3.12. POIANA RUSCĂ MOUNTAINS

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Introduction

Poiana Ruscă Mountains form the north-western part of the Southern Carpathians, occurring as a bridge that connects the latter with the Apuseni Mountains.

Poiana Ruscă is an arc-shaped mountains body bordered all-around by tectonic boundaries. To the north it is bordered by the Mureş basin, to the north-west there occurs the Neghiu-Lăpugiu corridor-depression, to the south there occurs Bistra tectonic trough - that separates Poiana Ruscă from Ţarcu Mountains, while to the east the adjoining neighbors are the Haţeg depression and Hunedoara hills.

The mountains body displays a topography which is levelled in a stepwise manner and dissected into elongated ridges. The maximum elevations occur at roughly 1300 m. Within the actual mountains area there occur two main distinct physiographic units: in the western part of the mountains body there occurs a deeply entrenched topography, with steep slopes, that rather rapidly climbs toward the central part of the mountains; alternatively, the eastern half of the mountains body occurs as a plateau that is deeply dissected by the stream waters. Within this plateau area, which is a peneplain of Badenian age, there are visible several leveling steps that occur at 400-500 m a.s.l. in the border areas, at 600-800 m a.s.l. in the median section and at 900-1000 m a.s.l. in the central part of the mountains body.

Carbonate rocks (dolomite and limestone) exhibit their maximum development toward the western end of the mountains body (Tomeşti-Luncani area) as well as toward its eastern end (Hunedoara-Runcu area), those two distinct areas being separated from one another by an important body of crystalline schists.

The streams network within the mountains body appears to be rather dense – 0.8-0.9 km/km^2 – when taking into account the rather low overall topography energy (Pascu, 1983).

While in the western area streams are tributaries to the Bega and Mureş rivers, the major stream of the eastern area is Cerna.

Rainfall is abundant all year long in the elevated, central part of the mountains body, with its amount progressively diminishing toward the border areas. Maximum values may reach 1000 mm/year (Pascu, 1983).

The average air temperature ranges between 2°C and 8°C in the mountains area, and between 9°C and 11°C in the bordering depressions located to the east, west and north.

1. Current Status of the Geological and Hydrogeological Investigations

The earliest information concerning that area is found in the works of F.S.Beudant (1822), F. Hauer and G. Stache (1862, 1885), Fr. Posepny (1871), J. Halaváts (1903), Fr. Schafarzik (1908).

K. Papp (1919) issued a paper that included a multitude of geological and mining data about the iron ores in the Poiana Ruscă Mountains. Other investigations addressing the same iron ores have been conducted by K. Möckel (1923), V. Laţiu (1928), D. Stănescu (1951), E. Ciucurel (1954) and Z. Naidin (1954-1955).

The issue of the relationships existing between the epi-metamorphic schists in the median part of Poiana Ruscă Mountains and the Hunedoara dolomite body, or the mezo-metamorphic rocks was investigated by G. Murgoci (1912), A. Streckeisen (1934), L. Pavelescu (1958).

In the year 1958 there have been initiated the investigations aimed at tracing the Poiana Ruscă crystalline formation separations. Those investigations were of outstandingly large extent, addressing the overall mountains body. H. Kräutner, Florentina Kräutner (1962), O. Maier, M. Mureşan, Georgeta Mureşan (1964) have been, among other, investigators that addressed this area.

C. V. Papiu et al. (1962, 1963, 1964) have performed petrographic investigations concerning the Hunedoara dolomite, while M. Savul and V. Ianovici (1959) have carried out the chemical investigation of the same formation.

In terms of tectonics and metamorphism of the crystalline formations, a different opinion from that of H. Kräutner et al. (1969, 1973) has been expressed by I. Balintoni and Veronica Iancu (1986).

The only few published papers with a hydrogeological topic have addressed the issues of the water supply of certain communities (Hunedoara, Teliuc - M. Năstase,1958 and N. Mauriciu,1960).

Hydrogeological investigations aimed at assessing the specific setting associated to the iron ores in Ghelari and Teliuc areas have been carried out by E. Anghel, I. Orăşeanu and Nicolle Orăşeanu (1971, 1972).

In order to assess the groundwater potential of the rock formations in the two carbonate areas (the eastern and the western one) of the Poiana Ruscă mountains body, further hydrogeological investigations have been conducted by Gh. Bandrabur and Rădiţa Bandrabur (1996, 2001).

2. Geological – Structural Setting

The geological constitution of Poiana Ruscă Mountains includes crystalline formations (of Late Precambrian – Early Carboniferous age), igneous formations and sedimentary formations (of Cretaceous – Quaternary age). Crystalline formations and part of the sedimentary formations are intruded by Alpine alkaline vein type igneous rocks of Mesozoic age, by igneous rocks representing sequences of the Alpine Cycle that in the western, northern and north-western part of the mountains body consist of agglomerates, bodies and veins of banatitic rocks.

