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Contributions to the Poieni Plateau hydrogeology investigation (Metaliferi Mountains, Romania)

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ABSTRACT

The Poieni Plateau is located in the Metaliferi Mountains, to the south of the Arieşul Mic river, and it occurs as a virtually horizontal surface, perched some 300–500 m above the surrounding rivers. It is shaped in massive crystalline limestone included in a monoclinal structure, that gently dips southward, underlain by crystalline schists and overlain by flysh-like deposits.
The water accumulations in the plateau, supplied almost exclusively by rainfall, discharge mainly to the north, through gravitational springs located at the contact of the crystalline limestone with the crystalline schists. The springs in the southern section of the plateau include on the one hand overflow type outlets that discharge the water of the karst aquifer at its contact with the overlying flysch-like deposits, and on the other hand the outlets in the Crişul Alb river valley, an area where the karst aquifer is dissected by this river course. To the east, the karst aquifer cover is locally eroded next to the village of Sohodol, the aquifer water emerging through the spring Feredeu. The cumulated flow rate of the main springs by which the karst aquifer discharges amounts to some 800 l/s. In hydro-chemical terms, the water is generally over-saturated with respect to calcite, many outlets exhibiting extended deposits of travertine.

Key words: karst hydrogeology, Apuseni Mountains, Romania.

Contributions à l'investigation de l'hydrogéologie du Plateau Poieni (Monts Metaliferi, Roumanie)

RÉSUMÉ

Le Plateau Poieni est situé dans les Monts Métaliferi, au sud de la rivière Arieşul Mic et il forme unne surface à peu près horizontale, perchée à 300–500 m au dessus des rivières qui l'entourent. Il est modelé dans des calcaires cristallins massifs englobés dans une structure monoclinale qui plonge légèrement vers le sud, ayant des schistes cristallins à leur base et des dépôts de type flyschoïde à leur toit.
Les accumulations aquifères du plateau, alimentées presque exclusivemement par des précipitations, se déchargent en principal vers le nord, par des sources gravitationnelles situées au contact des calcaires cristallins avec les schistes cristallins. Les sources du flanc sud du plateau sont représentées par des sources de trop-plein, qui évacuent l'eau de l'aquifère karstique au contact de celui-ci avec les dépôts de type flyschoïde du toit, ainsi que par les sources de la vallée de la rivière Crişul Alb, une région où l'aquifère karstique est sectionné par ce cours d'eau. Vers l'est, le toit de l'aquifère karstique est localement érodé aux alentours du village de Sohodol, l'eau de l'aquifère jaillissant à la surface par la source de Feredeu. Le débit cumulé des sources principales qui drainent l'aquifère karstique atteint environ 800 l/s. Du point de vue chimique, les eaux sont en genéral sursaturées en calcite, beaucoup de sources présentant des dépôts massifs de tuf calcaire.

Mots-clés: *hydrogéologie karstique, Monts Apuseni, Roumanie.*

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The Poieni Plateau extends south of Arieşul Mare river, over an area of 88 km^2, being delimited to the east and south-east by the Sohodol stream, a tributary of Arieş river at Câmpeni, and to the west by Vidrişoara stream, a tributary of Arieşul Mic at Avram Iancu. The southern boundary of the plateau consists of the headwaters of Crişul Alb river.

GEOLOGICAL DATA

The Poieni Plateau represents the most extended area of crystalline limestone occurrence (45.5 km^2) in the Metaliferi Mountains. In the close neighbourhood of the plateau, limestone also outcrops south of the headwaters of the Crişul Alb (11 km^2) and, on very small surfaces, in the upper catchment area of the Uibăreşti stream (1.5 km^2). It overlies a strip of black quartzites and graphitic schists, while its normal immediate caprock is, similarly to all the Medium Paleozoic marbles, unknown, the oldest overlying formations being those of Jurassic age (IANOVICI *et al.*, 1976).

The crystalline limestone is widely crystallized, saccharoidal, brittle, of various colours, from milky-white to grey-black, occasionally with pink-yellow tones. It is generally compact, occurring in meter thick beds, yet displaying frequent alternations of decimeter thick or plate-like layers, prevalently of grey, grey-black colours, that provide a stripped appearance. They are roughly 1000 m thick and they have a gentle southward dip. In structural terms, the limestone constitutes the Sohodol marbles series, included in the Baia de Arieş overthrust.

The mineralogical composition exhibits the following contents: 85-90% calcite; 6-7% sericite + muscovite; 3-5% hematite + limonite; 0-1% quartz. The rock structure is granoblastic, while its texture is compact, occasionally schistous.

