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# 3.13.3. BIHOR VLĂDEASA MOUNTAINS

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## Introduction

The Bihor Mountains consist of three distinct transverse compartments, that are well defined in what concerns both their topography, and their geologic framework: Vlădeasa, Bihor and Biharia mountains (V. IANOVICI et al., 1976).

Vlădeasa massif consists mainly of intrusive formations, which induce an overall heavy looking topography. The southern half of the intrusive body is surrounded by sedimentary formations, within which carbonate formations occupy a preeminent position: the karst area Meziad - Ferice - Valea Rea to the west and south-west, and the graben of Someşu Cald to the east and south-east.

The central compartment, for which the "Bihor mountains" denomination should be preserved, due to the fact that here the karstic topography, characteristic for these mountains (M. BLEAHU, S. BORDEA, 1981), is widely developed, is separated from Vlădeasa mountains by Someşu Cald and Crişu Pietros river courses. To the south, Arieşu Mare and Crişu Băiţa streams delimit this compartment with respect to Biharia massif, made up of crystalline schists.

By relying on geological considerations, namely on the circumstance that carbonate deposits in the Bihor mountains compartment extend also in the southern part of Vlădeasa mountains, across the morphological boundary between those two distinct physiographic units, we have decided to address both karst areas as a single entity, designated as Bihor Vlădeasa Mountains.

## 3.1. Orohydrography of the Bihor Vlădeasa Mountains

The complex geological constitution of Bihor Vlădeasa Mountains, that includes a puzzle of rocks, with limestones and dolomites prevailing, followed by sandstones, conglomerates and igneous rocks, results in a multitude of topography types, among which the most outstanding is clearly the karstic type, which considering its extent, variety and amplitude of the karstic landforms, ranks this specific area in the top position among all Romania's karstic territories.

Due to the presence of many ridges and isolated massifs, and to the absence - in the case of the large karst platforms - of major topographic leading lines, it is difficult to perform a systematic description of the orohydrography of this area, and as a result the presentation will follow the river catchment areas. This choice is also supported by the occurence in Bihor mountains of the most important water divide from all Apuseni Mountains, wherefrom the rivers Crişu Negru, Someşu Cald and Arieşu Mare originate.

The origins of those three major catchment basins are separated by two mountain ridges: one, striking north-south, marked by the summits Dealu Mare - Fântâna Rece - Măgura Vânătă - Glăvoiu - Piatra Grăitoare (Figure no. 3.1), borders Crişu Negru catchment basin to the west; the other one, striking west-east, branches perpendicularly to the previous one at Biserica Motului summit, to continue westward along Bătrâna summit - Clujului Summit. The latter separates the catchment basin of Someşu Cald, situated to the north, from that of Arieş, situated to the south.

At the junction of those three major catchment basins is situated the Padiş internally drainage area, surounded by a belt of ridges which preclude it from being included in any of the three previously mentioned basins.

Westward from Cornul summit branches the main ridge of Vlădeasa mountains, that along the section Cornul - Miclău - Măcieş forms the divide between the catchment basins of Crişu Repede, situated to the north, and that of Someşu Cald, situated to the south.

### 3.1.1. Crișu Negru catchment basin

Between the valley of Meziad to the north, and that of Crişu Băiţa to the south, Crişu Negru receivers from Bihor Vlădeasa Mountains a series of major tributaries: Beiuşele, Valea Mare, Ferice, Crişu Pietros, Crăiasa and Sighiştel. Those streams, together with the main tributaries of Crişu Pietros (Aleu, Bulz, Galbena), isolate a series of west-east striking ridges, that branch from the main ridge of Bihor mountains, to smoothly connect in the end to the hilly topography of the eastern part of Beiuş Basin.

Crişu Pietros stream originates as the confluence of the streams Bulz and Galbena, the corresponding junction spot being designated as Între Ape. Bulz valley collects its water from beneath the main ridge of Bihor, between the summits Cârligatele and Bălileasa, via a series of steep tributaries, some of which display inaccessible waterfalls (Boga, Oşelu, Bulbuci), while other benefit of less rugged courses (Valea Rea, Valea Plaiului). The topography of Bulz valley is dominated by the majestic Boga escarpment, with vertical, over 300 m high walls in its upper part, climbing just beneath Piatra Boghii peak. The landscape also includes many abundant karst springs (Boga, Oşelu, Bulbuci), peaks and bluffs, which make this area the wildest of the entire Bihor Mountains.