The hydrogeological maps of the two carbonate areas (Figs.1 and 2) made use of a geological background compiled from the geological maps of Maier et al. (1969), Kräutner et al. (1969, 1971), Mureşan and Orăşanu (1972) and Lupu et al. (1986), modified.

When the metamorphism intensity is considered, crystalline schists in Poiana Ruscă Mountains range into two distinct units, namely:

- *The meso-metamorphic unit* which consists of micaschists, quartzites, paragneiss and amphibolites belonging to the *Sebeş-Lotru series* (S.L.) in the southern end of the mountains body;
- *The epi-metamorphic unit*, or *the Poiana Ruscă crystalline formation*, which extends to the north of the meso-metamorphic unit and includes deposits of clastic, carbonate and igneous origin, that have been metamorphosed in the green schists facies (the northern facies), and Hercynian epi-metamorphic and Precambrian meso-metamorphic deposits, part of which have been subject to retrograde metamorphism (the southern facies).

These two units are separated by a major along-strike tectonic dislocation, namely the Cinciş-Vadu Dobrii-Tincova lineament, along which the southern unit is thrust over the northern one.

Four litho-stratigraphic entities have been distinguished by Kräutner et al. (1981-1990) within the epi-metamorphic unit: *the Bătrâna series* (Late Ordovician ?-Silurian), *the Govăjdia series* (Early Devonian), *the Ghelari series* (Devonian) and *the Padeş series* (Early Carboniferous), with carbonate formations prevailing only within the last two entities.

Specifically, within the southern facies of the Ghelari series the alkaline meta-tuffs and meta-tuffites of Ruschiţa-Alun region are associated with marble-like limestone – *the Ruschiţa-Alun marble-like dolomite and limestone* – $Gh_1(d^{RA})$. Also within the southern facies of the Ghelari series, the *white limestone-black dolomite formation* – $Gh_2(d^{an})$ includes limestone and dolomite, with sericite-chlorite schists inter-beddings. Within the northern facies of the Ghelari series, the second complex, that of the *chlorite-sericite schists with carbonate rocks and Bega alkaline meta-tuffs interbeddings* includes, besides chlorite-sericite schists, alkaline meta-tuffs and thick layers of dolomite and limestone. Carbonate rocks build up two main horizons, namely: *the Nandru-Valea Izvoraşului limestone and dolomite horizon* – $Gh_2(d^{NI})$, with a lower position, and *the Tomeşti-Groş limestone and dolomite horizon* – $Gh_2(d^{TG})$, with an upper position.

The Padeş series follows to the Ghelari series and its characteristic features are the prevalence of the clastic origin material and the extensive occurrence of the crystalline limestone and dolomite. In the northern facies, the latter occur at the lower part of the series, in the *sericite-chlorite schists and the Hunedoara-Luncani dolomite complex* – Pd_1(d) and they build up two bodies: one extending between the settlements of Hunedoara and Runcu Mare, and occurring as the "Hunedoara dolomite" (in the eastern section of Poiana Ruscă mountains body) and another one, in the Luncani village surroundings, occurring as the "Luncani dolomite" (in the mountains body western section). The dolomite bodies display lateral transitions toward deposits of clastic origin. The deposits thickness may reach up to 3000 m. The southern facies occurs within a small area, north of Vadu Dobrii and between Gladna Română and Ruschiţa. Carbonate rocks occur at the bottom of *The Gladna supra-dolomitic sericite-chlorite schists complex* (Pd_2), especially within the southern limb of the Arănieş-Poieni-Fărăşeşti anticlinorium. The formations thickness ranges between 1000 and 2500 m.

In the western part of Poiana Ruscă Mountains, igneous formations are a result of Mesozoic and the Neozoic magmatic activity.

Sedimentary deposits outcropping at the two ends of the mountains body are of Cretaceous (Albian, Vraconian+Cenomanian), Neogene (Badenian, Sarmatian and Pontian) and Quaternary (Holocene) age.

The tectonic evolution of the region has been to a large extent controlled by the position that epi-zonal schists occupied between two rigid rock masses: the dolomite body to the north and the meso-metamorphic formations to the south.

In structural terms, the epi-metamorphic unit of the mountains body consists of a central anticlinorium – the Arănieş- Poieni-Fărăşeşti anticlinorium – in whose limbs all the other folds are embedded.

The folds within the anticlinorium northern limb are broad, with their limbs dipping as a general rule in a gentle manner, while folds within the southern limb are more tight and their limbs are usually quite steep. The epi-metamorphic unit of Poiana Ruscă mountains body is intensely dissected by a multitude of inclined faults which occur both parallel and transverse to the strike. The faults have been generated during successive periods of time and some of them have been subject to several successive displacements.