THE PLATEAU LANDFORMS

Differential erosion, rather weak on the terrains that are covered by crystalline limestone, yet well developed on the terrains adjoining the plateau, led to limestone occurrence in distinct landforms, that resulted from the shaping of an abrasion platform located at 1100–1200 m elevation, which, in terms of landforms shaping is ascribed to the Fărcaşa-Cârligaţi Platform (COCEAN & IFTENE, 1985). Only a few rounded, isolated peaks, among which Ştiubeiul (1215.8 m), the highest peak of the plateau, protrude above this surface.

A specific feature of the topography in this geographic area is the strong contrast which exists between the flat, virtually horizontal appearance of the plateau, strewn with rounded ridges, and the youth of the valleys that surround it. To the north the plateau is delimited by a 300-500 m high bluff facing the Arieşul Mic river course. The continuity of this bluff is broken only at Ponorel by Morii stream, which cuts a deep, roughly 1.5 km long valley through the crystalline schists in the northern part of the plateau.

The other boundaries of the plateau toward the Vidrişoara, Crişul Alb and Sohodol valleys display the same features, with steep slopes, yet with smaller absolute values of the elevation ranges.

The Valea Morii, through its tributaries Dolea Mare and Zugău, divides the Poieni plateau in two parts, with different extensions: a western part, most of which is occupied by the Poieni closed drainage basin (12.4 km^2), and an eastern part, where the Sicoieşti–Dăieni depression (2.4 km^2) occurs.

Inside the basin, a series of concatenated ridges with elevations in excess of 1000 m, much alike to the bordering chain, delineate a series of closed drainage sub-basins, sharply defined in terms of

Table 1. Characteristic discharges of the springs and results of the correlation and spectral analysis.
Caractéristiques des sources et les résultats de l'analyse corrélatoire et spectrale.

	Sursa	Q_{med} l/s	Q_{min} l/s	Q_{max} l/s	n_v	B_f	T (°C)	Correlation and spectral analysis ME	TF	RT
1	Morii spring, Ponorel	229	63	1700	27.0	0.36	8.3 – 9.0	27	0.064	19
2	Feredeu spring, Sohodol	98	18	290	16.1	0.26	8.7 –10.5	28	0.060	20
3	Lerţii spring, Avram Iancu	90	8	1605	200.6	0.13	6.8 – 8.8	4.5	0.016	8
4	Pişoaia Vidrii spring, Vidra	40	4	392	98.0	0.30	6.8 – 8.8	6.5	0.060	12

n_v, index of discharge variability; B_f, base flow index; T, water temperature; ME, memory effect; TF, truncation frequency; RT, regulation time.

Table I. Main parameters characterizing the recession curves (see Fig. 2 for definition of parameters)
Principaux paramètres caractérisant les courbes de récession (voir Fig. 2 pour les définitions des paramètres)

Source	Morii spring	Pişoaia Vidrii spring	Lerţii spring	Feredeu spring
Recession period	06.12.1988–20.02.1989	04.12.1988–20.02.1989	05.12.1988–19.02.1989	05.12.1988–19.02.1989
α [day $^{-1}$]	0.0024	0.0227	0.0100	0.0100
η [day $^{-1}$]	0.0400	0.0385	0.0400	0.0400
ε [day $^{-1}$]	0.824	0.142	0.337	0.085
Q_0 [l/s]	415.0	115.0	150.0	180.0
Q_2 [l/s]	113.0	32.0	15.0	30.0
Q_{R0} [l/s]	120.0	23.4	32.1	64.2
q_0 [l/s]	295.0	91.6	117.9	115.8
t_i [days]	25	26	25	25
Q'_0 [l/s]	113.0	13.0	25.0	50.0
V_{dyn} [m^3]	4330000	89300	227000	554000
V'_{dyn} [m^3]	4070000	49600	216000	431000
v_{inf} [m^3]	69000	54000	43000	79000
V_0 [m^3]	4399000	143300	270000	633000
V_{dyn}/V_0 [%]	98.4	62.3	84.1	87.5
v_{inf}/V_0 [%]	1.6	37.7	15.9	12.5

α, depletion (recession) coefficient of the flooded zone; η and ε, parameters adopted for the falling discharge curves; Q_0, discharge for t=0; Q_2, discharge at the end of the recession period; Q'_0, discharge at t=t_i; V_{dyn}, dynamic volume of the flooded zone, beginning with t=t_0, [V_{dyn}=C (Q_{R0}/α), where C is a constant equal to 86400 when discharge is expressed in m^3/sec and α in days^{-1}; V'_{dyn}, dynamic volume beginning with t=t_i, [V'_{dyn}=C (Q'_0/α)]; v_{inf}, volume evacuated from aquifer in falling period; V_0, total volume, (V_0=V_{dyn}+v_{inf}).