Galbena valley originates in terrains consisting of sandstones and conglomerates of the Arieşeni unit. The stream is called Luncşoara here. When entering a limestone substratum, the valley sink into the streambed fissures, most of the time of the year completely.

Downstream of this losses, Luncşoara receives a powerful right hand tributary that originates in Galbena spring, one of the major outflows of the Padiş internally drainage basin. From here downstream the valley is called Galbena and assumes a perennial character, while receiving only left hand tributaries (Valea Seacă, Păuleasa, Buteasa). Before the junction with Păuleasa valley, the flow rate of Galbena doubles, as a result of the inflow of Păuleasa spring. Along its entire course, from beneath Vârtop peak and down to the site called Între Ape, Galbena valley displays a rectilinear course, tectonically controlled by the major Galbena fault.

Valea Seacă, the origin of which is located in Groapa Ruginoasă, beneath Tapul peak, has the most extensive catchment basin of all Galbena valley tributaries. In spite of this, due to the multitude of karstic stream piracy processes that occur both in its own catchment basin, as well as in that of its main tributary, Tiganului valley, Valea Seacă carries water only during heavy rainfall periods, and as a consequence its direct contribution to the Galbena valley flow rate is small.

To the south of Crişu Pietros stream there occur the catchment areas of the streams Crăiasa, Sighiştel and Crişu Băiţa, that are separated from one another by ridges with altitudes in excess of 1000m, while the karst plateau on Tătăroaia peak, the show cave Peştera Urşilor at Chişcău, Fagului cave, intercepted by a mining gallery excavated on the left side of Fagului valley, and Micula cave, whose underground stream emerges in the Giuleşti spring, as well as the abundance of caves located in the karst landscape of Sighiştel valley.

The Sighiştel catchment basin extends mostly on limestone deposits where the stream has excavated a deep valley, which in its upper reaches has a canyon appearance. The summits of the ridges that surround it are covered by quartzite sandstones ascribed to the Arieşeni overthrust. Those deposits favor the organization of a scanty runoff, that when reaching limestone terrains sinks underground via a multitude of swallets, to supply a well developed karstic aquifer. The intense karst processes of this area resulted in the development of a large number of caves (about 70), out of which Măgura, Coliboaia, Pişolca and the pothole in Secătura are worth mentioning.

Crişu Băiţa catchment area, extending west of Piatra Grăitoare peak and south of the Tapul ridge, displays a high energy environment and steep slopes, across which the streams -most of them temporary (Hoanca Moţului, Fleşcuţa, Corlatul, Coşuri, Hoanca Codreanului), have incised deep, canyon-like valleys, broken by many waterfalls which make progression extremely difficult. Outstanding karst features of this catchment basin are the outflow cave Izvorul Crişului, as well as the temporary stream cave Poarta Bihorului, the latter especially due to the size of its entrance porch.

The flow regime of both surface streams and groundwater in the karst area of the upper Crişu Băiţa catchment basin is dramatically influenced by the existing mining activities.

### 3.1.2. Padiș internal drainage basin

Padiş internal drainage basin extends over a surface of 37.2 km$^2$ and is surrounded by a belt of ridges that prevent surface flow connections with any of the adjoining catchment basins. However, tracer tests have proven that its groundwater flow discharges into the Crişu Negru catchment basin.

The origin of the internally drainage basin related to the geological constitution of the area, specifically to the alternating karstic and non-kartsic substratums. The sandstones and shales on Măgura Vânată allow a scanty organization of the rainfall water into perennial streams, which sink when entering a limestone substratum, with a resulting dissection of the morphology terrain, leading to the existence of 9 subordinate basins, within the overall Padiş area: Vărăşoaia (0.92 $km^2$), Padiş (15.2 $km^2$), Bălileasa (1.6 $km^2$), Groapa de la Barsa (2.6 $km^2$), Valea Cetăţilor (3.4 $km^2$), Poiana Ponor (2.1 $km^2$), Paragina (2.65 $km^2$), Lumea Pierdută (7.7 $km^2$) and Barsa Cohanului (1.1 $km^2$).

### 3.1.3. Someșu Cald catchment basin

Characteristic to Someşu Cald upper reaches are the outstanding morphology and karst topography of Cetăţile Rădesei and the associated spectacular canyon.

When reaching out of the canyon, the river receives four main, left hand tributaries from Vlădeasa Massif: Alunul Mare, Alunul Mic, Ponorul and Valea Firii, all of which cut across the prevalently carbonate deposits of the Someşu Cald graben, displaying a characteristic karst topography, with karst plateaus (Piatra Altarului, Humpleu, Onceasa etc.), potholes, springs and swallets.