3. The Carbonate Deposits Hydrogeology

As previously mentioned, carbonate rocks (limestone and dolomite) display their maximum extent toward the eastern (Hunedoara-Runcu Mare area) and the western (Tomeşti-Luncani area) extremities of the mountains body, and that is why these two areas shall be addressed separately.

3.1. Hunedoara – Runcu Mare Area

Toward the eastern end of Poiana Ruscă Mountains, the main groundwater reservoir consists of the dolomite and the limestone of Early Devonian - Early Carboniferous age (Fig.1).

Although carbonate rocks and karst topography occupy a large area in the eastern part of Poiana Ruscă Mountains (113 km^2), only few caves are known so far. This is due to the fact that within the large carbonate rocks bodies at Hunedoara-Runcu and Groş, limestone occurs as a small fraction, most of the indicated area being instead occupied by dolomite (a rock that is less favorable to the development of the underground karst processes). Caves known so far are small and of little speleological significance. Carbonate deposits belong to the Ghelari series and to the Padeş series.

The formation consisting of *white limestone - black dolomite* occurs as a continuous strip at the upper part of the Ghelari series (the southern facies). Because of that formation being thin, and also because of the schists inter-beddings, groundwater accumulations are poor.

The Ghelari series northern facies, which occupies the northern part of the area, includes several carbonate sequences occurring as two patches that have been subject to relatively intense tectonic deformation. Their thickness and outcrop areas are relatively large, thus favoring groundwater accumulation.

The first patch, located on the northern flank of the Arănieş-Poieni-Fărăşeşti anticline, has been subject to intense fracturing. No groundwater source was identified in that area. Along the valley Semişag, within its section that crosses the *Nandru-Valea Izvoraşului dolomite*, a water loss of about 2 l/s (24 % of the overall stream flow rate) has been detected by means of stream flow gauging.

The second patch, located southward with respect to the first one, includes several springs with flow rates in the 0.1-0.5 l/s range, located both on the stream Valea Roatei, as well as on the stream Zlaşti.

At the entrance of Groş village (when coming from Boş), a well bore has been drilled during the sixties. When drilling reached a depth of about 200 m, a strong water inflow was met which caused the well to be abandoned. By the present time the well discharges an artesian flow rate varying from 0.6 to 0.8 l/s, at a temperature of about 14°C.

Still on the Zlaşti valley, some 300 m downstream the previously mentioned well bore, there is a spring whose flow rate fluctuates in the 1-4 l/s range, while its water has always, irrespective of season, a temperature of roughly 18°C.

Stream flow gauging performed on the Zlaşti valley has outlined two sections where partial flow losses occur. One section occurs immediately upstream the junction with Cerbăl stream (losses of about 25 l/s-16 %), while the second one is located upstream the previously indicated well bore in Groş village (losses of about 10 l/s - 7%). A fraction of the sunk flow emerges in a few outlets located immediately downstream the sinking points, while another fraction, by way of fractures or through the (deeply located) sections where *the Tomeşti-Groş limestone and dolomite* are in direct contact with the *Hunedoara-Luncani dolomite*, contributes to the recharge of the aquifer hosted by that latter formation.

The main reservoir rocks in the eastern part of Poiana Ruscă mountains body belong to the *Hunedoara-Luncani formation*, whose overall outcrop area extends over about 95 km^2.

In terms of petrography, the carbonate rocks body consists of white and gray compact dolomite, of dolomitic limestone, of limestone, quartz dolomite, white and gray quartzite etc, being however noticeable a net prevalence of the dolomitic rocks, which are the main constituents of the carbonate rocks body.

Earlier, as well as more recent geological investigations have delineated a large, east-west striking syncline („The Hunedoara dolomite syncline"), bounded by the settlements of Hunedoara (to the east) and Lelese (to the west). The syncline was subject to faulting and cracking and its deposits occur to a large extent beneath the present day streams network.

Groundwater accumulations in the Hunedoara dolomite are poorly noticeable, as the amount of springs and their discharges are not quite significant when compared to the extension of the carbonate rocks body.

In the southern part of the area, close to the dolomite contact with the crystalline schists, there occur a few springs whose flow rates range between 0.1 and 0.5 l/s.

In the Nădrab valley catchment area, the flow rates of the most significant springs range between 0.6 and 0.8 l/s. During draught periods, water flowing along Nădrab valley completely sinks upstream the junction with Poieniţa stream. The same happens to the water flowing along Alunul stream (a tributary of Nădrab).

By getting farther in the interior of the mountains body, in the Runcu valley catchment area, the same aquifer is similarly poorly noticeable by way of spring discharges. In the very heart of the dolomite area several springs occur at the bottom of the local erosion level, with their flow rates ranging between 0.01 and 4.0 l/s.