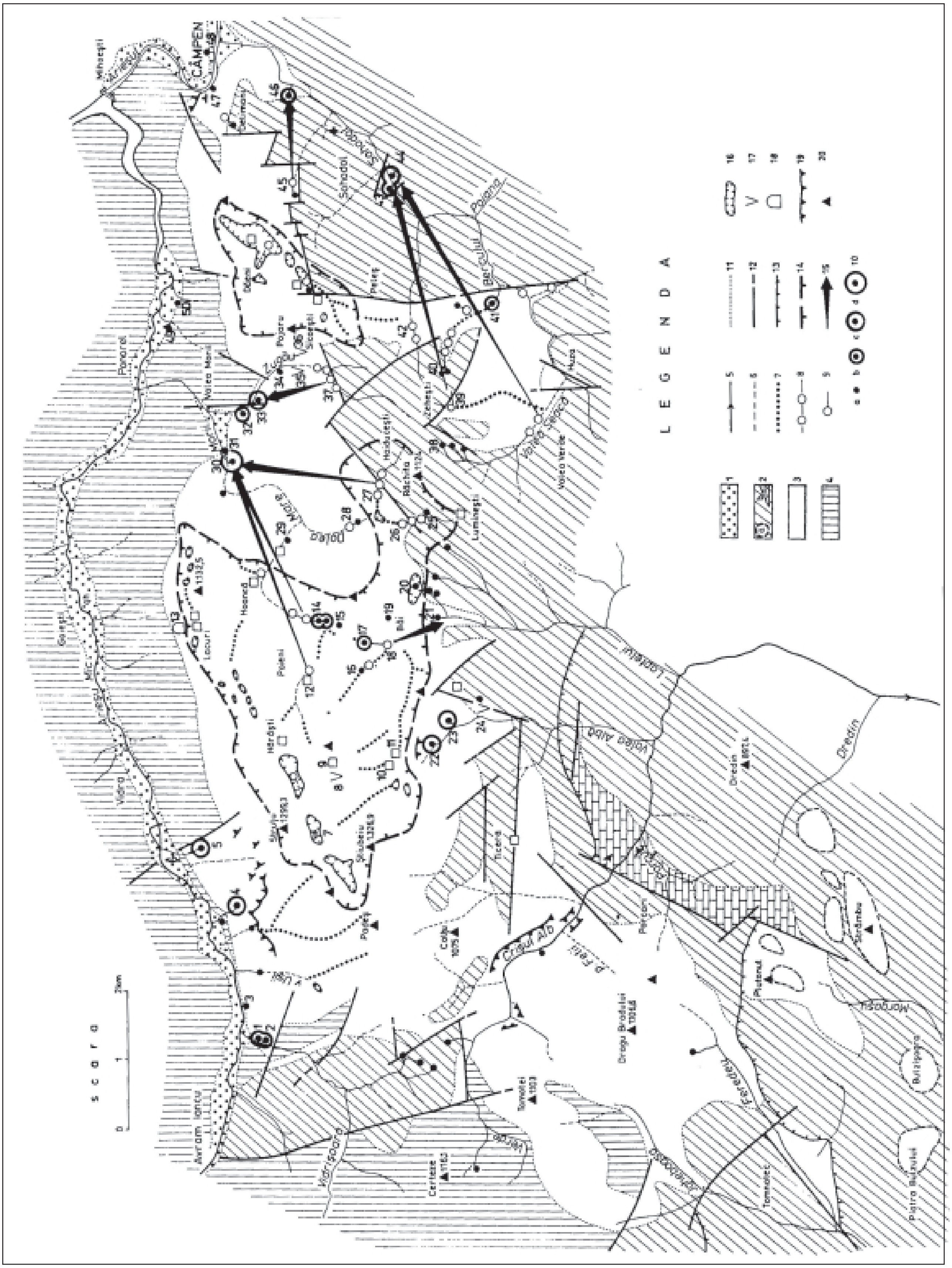
landforms shaping, among which we mention: the sub-basin Crucea cea Lungă (Fig. 1, no. 7) - Hărăşti-Lacuri and Băii sub-basin (Fig. 1, the area no. 16–19).

The Sicoieşti–Dăieni depression mainly consists of a succession of large sinkholes, aligned along a NE-SW striking axis. It is completely devoid of surface stream courses, the local people water supply being restricted to a few wells and springs, located close to Sicoieşti hamlet, and a well dug in the north-eastern end of the depression, at Dăieni.