From the Bihor mountains karst area, Someşu Cald receives two main, right hand tributaries: Batrâna and Beliş. The first one originates in the junction of the streams Izbuc and Călineasa, the flows of which are collected from the karstic plateaus Bătrâna and Călineasa, while the second one, Beliş, has its fountain-head east of Călineasa plateau and receives as its main tributary Apa Caldă, the source of which is located beneath Ursoaia Saddle (the latter stream is delimiting Bihor from Gilau Mountains).

### 3.1.4. Arieșu Mare catchment area

A significant part of the carbonate terrains in Bihor Mountains occurs in the Arieşu Mare catchment area, more specifically on the left side of the river, between its source area and the junction with Albac stream.

The most important tributary of Arieşu Mare in the Bihor mountains karst area is Gârda Seacă. The latter is almost 20 km long, having its fountain-head beneath Sesul Gârzii, close to Padiş, while its first significant inflow is provided by the spring at Gura Apei. After a rectilinear course along a narrow valley, where the flow rate doubles via the Apa din Piatra and Coliba Ghiobului springs inflow, the entire flow of the stream that in this section is called Gârdişoara, sinks into the cave Coiba Mică. Further on, from Casa de Piatră hamlet downstream the valley is called Gârda Seacă. It enters a narrow gorge section and receives the left hand tributary Vulturul, then next to Fileşti, via Tăuz spring, the valley recovers the flow sunk in Coiba Mică. When leaving that gorge section, the flow rate of Gârda Seacă increases on account of the discharge provided by the Coroaba spring, which after follows a long course across Permian - Werfenian sandstones and conglomerates, interrupted by the Ladinian limestones at Coteţul Dobreştilor hamlet, where the homonym outflow cave is located.

Before reaching the course of Arieşu Mare, in the center of the village Gârda de Sus, Gârda Seacă valley receives from the left side its most important tributary, Ordâncuşa. Between the valleys of Gârda Seacă and Ordâncuşa is perched the second internal drainage basin in Bihor mountains, Ocoale - Gheţar. Ordâncuşa flows, on its first 4 km upstream of the confluence with Gârda Seacă, through a narrow canyon, with up to 200 m high walls, cut into the limestone substratum. Within the canyon, Ordâncuşa stream receives its most important supply, the discharge of the cave Poarta lui Ioanele.

The internally drainage basin Ocoale - Gherţar, situated at 1100 - 1300 m altitude, is traversed by Ocoale brook in its upstream section, that when passing from quartzite sandstones on a limestone substratum gradually sinks, eventually to disappear completely. The downstream valley assumes the appearance of a wide depression, with its bottom strewn with sinkholes, where also the entrance of the Sesuri pothole is located.

On the southern limit of the basin, opens the wide entrance of the shaft that leads to the Scărişoara Glacier, while southern of this, is located one of the most beautifully decorated caves in Romania, Pojarul Poliţei.