Figure 1. Hydrogeological map of the eastern area of the Poiana Ruscă Mountains.

Legend:

1 - Palaeozoic carbonatic deposits [$Gh_1(d^{RA})$, $Gh_2(d^{an})$, $Gh_2(d^{NI})$, $Gh_2(d^{TG})$, $Pd_1(d)$, $Pd_2(d)$];
2 - Alluvial deposits, colluvial deposits [qh];
3 - Sarmatian clays, sands, gravels, sandstones and limestones [sm];
4 - Middle Miocene sands, gravels and clays [m_2];
5 - Cretaceous marly-sandstones [vr+cm];
6 - Precambrian and Palaeozoic shists [S.L., Bt, Gv, Gh_1, Gh_2, Pd_1, Pd_2];
7 - Geological boundary;
8 - Lithological boundary;
9 - Unconformity boundary;
10 - Normal fault;
11 - Reverse fault;
12 - Anticline;
13 - Syncline;
14 - Perennial surface course;
15 - Temporary surface course;
16 - Spring discharge (l/s);
17 - Catchment;
18 - Cave;
19 - Ponor;
20 - Dump;
21 - Quarry;
22 - Mine;
23 - Well;
24 - Group of wells;
25 - Limit of the hydrographic basin checked by hydrometric gauging sections;
26 - Underground flow direction established by tracer experiments;
27 - Hydrogeological cross-section line.

Stream flow gauging performed along the entire course of Runcu stream, between the village Runcu Mare and the junction with Riţişoara stream – an area where the stream bed is continuously occupied by dolomites – resulted in the identification of two sections subject to partial flow losses. The first section, located immediately downstream the junction with Lunga stream (a left side tributary), displays losses of about 35 l/s (15 %). The second section subject to partial stream flow losses, which amount to about 50 l/s (15 %), is located along the lower course of Runcu stream, before its junction with Riţişoara stream.

Another valley that in its last part crosses through the „Hunedoara dolomite" is that of Zlaşti. It flows close to the contact between the Padeş series dolomite (of Early Carboniferous age) and the Medium Miocene deposits that consist of sands, gravel and shales.

A major outlet located in this valley is that at Boş. It is located upstream the village bearing the same name, being located on the site of an old and important group of springs. The water taping wells are about 20 m deep and their bottoms reach the dolomite formation. The water flow conveyed to the town of Hunedoara amounted to about 75 l/s (in the year 1996).

The water intake in Sânpetru hill, located immediately to the west of Hunedoara town, consists of 5 well bores with their depth ranging between 120 and 200 m, drilled entirely in dolomite rock. The maximum flow rates have been 36 l/s, the corresponding draw down being 0.50 m at maximum. By the end of the year 1959, this water intake began supplying water to the town of Hunedoara. During the period 09.1995-08.1996, water flow provided by this intake amounted to about 277,000 m^3/month.

The extensive outcrop area of the dolomite deposits, as well as their important thickness - that reaches about 1200 m in the Hunedoara syncline axis, with 800 m of them occurring beneath the present day streams network – lead to the inference of a major groundwater reserve. By taking into account that this east-west striking, syncline-shaped structure dips gently toward the east, beneath Neogene deposits, one may infer that also groundwater flow may occur in that direction. However, there are virtually no additional discharges of the aquifer occupying the „Hunedoara dolomite" at its eastern end, besides those at Boş and Sânpetru.

The recharge of the groundwater complex occupying this structure that has been subject to faulting, cracking and karst processes is provided by rainfall occurring over the entire outcrop area of the dolomite, as well as, locally, from overlying Neogene sedimentary deposits and through seepage from stream courses that flow on the dolomite deposits. The major groundwater flow occurs from west to the east.

In order to check the hypothesis concerning the groundwater flow direction within the aquifer hosted by the "Hunedoara dolomite", a fluorescein tracer test has been performed (Table 1). The tracer has been injected in the water of Alun stream (a right-hand tributary of Nădrab stream), in the area where the surface stream flow (about 0.6 l/s) sank completely (at 690 m elevation a.s.l.). Two selected outlets have been monitored, by using charcoal bags. Tracer was detected in both outlets (Table1), yet it it was not possible to establish the precise arrival time (by any rate, it was less than 7 days).