A specific feature of the shape of the slope that descends from the south-eastern border of the Sicoieşti - Dăieni depression toward the Sohodol stream is provided by a NE-SW striking row of small karst piracy depressions, positioned along the 800 m elevation contour. They are the Delimani, Napoieşti (Fig. 1, no. 45), Hoanca (no. 42), Troaca Dealului (no. 40) and Zeheşti (Dolea Sohodoalelor) depressions, the latter being however situated at a higher elevation. They all display perennial, complete, either diffuse or concentrated sinks.

Sohodol stream surrounds the limestone plateau to the south-east and east, collecting most part of its flow on non-karst terrains, situated to the south of the plateau. In its upper reaches (Valea Seacă) it has a temporary character, as a result of water sinking through the streambed alluvia, into the limestone substratum, the same water being further on discharged through the Feredeu spring, after about 3 km of underground flow.

The surface karst landforms (grikes, sinkholes, dry valleys, gorges) are frequent, while, alternatively, underground karst landforms are generally poorly developed. A few caves of small extension are known, Poieni pothole appearing, in terms of excavated spaces amplitude, as a particular occurrence in this area (150 m in depth, TODA & BOSDOC, 1980).


L E G E N D A
s c a r a
2km
CÂMPEN
Avram Iancu
Mihoeşti
Ponorel
Vidra
Dredin
Huza
Valea Verde
Ticera
Cârţeşti
Lumineşti
Hoanca
Hărăşti
Poieni
Locuri
Certeze
Tomeşti
Petrosul
Dragu Bradului
Piatra Bulzului
Sohodol
Vârtop
Valea Mare
Steghiu
Pojaru
Răchita

THE PLATEAU HYDROGEOLOGY

In the cracks and the karst dissolution voids of the crystalline limestone in the Poieni Plateau important groundwater accumulations are stored, their impervious bedrock being provided by crystalline schists of the Muncel overthrust. In the southern part of the considered domain these groundwater accumulations are confined, their caprock being provided by the Senonian deposits of the Bucium Unit (the sedimentary cover of the Muncel overthrust) and of the Cretaceous ones of the Criş overthrust.

The recharge of the groundwater accumulations originates mainly in rainfall on limestone outcrops, the karst plateau being generally devoid of overlying deposits. An exception to this rule is recorded on the south-eastern border of the plateau, along the Răchita peak–Napoieşti lineament, where the Senonian, essentially sandstone deposits, store water accumulations that discharge through small flow rate springs of perennial character. In these springs originate stream courses which when reaching the crystalline limestone substratum, both to the north, in the Dolea Mare and Zugău catchment area, and to the south, in the Sohodol stream catchment area, totally or partially sink, to participate to the recharge of the water accumulations.

