the ENE—WSW and NW—SE direction.

The statistic study of the fracturing

After comparing the lengths of faults gathered on angular sections of 10°, on the one hand and the number of fissures, on the other, the following coefficients of correlation „r" resulted :

— the Bătrînului cave area :

— for the interval between 0°—180°, r = 0.235 and the equation of the regression right line (Fig. 8),

$$y = 4.48 + 0.17\,x\,;$$

— for the interval between 121°—150°; r = 0.843;

For the other intervals the correlations are insignificant. The comparison between the lengths of the faults and the rectilinear parts of the

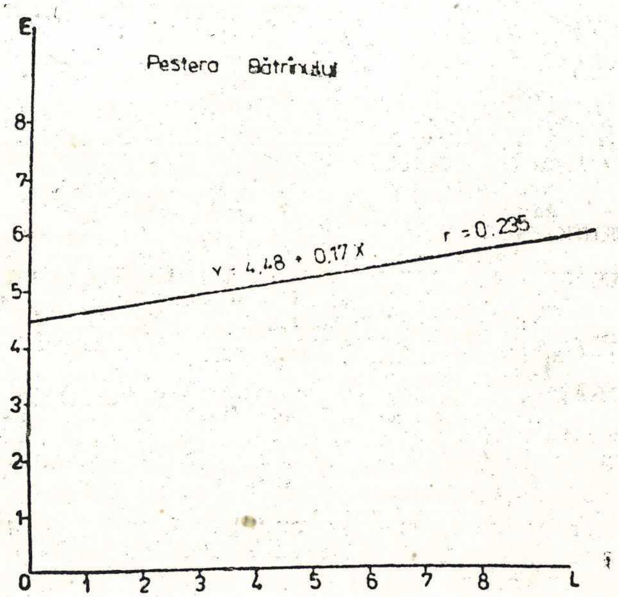

Fig. 8. The relation between the cumulated lengths of the faults on angular sections of 10° and the number of fissures in the Batrinului cave area.

gallery in the Bătrînului and Vadu Crişului caves, gives the following coefficients of correlation „r'':

a. the Bătrînului cave:
- for the interval 0°—30°, r = 0.662
- for the interval 31°—60°, r = 0.957
- for the interval 91°—120°, r = 0.860
- for the interval 151°—180°, r = 0.619

b. the Vadu Crişului cave;
- for the interval 0°—30°, r = 0.663
- the for interval 31°—60°, r = 0.689
- for the interval 61°—90°, r = 0.943
- for the interval 91°—120°, r = 0.785
- for the interval 121°—150°
- for the interval 151°—180°, r = — 0.759

Analysing these data it results that the galleries of the Bătrînului cave are well and directly correlated on the 0°—30°, 91°—120°, and 151°—180° intervals and very well, but well enough on the 31°—60° interval.

The rectilinear parts of the galleries in the Vadu Crişului cave are well correlated to the faults in the area on the 0°—30° and 31°—60° intervals and very well, but conversely, on the 91°—120° and 151°—180° intervals.

It can be concluded that the transversal rectilinear lines of drainage adjust themselves to the same distribution of the fault network and one orientated according to the preferrential directions of the microfracturing, together with the local hydraulic gradient.