3.1.1. Water balance within the eastern section of Poiana Ruscă Mountains

Rainfall recorded during the hydrological year 01.10.1995-30.09.1996 at the rain gauging stations in that area amounted to rather similar values, namely: 664.2 mm at Topliţa gauging station (310 m elevation a.s.l.), 688.3 mm at Teliucul Superior gauging station (270 m elevation a.s.l.) and 711.2 mm at Ghelari gauging station (740 m elevation a.s.l.). Actual evapo-transpiration deter-

No.	Sinking point	Resurgence	L (m)	H (m)	Date of labelling
1	Losses of Alun V.	Outlet on Nădrab V.	3000	170	18.07.1996
2	Losses of Alun V.	Outlet on Riţişoara V.	4200	210	18.07.1996

Table 1. Results of tracing operations in Hunedoara - Runcu Mare karst area.
L = Horizontal distance between the sinking point and the resurgences;
H = Elevation drop from the sinking point to the resurgences.

mined over the same time interval at Ghelari gauging station was 314.1 mm.

Surface flow was monitored at the stream gauging stations installed on the streams Valea Roatei, Zlaşti, Govăjdia, Runcu and Riţişoara.

Over the hydrological year 01.10.1995-30.09.1996, rainfall on the 263.88 km^2 surface area has been 589.88 mm (4922.40 l/s), surface flow has amounted to 211.63 mm (1766 l/s), a flow rate of 535.31 l/s (64.15 mm) has sunk in the underground, 314.10 mm (2621.10 l/s) has been lost through evapo-transpiration, while 9.15 mm (76.34 l/s) has been extracted as tapped groundwater.

In this case, the losses (outputs) from the system exceed the inflows (inputs). The recorded deficit could be a consequence of the fact that the catchment area for which the water balance was assessed is smaller than the corresponding groundwater catchment area.

3.2. Tomeşti - Luncani Area

Carbonate bodies in the western part of Poiana Ruscă Mountains have the same petrographic constitution as bodies in its eastern section.

Out of the 1350 km^2 total surface area of that mountain body, carbonate rocks occupy almost 20%. In Tomeşti-Luncani area, carbonate terrains occupy 47% of Bega stream catchment area (Fig. 2).

By the present time, 150 caves have been identified in the that mountain body. Karst processes of average intensity are suggested by the corresponding speleogram, that includes 1.85% of the total number of caves within the country. The caves cumulated length is 9515 m, and the corresponding cumulated elevation drop is 1115 m. The caves areal density is 2 caves/km^2 (Lupu et al., 1984). Among the most important caves in that area worth mentioning are Peştera Mare de la Româneşti (1386 m long) and Peştera de la Pietroasa (1455 m),

Spring number	Source	Q (l/s)	T (°C)	Date/Period
APA GLADNEI STREAM CATCHMENT AREA				
1	Floroni spring	3.0	8.8	12.05.2000
2	Gladna Română Gallery	40.0	9.8	11.05.2000
URSULUI VALLEY CATCHMENT AREA				
3	Bolborosu spring	0.5-2.0	15.4-15.5	07.07.2000/20.04.2001
BEGA LUNCANI STREAM CATCHMENT AREA				
4	Florian spring	2.03-3.50	17.2-18.0	01.10.1999-30.09.2000
5	Izvorul Cald spring	22.7-208.0	10.3-14.0	01.10.1999-30.09.2000
6	Springs from Ştefania brook	0.1-6.5	9.0-18.0	18.07.2001/22.08.2001
7	Alexandru Macedon spring	25.0	10.0	18.07.2000
8	Spring from Stâlpului brook	1.0	9.3	18.07.2000
9	Group of springs from Stâlpului brook	30.2-50.3	8.5-9.5	21.06.2000-13.09.2001
10	Spring from Bură̆u brook	21.4	9.0	22.08.2001
11	Spring from Padina Seacă brook	4.5-5.5	7.5-8.5	29.03.2001/22.08.2001
12	Springs from Căprişoara brook	1.0	10.0-10.5	16.08.2000/18.08.2001
BEGA POIENI STREAM CATCHMENT AREA				
13	Izvorul Miron Monastery - NE spring	24.9-36.9	17.2-18.4	01.10.1999-30.09.2000
14	La Izvoare spring	5.0-9.0	11.0-11.2	08.08.2000/25.08.2001
15	Izvorul Cald spring	4.9-6.7	16.5-17.8	01.10.1999-30.09.2000
16	La Tarniţă spring	10.5-23.0	10.4-11.5	01.10.1999-30.09.2000
17	7 Izvoare spring	53.3-165.6	9.0-11.5	01.10.1999-30.09.2000
18	Păstrăvarie spring (Poieni)	17.2-38.6	12.0-13.0	01.10.1999-30.09.2000
19	Izvoraş cave	13.2-28.0	8.5-9.0	11.09.2000-13.10.2001
DOBRA VALLEY CATCHMENT AREA				
20	Izvorul Alb spring	36.2-151.0	9.5-10.8	01.10.1999-30.09.2000
21	Baniului spring	50.0	13.0	15.10.1999

Table 2. The main springs in the western area of Poiana Ruscă Mountains.

both of which occur in Bega Poieni catchment area and include perennial stream-flows.