Fig. 1. Hydrogeological map of the Poieni Plateau (Geological data after BEJAN *et al*., 1985, BORDEA & CONSTANTINESCU, 1975, PURECEL *et al.*, 1986-1988)
Legend: 1–Detritic Quaternary deposits with reduced thickness and high permeability, hosting reduced water accumulation; 2–Prevalent detritic Mesozoic deposits (sandstones, conglomerates, argillaceous shales and less frequently limestones), with different permeability. Reduced local water accumulation. a–Limestone olistolits of tithonian-barremiene age; b-Limestone complex of tithonian-hauterivian age; 3–Carbonate Paleozoic series (crystalline limestones) with great thickness, highly fractured and karstified, characterised by very high effective infiltration and intensive groundwater flow. Important water resources; 4-Sericitic-quartzitic schists with permeability of fissures with discontinuous distribution and intensity. The weathering zone is well developed and provides a continuous and important supply of springs with discharges under 1 l/s; 5–Course of perennial stream; 6–Course of temporary stream; 7–Dry valley; 8-Diffuse sinks in river beds; 9-Ponor; 10–Mean annual discharge of the springs (l/s): a- under 1; b-1 to 10; c-10 to 100; d-100 to 300; 11–Geological boundary; 12-Fault; 13–Overthrust front; 14–Boundary of endoreic areas; 15–Proved groundwater flow direction; 16-Karstic depression; 17-Pothole; 18-Cave; 19-Abrupt; 20-Summit.
Carte hydrogéologique du Plateau Poieni (Géologie d'après BEJAN et al*., 1985; BORDEA & CONSTANTINESCU, 1975; PURECEL* et al.*., 1986–1988).*
1. Depôts quaternaires detritiques d'épaisseur reduite et grande perméabilité emmagasinant des accummulations d'eau faibles; 2. Dépôts Mesozoïques, predominant detritiques (grès, conglomèrats, marnes argilleux et calcaires) à perméabilités divers. Accummulations d'eaux locales. a: Olistolites calcaires d'âge Tithonique–Barremienne; b: Complex calcaire d'âge Tithonique–Hauterivienne; 3. Sèrie carbonatée Paléozoïque (calcaires crystallines) à grande épaisseur, karstifiées et fracturées, caracterisées par une grande perméabilité effective et des drainages souterraines. Ressources d'eaux importantes. 4. Schistes séricito-quartzitiques avec une perméabilité fissurale discontinue. La zone d'alterration est bien developpée et assure une alimentation continuelle des sources avec des dèbits moins de 1 l/s; 5. Rivière permanente; 6. Rivière temporaire; 7. Vallée seche; 8. Infiltrations difuses; 9. Perte; 10. Dèbit moyen annuel des sources en l/s: a: moins de 1: b: 1 à 10; c: 10 à 100; d : 100 à 300; 11. Limite géologique; 12. Faille; 13. Charriage; 14. Limite des zones endoreïques; 15. Directions des traçages; 16. Depression karstique; 17. Aven; 18. Grotte; 19. Abrupt; 20. Sommet.
Key of numbers on the map. *Numèros sur la carte indiquent (sources où pertes)*: **1-Vidrişoara spring; 2–Morcos spring; 3–Spring of Patacu; 4–Lertii spring; 5-Pisoaia Vidrii spring; 6-Maritii Lae Drontului spring; 7-Lake of Crucea Lunga; 8–Poieni pothole; 9–Sinului dug-well; 10–New dug-well; 11–Old dug-well; 12–dug-well of Strunji; 13–Bârlogului cave; 14- springs of Fântânele; 15–Izvorul din Dos spring; 16–Barâcea spring; 17–Troaca spring; 18-swallet of Băi; 19–spring of Faţa Baii; 20-spring of Dosul Baii; 21-cave of Valea Laptelui; 22–Albii spring; 23-Pişoaia Albii spring; 24-Piatra Bocului pothole; 25- Ţiganilor spring; 26- diffuse sinks of Lumineşti brook; 27-diffuse sinks of Haiduceşti brook; 28-Pârâul din Dolea Mare spring; 29-Pârâul în Dolea spring; 30–Morii spring; 31–Veteranului spring; 32–spring and cave Huda Sivului; 33–"La Izvor" spring; 34- Zugau spring; 35- Pothole of Hoanca Sturului (Coasta Rea); 36-Vânateaua pothole; 37-diffuse sinks of Zugau brook; 38–Mitului spring; 39-swallet of Dolea Sohodolului; 40-spring of Troaca Dealului; 41-Bârlogului spring; 42-swallet of Hoanca; 43-Iruga lui Dubaş spring; 44-Sohodol spring; 45–spring and swallet of Napoieşti; 46–Topliţa spring; 47-Lucia spring; 48-Izvorul din Drum spring; 49-Cold spring; 50–Bogdaneştilor spring.**

Table 3. Results of the tracing operations. *Résultats des opérations de traçage*.

Insurgence	Resurgence	L(m)	ΔH (m)	Tracer	T (hours)	Velocity (m/h)
Napoiesti swallet	Toplita spring	2450	207	In-EDTA	288	8.5
Fântâna din Strunji swallet	Morii spring	6700	395	$BrNH_4$	264	25.4
Diffuse sinks of Dolea Mică	Morii spring	5000	290	$BrNH_4$	48	104.2
Diffuse sinks of Hoanca Haiduceşti	Morii spring	4500	250	KI	105	42.5
Diffuse sinks of Valea Seacş	Feredeu spring	8500	150	In-EDTA	432	19.7
Zehesti swallet	Feredeu spring	6850	340	In-EDTA	216	31.7
”	Spring of Iruga lui Dubas	6550	330	”	408	16.1
Diffuse sinks of Haiduceşti brook	“La Izvor” spring	2350	250	NaI	48	50.0
Diffuse sinks of Troaca Bai brook	Spring of Laptelui brook	1900	210	In-EDTA	96	17.7

L, horizontal distance between insurgence and resurgence; ΔH, difference in level between insurgence and resurgence; T, time of first arrival of tracer; V, apparent velocity.

The absence of impervious intercalations in the crystalline limestone body suggests that a single karst aquifer exists, whose discharge occurs at its boundaries, being controlled by the systems of fractures and cracks that dissect the crystalline limestone body.