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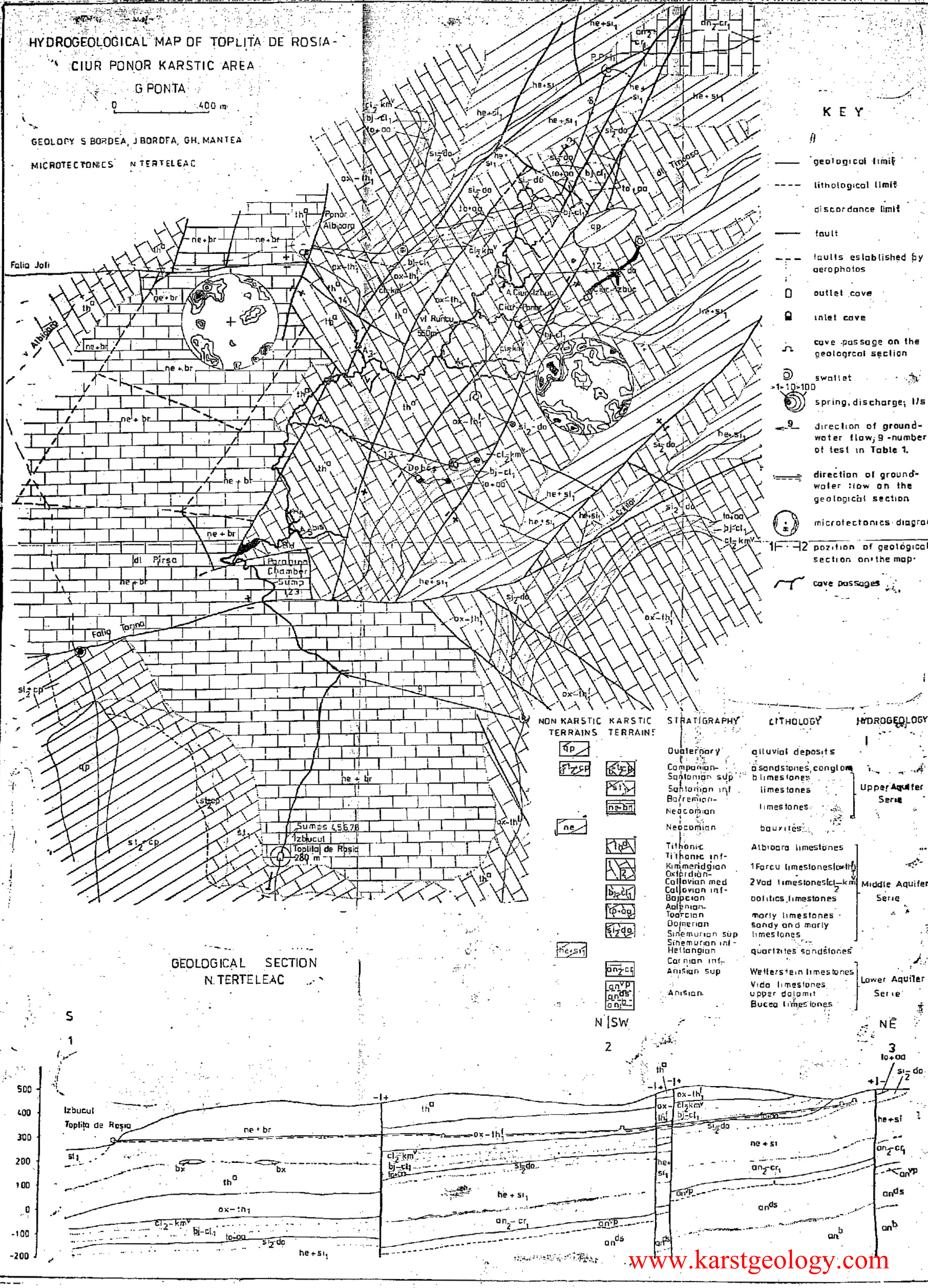
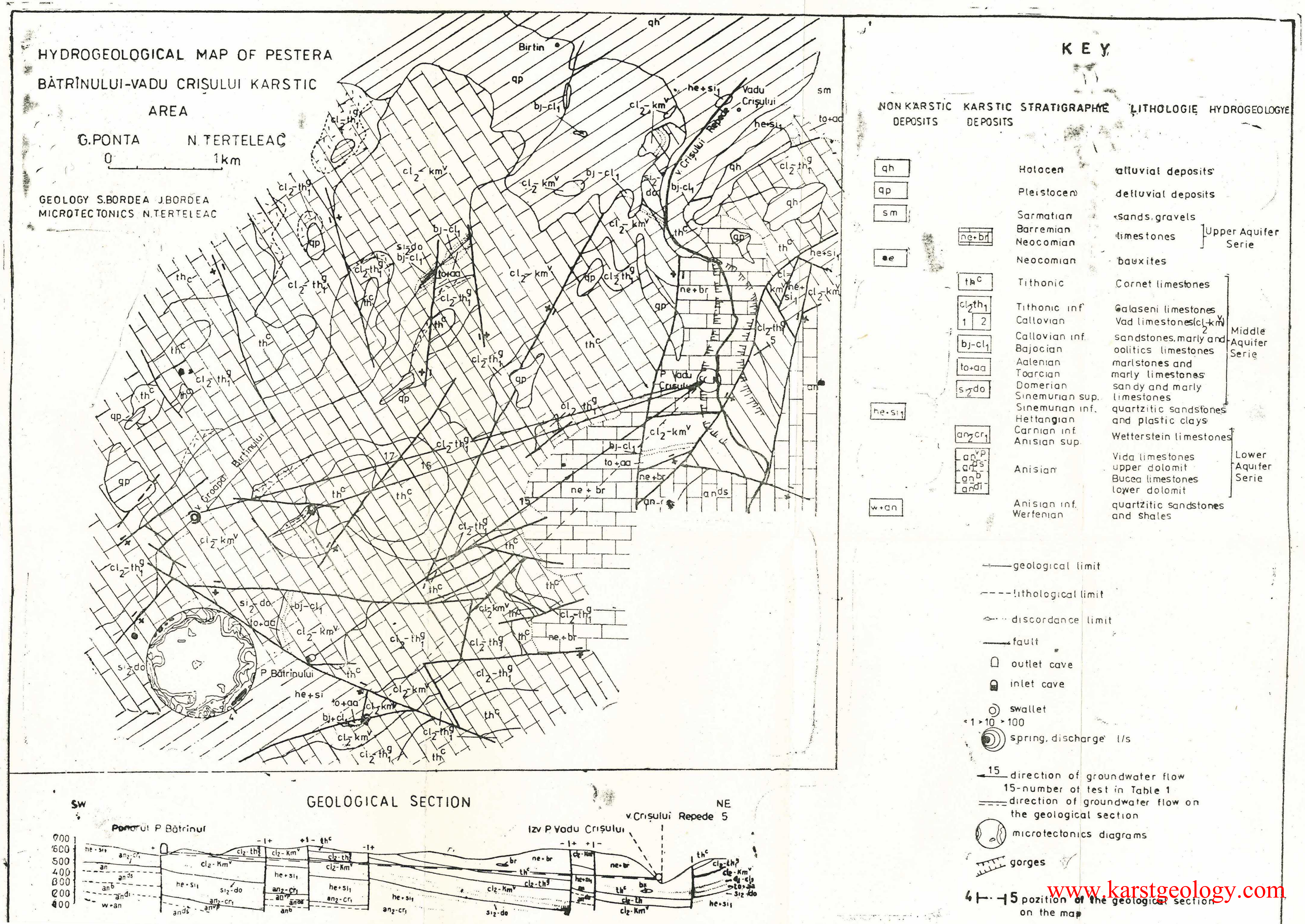