The carbonate deposits belong to the Ghelari and the Padeş series.

The Ghelari series in a northern facies, outcropping mainly in the median part of that area, includes several carbonate sequences. Specifically, within the *Nandru-Valea Izvoraşului limestone and dolomite*, as well as within the *Tomeşti-Groş limestone and dolomite* there have been identified 99 outlets with discharges ranging between 0.01 l/s and about 30 l/s.

Like in the eastern section of Poiana Ruscă Mountains, also in its western part the *Hunedoara-Luncani dolomite* represents the main reservoir formation, as testified by the 231 existing springs with flow rates ranging from a few l/s to almost 210 l/s (Table 2).

In the following, relying on the hydrological observations and measurements performed in that area, there shall be discussed the outlets which have been identified as being the most significant. We

Figure 2. Hydrogeological map of the western area of the Poiana Ruscă Mountains.
Legend:
1 - Palaeozoic carbonatic deposits [$Gh_1(d^{RA})$, $Gh_1(d^{I})$, $Gh_2(d^{NI})$, $Gh_2(d^{TG})$, $Pd_1(d)$, $Pd_2(d)$];
2 - Alluvial deposits, colluvial deposits [qh];
3 - Pontian gravels and quartzitic sands [p];
4 - Badenian clays and sandy clays [bn];
5 - Cretaceous conglomerates and quartzitic sandstones [vr+cm];
6 - Quartzitic blocks ± Fe, ±Mn, red clays – Poieni Formation [al];
7 - Paleogene and Neogene magmatites [α_{Pg}, α_{Ng}];
8 - Palaeozoic shists [Gv, Gh_1, Gh_2, Pd_1, Pd_2];
9 - Geological boundary;
10 - Lithological boundary;
11 - Unconformity boundary;
12 - Fault;
13 - Anticline;
14 - Syncline;
15 - Perennial surface course;
16 - Temporary surface course;
17 - Spring discharge (l/s);
18 - Catchment;
19 - Cave;
20 - Pothole;
21 - Ponor;
22 - Mine;
23 - Limit of the hydrographic basin checked by hydrometric gauging sections;
24 - Underground flow direction established by tracer experiments
25 - Presumptive underground flow direction.

shall start from west to the east, by considering each catchment area separately.

Apa Gladnei stream catchment area. The most important outlets occur on Floroni stream (1- the number in Table 2) and in Gladna Română mining passage (2). Although they emerge from the sericite-chlorite schists of the Padeş series, they actually originate in the dolomite included in the same series.

Gladna Română mining pasage (2) is about 4 km long and it provides the connection with Bega Luncani catchment area (downstream the village Luncanii de Jos). It has been excavated in order to be used as a transit pathway for part of the Bega Luncani stream water toward the stream Apa Gladnei, thus providing an additional supply to Fârdea (Surduc) lake, which is an important water supply source in that area.

The passage, which is not yet operating, conveys part of the groundwater flowing across the Hunedoara-Luncani dolomite, between the valleys of Bega and Apa Gladnei.

Ursului valley catchment area. *Bolborosu spring* (3), located on the left side of Ursului valley, some 2.5 km upstream the village of Baloşeşti, is the most important karst outlet in that area. It emerges from a dolomite strip of the Padeş series and it actually consists of a group of three springs (Table 2).

Bega Luncani stream catchment area. *Izvorul Florian* (4) is located on the left side of Bega stream, in the village Tomeşti (Colonia Fabricii). It emerges from the Tomeşti-Groş dolomite. Out of the four existing outlets, two operate as water intakes.

In that area there have been identified total water losses from the streams Dobrota and Strugazului (on the left side of Bega Luncani stream, immediately upstream the junction with Dobrota valley).

Izvorul Cald (5) is located some 2 km SSW of the village Luncanii de Jos, on the right side of Topla stream. The spring was used for supplying water to a trout hatchery, located immediately downstream. The spring emerges from the Hunedoara-Luncani dolomite of the Padeş series, and its main characteristics are indicated in Table 2 and 3.

It could be possible that part of the water discharged by this spring originates in the water losses detected along the stream course of Ştefania valley (a right hand tributary of Topla stream).