The water accumulations in the Poieni Plateau discharge through a series of springs located at its boundary. The springs at the bottom of the northern slope, in the Arieşul Mic river catchment area, are lithologic contact springs, that discharge the unconfined groundwater accumulations at the boundary between the crystalline limestone and the underlying graphitic and sericitic schists. The main springs in this part of the plateau are: Morii spring (fig. 1, no. 30), Lerţii (no. 4), Pişoaia Vidrii (no. 5), Zugău (no. 34) and “La Izvor” (no. 33). They are no tapped and exhibit, except for the last one, massive travertine deposits.

Over the hydrologic year October 1988–September 1989, flow rate gauging stations have been installed at the main karst springs in the Poieni Plateau, in order to establish their discharge regime. The considered hydrologic year exhibits, while taking into account the main rivers in the Apuseni Mountains, values that slightly exceed (102%) the multi-annual average. The previous year had exhibited a certain flow deficit (85.7%), and the following year exhibited the peak deficit (70.8%) over the entire 78/79–97/98 period (ORĂŞEANU, 2000). Tables 1 and 2 show the characteristic flow rates and the parameters derived from these springs flow rate recession, while Table 3 shows the results of the activable tracer tests, performed in co-operation with E. Gaşpar, I. Pop and T. Tănase, during the 1989–1990 period.

Izvorul Morii karst system

Izvorul Morii is located in the small Valea Morii depression, some 2 km south of Ponorel village, and it emerges from an outlet cave excavated at the bottom of the cliff under Colţul Sturului (CHIRILĂ *et al*, 1987). Over the roughly 50 m distance that separates the cave from the Dolea valley streambed, the spring flow runs across limestone boulders and, in its last section, past a series of small, stepwise positioned lakes, shaped in the travertine substratum.

The analysis of the recession curve recorded during the 1988–1989 winter (Table 2) indicates that the aquifer discharging through Izvorul Morii has important dynamic reserves, the contribution of the base flow being essential in building them (98.4%). The significant amount of the groundwater reserves is also substantiated by the very small value of the recession coefficient (α =0.0024).

The activable tracer tests have indicated that Izvorul Morii discharges water sunk in the swallet at Fântana din Strunji and in the diffuse sinks of the Dolea Mică and Hoanca Haiduceşti valleys (Table 3).

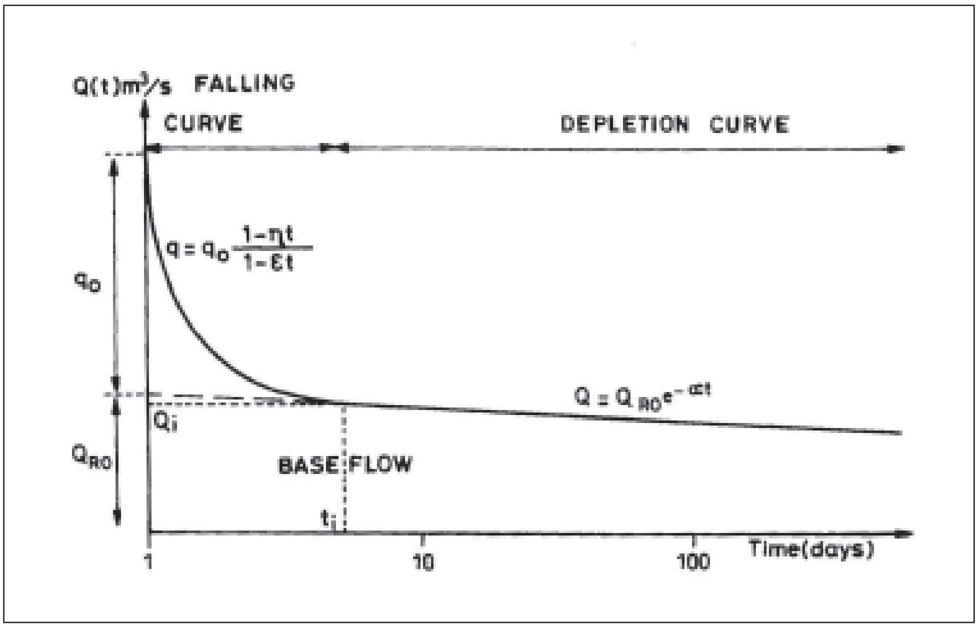


Fig. 2 Recession curves analysis (Mangin, 1994).

Analyse des courbes de récession.

Izbucul Lerții karst system

Izbucul Lerţii discharges from a boulders accumulation situated at the bottom of an over 200 m high wall, under Struţul peak. A descending cave, partly plugged with limestone boulders, situated some 20 m upstream (BOSDOC, 1981), acts as an overflow during the high rainfall periods. In time, the spring has deposited a huge amount of travertine, that extends almost down to the Arieş river, the spring flow cutting its streambed, in its upper stream course, through its own deposits, that form a virtually horizontal flat ground.