HYDROGEOLOGICAL MAP OF TOPLITA DE ROSIA - CIUR PONOR KARSTIC AREA
G PONTA
0 400 m
GEOLOGY S BORDEA, J BORDEA, GH. MANTEA
MICROTECTONICS N TERTELEAC
KEY
geological limit
lithological limit
discordance limit
fault
faults established by aerophotos
outlet cave
inlet cave
cave passage on the geological section
swallet
>1-10-100
spring, discharge; l/s
direction of ground-water flow; 9 - number of test in Table 1.
direction of ground-water flow on the geological section
microtectonics diagram
position of geological section on the map
cave passages
NON KARSTIC TERRAINS
KARSTIC TERRAINS
STRATIGRAPHY
LITHOLOGY
HYDROGEOLOGY
Quaternary
alluvial deposits
Companian-Santonian sup
a sandstones, conglom
b limestones
Santonian inf
limestones
Barremian-Neocomian
limestones
Upper Aquifer Serie
Neocomian
bauxites
Tithonic
Albioara limestones
Tithonic inf-Kimmeridgian
1 Farcu limestones
Oxfordian-Callovian med
2 Vad limestones
Callovian inf-Bajocian
oolitics limestones
Aalenian-Toarcian
marly limestones
Domerian
sandy and marly limestones
Middle Aquifer Serie
Sinemurian sup
Sinemurian inf-Hettangian
quartzites sandstones
Carnian inf-Anisian sup
Wetterstein limestones
Anisian
Vida limestones
upper dolomit
Bucea limestones
Lower Aquifer Serie
Falia Joli
Falia Tarina
v. Albioara
Ponor Albioara
Ciur Izbuc
Ciur Ponor
vf Runcu 550m
Dobos
dl Pirsa
Paranina Chamber
Sump 1,2,3
Sumps 4,5,6,7,8
Izbucul Toplita de Rosia 280 m
dl Timosa
GEOLOGICAL SECTION
N. TERTELEAC
S
NE
N SW
Izbucul Toplita de Rosia
500
400
300
200
100
0
-100
-200


HYDROGEOLOGICAL MAP OF PESTERA BĂTRÎNULUI-VADU CRIŞULUI KARSTIC AREA
G.PONTA N.TERTELEAC
0 1km
GEOLOGY S.BORDEA J.BORDEA
MICROTECTONICS N.TERTELEAC
KEY
NONKARSTIC DEPOSITS
KARSTIC DEPOSITS
STRATIGRAPHIE
LITHOLOGIE
HYDROGEOLOGYE
qh Holocen alluvial deposits
qp Pleistocen delluvial deposits
sm Sarmatian sands, gravels
ne+br Barremian Neocomian limestones
Upper Aquifer Serie
Neocomian bauxites
th^c Tithonic Cornet limestones
cl2-th1 Tithonic inf Callovian Galaseni limestones Vad limestones (cl2-km^v)
bj-cl1 Callovian inf. Bajocian sandstones, marly and oolitics limestones
to+aa Aalenian Toarcian marlstones and marly limestones
si2-do Domerian Sinemurian sup. sandy and marly limestones
Middle Aquifer Serie
he+si1 Sinemurian inf. Hettangian quartzitic sandstones and plastic clays
an2-cr1 Carnian inf Anisian sup Wetterstein limestones
an^vp an^ds an^b an^di Anisian Vida limestones upper dolomit Bucea limestones lower dolomit
Lower Aquifer Serie
w+an Anisian inf. Werfenian quartzitic sandstones and shales
geological limit
lithological limit
discordance limit
fault
outlet cave
inlet cave
swallet
<1 >10 >100
spring, discharge l/s
15 direction of groundwater flow
15-number of test in Table 1
direction of groundwater flow on the geological section
microtectonics diagrams
gorges
4 5 pozition of the geological section on the map
GEOLOGICAL SECTION
SW
NE
Ponorul P Bătrînul
Izv P Vadu Crişului
v.Crişului Repede 5
Birtin
Vadu Crişului
P Vadu Crişului
P Bătrînului
v. Groapa Birtinului
v. Crişului Repede