Source number	Source	Qmax (l/s)	Qmin (l/s)	Qmax/ Qmin	Qmean (l/s)	α	Dyn.vol. (m^3)	M.E. (days)	R.T. (days)
5	Izvorul Cald spring	208.0	22.7	9.12	37.9	0.0052	894	15	23
13	Izvorul Miron Monastery-NE spring	36.9	24.9	1.48	30.9	0.0019	1410	67	–
20	Izvorul Alb spring	161.0	36.2	4.44	55.5	0.0033	1310	46	45

Table 3. Characteristic discharges of some springs in the western area of Poiana Ruscă Mountains. (01.10.1999 - 30.09.2000).
α – recession coefficient; M.E. – memory effect; R.T. – regulation time

About 1 km upstream the junction with Topla stream, in the valley of Ştefania stream, on both sides of the valley and very close to one another, there occur no less than 6 springs (6). Their flow rates range between 0.1 and 6.5 l/s. The temperatures of the outlets on the right side of the valley range between 9 and 13°C, while outlets on the left side of the valley have their temperatures in the range 16-18°C.

Among the other outlets in that catchment area, worth to be mentioned is the *group of springs in Stâlpului valley* (9). In Stâlpului valley, some 4 km upstream the junction with Bega Luncani stream, on the right side of the valley, at streambed level, a group 9 springs occur over a linear distance of about 30 m. Three of them have a cumulated flow rate which varies in the 30.2 - 50.3 l/s range.

Bega Poieni stream catchment area. Out of the 214 springs identified in that catchment area by the present time, we shall address only the most important.

In the area of the «Izvorul Miron» Monastery (to the north of Româneşti village) 19 springs have been identified. Although they emerge from Quaternary deposits, they actually are the discharge of a groundwater accumulation stored in the carbonate deposits that occur in the north-western part of Poiana Ruscă mountains body.

The springs flow rates vary between 0.1 and 37 l/s, while their temperatures range between 16.8 and 19.5°C.

The fact that the temperatures of the springs in the proximity of the «Izvorul Miron» Monastery are more elevated than those which are normal for springs in that area (10-12°C) could be ascribed to a groundwater flow developing along deeper pathways, favored by a fracture whose delineation is made difficult by the overlying Quaternary deposits.

The main characteristics of the spring located to the NE of the «Izvorul Miron» Monastery (13) are indicated in Table 3.

La Tarniţă spring (16) is located about 1 km upstream Izvorul Cald, on the left side of Bega Poieni stream. The spring discharges from a dolomite blocks and debris accumulation, its recharge area occurring in the Pietrii valley catchment area, that is located immediately to the south.

The outlet 7 Izvoare (17) consists of a group of springs located on the right side of Bega Poieni stream, about 2 km downstream the village Poieni.

Şasa-Valea Mică hydro-karst district.

This district extends along the streams Şasa and Valea Mică and includes carbonate rocks (limestone and dolomite) alternating with impervious, non-carbonate rocks (sericite-chlorite schists).

Within a roughly 2 km^2 area there have been explored 13 caves, whose accessible passages total 1155.5 m cumulated length and 236.6 m cumulated elevation drop (Lupu et al., 1984). Besides underground karst landforms, surface karst landforms such as sinkholes and dry creeks also occur.

No.	Sinking point	Resurgence	L (m)	H (m)	T (hours)	V (m/day)	Date of labelling
1	Losses of Haugu V.	Izvoras cave source	850	55	70	300	13.10.2001
2	Losses of Pii brook	Izvorul Alb source	2200	1450	80	200	11.10.2000

Table 4. Results of tracing operations in the western area of Poiana Ruscă Mountains.
L – Horizontal distance between the sinking points and the resurgences
H – Vertical drop from the sinking points to the resurgences
T – Time of the tracer first arrival
V – Velocity

Şasa stream, collected on impervious rocks, subsequently cuts across the limestone and dolomite stack to finally reach another impervious rocks section and provides the present-day base level of this district. The other well-defined valley, that of Valea Mică (~ Izvoraşul) stream, flows longitudinally along the karst area. The streams network also includes several small valleys, subject to temporary flow (Sec steam, Hăugu valley).

Paralleling the surface streams network, there occurs also an underground flow-paths network supplied both by rainfall and by the sinking surface streams.

It is also worth mentioning the multitude of springs (14) identified along Valea Mică stream and their flow rates that vary mainly in the 1.0-2.0 l/s range.

On the left side of Şasa valley, some 350 m upstream its junction with Valea Mică, there occurs Izvoraş cave (19) which is excavated in the carbonate deposits of the Ghelari formation. It was explored over a length of only 15 m, yet its main interest stems from being a significant stream cave of that area (Table 2).

A fluorescein tracer test has outlined the existence of a karst aquifer occurring on the left side of Şasa stream, Hăugu valley, in the section where the latter crosses the carbonate deposits (Table 4).

Dobra stream catchment area. *Izvorul Alb* (20) is located on the left side of Dobra stream, some 2 km south of Roşcani village (Table 2).

The spring emerges from a crystalline schists accumulation, yet the conducted tracer tests indicate that its recharge area extends further to the south, in an area where the Padeş series dolomite outcrops. The hydrodynamic characteristics of that spring are indicated in Table 3.