The spring flow rate is highly fluctuating, the outlet displaying the highest variability index among all gauged springs in the Poieni Plateau (n_v = 200.6). It is also conspicuous because of its smallest base flow index value (B_f = 0.13, Table 3).

Pişoaia Vidrii karst system

Pişoaia Vidrii spring is the third important outlet on the northern slope of Poieni Plateau. It is located some 1 km downstream with respect to Izbucul Lerţii, with its water emerging from a limestone boulders accumulation. A cave situated above the spring, descending down to –5 m and extending over 38 m length, acts as an overflow to the karst system (BOSDOC, 1981). The massive travertine deposits have built a horizontal platform, from which the spring flow jumps over some 15 m, to form a spectacular waterfall.

By processing the flow rates series recorded during the recession period of the 1988–1989 winter, a low groundwater reserves value was derived, together with a significant weight of the fast flow in building these reserves (37.7%, Table 2).

'La Izvor' karst system

'La Izvor' karst outlet is located on the left side of Zugău stream, some 100 m upstream with respect to the last house of Valea Morii hamlet. It emerges at the bottom of a crystalline limestone wall, from a boulders accumulation, at 670 m elevation. During the October 1988–September 1989 hydrologic year, the spring flow rate fluctuated between 10.8 and 123.4 l/s, with a 21.8 l/s average flow rate value. During the period May 1991–December 1992, the average gauged flow rate was 8 l/s, while the water temperature fluctuated between 7.6 and 8.8 °C.

The spring collects its water from Zugău stream upper catchment area, a fact which was proven by a NaI tracer test performed in the diffuse sink of Haiduceşti stream, a tributary of Zugău stream.

Feredeu karst system

The occurrence of Feredeu spring is related to a small nappe inlier, that allows crystalline limestone to outcrop in the middle of the Cretaceous sandstone-carbonate flysch body. The spring is situated on the right side of Sohodol stream, some 1 km upstream from the center of the homonymous village. Upstream with respect to the karst spring, in its close proximity, from the gravel and sand of an alluvial fan, diffusely emerges a spring discharging 0.1–2 l/s together with gas outflows.

The karst spring system extends in the south-eastern part of the Poieni Plateau, discharging in a perennial way, and temporarily in a complete way, the stream course of Valea Seacă.

The karst system has relatively important reserves, and its recharge from surface streams is mirrored also by the relatively large weight that the fast flow occupies in the water volumes that the system discharges (12.5%).

Other outlets

The springs at Morcoş (Fig. 1, no. 2) emerge from the right side of Vidrişoara stream, at the bottom of a small limestone escarpment, some 500 m upstream the junction with Arieşul Mic river. They are situated some 40 m apart from one another and have an average cumulated flow rate of 10 l/s. The temperature of the spring located downstream fluctuates between 7.7 and 9.5 °C, while the one located upstream exhibits larger fluctuations, 5.3–11°C, probably as a result of water inflows originating in the Vidrişoara stream alluvia.

Zugău karst spring (no. 34). Downstream with respect to the Haiduceşti and Ponoraş streams junction, over a distance of about 1 km, Zugău stream flows down a gorge section strewn with waterfalls and cauldron pots, that deny access even to the most resolute pedestrian, local people using, in order to avoid this area, a footpath which reaches high up the right side of the stream.

At the gorge exit, on the left side, a water spout that locals call Zugău spring gushes out from a crack enlarged by water corrosion. The average flow rate is 11.7 l/s, fluctuations ranging between 5.7 – 6.0 l/s. The travertine deposits (that locals call "galiţa") make the outlet area conspicuous in the topography.

Iruga lui Doboş spring (no. 43) is located on the left side of Sohodol stream, opposite to Feredeu spring. It emerges from a crack in crystalline limestone, with a flow rate ranging between 1 and 10 l/s. It is not tapped.

Topliţa spring (no. 46) is the easternmost outlet in Poieni Plateau. It is located opposite to the Sohodol quarry and it emerges from crystalline limestone. The spring is tapped in a concrete pool. The spring flow rate fluctuates over the 1.5–30.0 l/s range, displaying an average value of about 10 l/s. The measured temperatures fluctuated between 8.8 and 9.9 °C over the investigation period. Worth mentioning are the massive travertine deposits. The spring discharges the water accumulations at the easternmost end of the plateau, mainly those in the Napoieşti area.

Bârlogului spring (no. 41) is located in the south-eastern part of the Poieni Plateau, in Berbecului stream catchment area. It emerges in a typical dead-end valley, from a limestone boulders accumulation, at the bottom of a ca. 15 m high escarpment. The outlet minimum flow rate is 2 l/s, while the average flow rate amounts to 12 l/s. The spring exhibits no travertine deposits.