Tracer injected into the swallet where Pii stream completely sank has reached Izvorul Alb after 80 hours. This result suggested a well-organized underground flow, whose apparent transit velocity amounted to 0.2 km/day.

Baniului spring (21) is located about 1 km upstream Izvorul Alb, also on the left side of Dobra stream (Table 2). The spring is tapped and used for the water supply of the villages in that area.

Baniului spring emerges from the Padeş series carbonate deposits. Analogously to Izvorul Alb, also the recharge area of Baniului spring extends further to the south, in the area of Căsagului valley, where several sinking points of the stream have been identified.

3.2.1. Water balance within the western section of Poiana Ruscă Mountains

Rainfall values recorded for the hydrological year 01.10.1999-30.09.2000 at the rainfall gauging stations in that area amounted to: 626 mm at Curtea (200 m elevation a.s.l.), 598.4 mm at Roşcani (250 m elevation a.s.l.), 729.4 mm at Luncanii de Jos (360 m elevation a.s.l.) and 994.5 mm at Vadu Dobrii (980 m elevation a.s.l.).

The annual rainfall values adopted in order to assess the water balance for the Begei and for the Bega Luncani streams catchment areas have been, in accordance with the coresponding average elevations, 845 mm and 860 mm respectively.

Multi-annual observations addressing the main climate features recorded within Poiana Ruscă mountains body have pointed to the fact that at large elevations, in the western part of that area, average evapo-transpiration derived from the water balance is by 100-150 mm lower on the eastern slopes, the corresponding values becoming uniform at 600-650 m elevation a.s.l. (Ilinca,1994).

Direct measurements aimed at assessing water losses due to evapo-transpiration at the ground surface haven't been performed in the area. Alternatively, the evapo-transpiration term was assessed by computation performed in the specific case of Begei stream catchment area, where assumedly no infiltration occurs.

In Poiana Ruscă Mountains all streams range in the small streams category and they pertain to the catchment areas of three major stream courses – Mureş, Bega and Timiş, which flow outside the mountains body boundaries.

The fluctuation range between the minimum and maximum monthly and annual average flow rates has amounted to 4 m^3/s for Bega Luncani stream over the period 1938-1980, and to 3.5 m^3/s for Bega Poieni stream over the period 1966-1971 (Ilinca, 1994).

In the western area of Poiana Ruscă mountains range, the surface flow has been monitored within two catchment areas, namely: Begeiului stream catchment area – 4.25 km^2 and 702 m average elevation (developed entirely over crystalline rocks terrains), and Bega Luncani stream catchment area – 88.63 km^2 and 732 m average elevation (with carbonate rocks occupying 47 % of the indicated area).

By comparing the two specific flow rates (q) which have been obtained, and taking into account that the average elevations of the two catchment areas are pretty similar, there can be noticed a 12.79 l/s/km^2 deficit when from the crystalline formations catchment area value (q=36.14 l/s/km^2) is substracted that of the catchment area where the carbonate rocks occupy almost half of the surface (q=23.35 l/s/km^2). ***We presume that this water deficit recorded in the computed specific flow rate of the Bega Luncani stream catchment area is due to large amounts of water that infiltrate in the underground.***

Over the hydrologic year 01.10.1999-30.09.2000, on the 88.63 km^2 surface area of the Bega Luncani stream catchment area rainfall has amounted to 860 mm, surface flow has amounted to 2069.5 l/s (738 mm), a flow rate of 1133 l/s (404 mm) has sunk in the underground, and 40 l/s (298 mm) has been lost through evapo-transpiration.

The computed balance indicates that the losses exceed the inflows, the recorded deficit leading to the assumption that groundwater inflows from outside the considered system are required in order to compensate for that deficit, and/or that the catchment area for which the water balance was assessed is smaller than the corresponding groundwater catchment area. In this respect, we presume that the groundwater catchment area could possibly extend further to the north-east.

4. Hydrochemistry Issues

Water samples collected from aquifers hosted in limestone or dolomite reservoir rocks mirror the corresponding calcium or magnesium bicarbonate character.

Total mineralization values range between 308.8 and 567.5 mg/l for the water samples collected in the Hunedoara-Runcu area, and between 141 mg/l and 538.6 mg/l for samples of the Tomeşti-Luncani district.

Free gas outflows associated to certain springs have been also analyzed, their composition resulting to be similar to that of the air in the atmosphere.

Radioactivity analyses performed for certain springs indicate alpha and beta global radioactive contents in the 0-0.571 Bq/l range.

The fact that some of the previously discussed springs temperatures are more elevated than those which are normal for that area (10-12°C) could be ascribed to a groundwater deeper flow, during which the fluid is heated and then rapidly rises to the ground surface. Such a groundwater flow is possibly favored by fractures occurring in the immediate proximity.

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