The spring in Valea Laptelui (no. 21) discharges 3 l/s from a cave entrance (speleological code 3100/36), excavated in a ca. 70° steep mountain slope. At the bottom of the cave there is a 10 m high waterfall, with no travertine deposits.

Albii spring (no. 22) emerges through a rift that is widely opened by water flow, and can be entered over at least 4 m, located at the bottom of Coasta Albii, a vertical wall of strongly cracked and corroded crystalline limestone. 10 m downstream with respect to the spring, over a distance of at least 50 m, there occur massive travertine deposits, with the spring flow running around their right side, to form a series of waterfalls. Upstream with respect to the spring, Valea Albii displays a temporary flow regime and is marked by many fossil cauldron pots. The outlet minimum flow rate is about 15 l/s, its average value reaching about 55 l/s.

Pişoaia Albii spring (no. 23) emerges from a dissolution conduit (70 x 30 cm) located at the bottom of a 7 m high crystalline limestone cliff. After crossing for some 40 m a virtually horizontal, grass-covered flat, the water falls down a 15–20 m high waterfall toward Valea Alba. The outstandingly scenic flat and waterfall are made of travertine, deposited by the spring flow. Local people claim that the spring never discharges muddy water. The minimum spring flow rate is 20 l/s, and the average one is 60 l/s.

The springs in the Crişul Alb streambed. In the Crişul Alb upper reaches, in the section where it

Table 1. Major ions and saturation indices of water sources.
Principaux ions et indices de saturation des sources d'eau.

Spring name	Date	T(^{0}C)	ph	Cl	SO_4	HCO_3	Na	K	Ca	Fe	Mg	TDS	S.I.	
								ppm					calcite	aragonit
Izvorul Morii	X. 88	8.7		7.1	7.7	219.6	1.2	1.1	80.2	0.1	sld	386.7		
Izvorul Morii	VIII. 96	8.2	7.64	7.1	17.2	231.8	1.5	sld	84.4	sld	1.0	415.3	0.239	0.084
Izvorul Morii	IV.00	8,8	8.45	5,7	0	225.7	0.8	0.6	76.2	0.2	0	338.5	0.938	0.782
Lerii	X. 88	7.7		7.1	9.0	146.7	21.0	1.9	41.3	0.1	0.7	258.8		
Lerţii	VIII. 96	7.8	7.90	7.1	15.4	256.2	0.6	sld	94.8	sld	sld	441.0	0.535	0.377
Pişoaia Vidrii	VIII. 96	8.1	7.38	7.1	17.3	256.2	1.5	sld	92.9	sld	1.0	449.4	0.029	-0.128
La Izvor	X. 88	7,2		7.1	17.3	244.0	38.0	1.0	57.7	sld	sld	376.2		
Zugău	X. 88	7,5		28.3	36.4	341.6	67.5	1.0	84.1	sld	sld	571.5		
Feredeu	X. 88	11.8		7.1	9.0	198.2	21.6	2.4	48.1	0.1	1.2	307.3		
Pişoaia Albii	VI. 89	8,0		7.1	8.9	146.4	4.1	sld	52.1	0.1	sld	231.7		
Izvorul Albii	VI. 89	8,0		7.1	16.4	158.6	3.5	1.8	56.9	0.1	sld	253.9		
Spring of Baii	VI. 89	7,2		7.1	8.9	146.4	4.2		43.3	0.1	5.4	228.4		
Fântânele	V. 90	7,5		7.1	28.8	134.2	13.3	0.4	48.1	0.3		232.2		
Hărăşti dug well	V. 90	8,0		7.1	20.2	256.2	5.8	11.0	50.1	0.1	21.6	372.1		

crosses the crystalline limestone of Poieni Plateau, diffuse groundwater inflows occur through the streambed alluvia. Expeditionary flow rate gauging outlined minimum groundwater inflows of 110 l/s and average inflows estimated to 200 l/s. The inflows occur along the river section that extends between the elevations 680–570 m, in the area of its junction with the stream that has its headwaters beneath Ştiubeiul peak. The primary chemical characteristic of the water discharged by the main springs in Poieni Plateau (Ca-HCO_3 type) is over-saturation with respect to calcite, resulting in abundant precipitation of this mineral immediately downstream with respect to the springs, as a result of the release of CO_2 from solution. The positive values of the calcite saturation indexes, computed for the water of the springs Mori, Pişoaia Vidrii and Lerţii, confirm this fact (Table 4).

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