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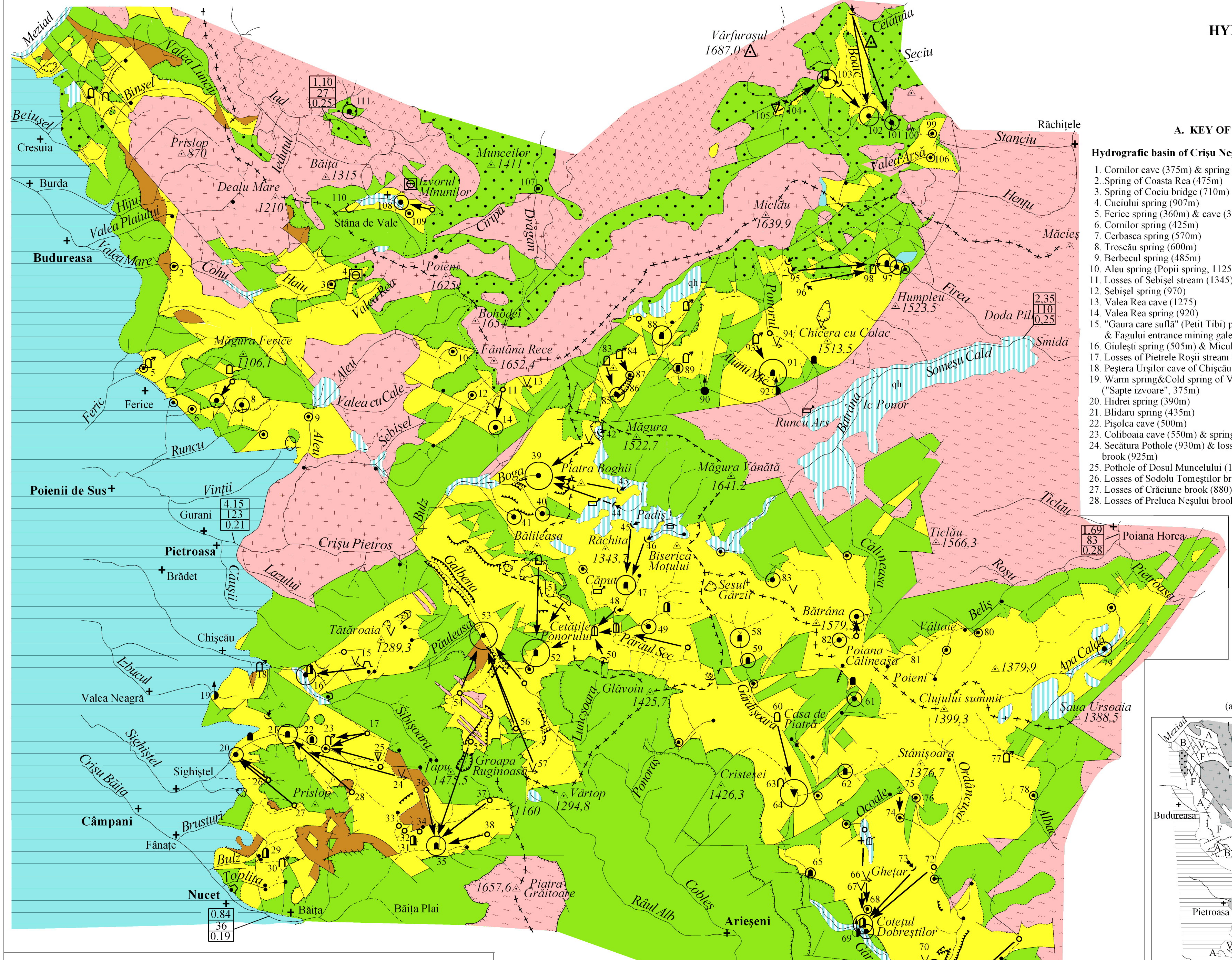
# HYDROGEOLOGICAL MAP OF THE BIHOR VLĂDEASA MOUNTAINS KARST AREAS

0 1 2 3 km

( Legend as in figure 1 )



## A. KEY OF THE SITE ON THE MAP ( in brackets, altitude of the site in meters a.s.l.)

### Hydrografic basin of Crişu Negru river

1. Cornilor cave (375m) & spring (370m)
2. .Spring of Coasta Rea (475m)
3. Spring of Cociu bridge (710m)
4. Cuciului spring (907m)
5. Ferice spring (360m) & cave (370m)
6. Cornilor spring (425m)
7. Cerbasca spring (570m)
8. Troscău spring (600m)
9. Berbecul spring (485m)
10. Aleu spring (Popii spring, 1125m)
11. Losses of Sebişel stream (1345)
12. Sebişel spring (970)
13. Valea Rea cave (1275)
14. Valea Rea spring (920)
15. "Gaura care suflă" (Petit Tibi) pothole (960) & Fagului entrance mining galery
16. Giuleşti spring (505m) & Micula cave (510m)
17. Losses of Pietrele Roşii stream (800m)
18. Peştera Urşilor cave of Chişcău (440m)
19. Warm spring&Cold spring of Valea Neagră ("Sapte izvoare", 375m)
20. Hidrei spring (390m)
21. Blidaru spring (435m)
22. Pişolca cave (500m)
23. Coliboaia cave (550m) & spring (515m)
24. Secătura Pothole (930m) & losses of Secătura brook (925m)
25. Pothole of Dosul Muncelului (1100m)
26. Losses of Sodolu Tomeştilor brook (550)
27. Losses of Crăciune brook (880)
28. Losses of Preluca Neşului brook (815)
29. Cave(500m)&spring of Fânaţe (450)
30. Secătura cave (610)
31. Poarta Bihorului Cave (640)
32. Losses of Coşuri brook (975)
33. Losses of Hoanca Codreanu (850)
34. Elena Pothole (845)
35. Crişului spring (700)
36. Losses of Corlatu brook (1040)
37. Losses of Flescuţa brook (1150)
38. Losses of Hoanca Moţului brook (925)
39. Boga spring (675m)
40. Oşelu spring (910)
41. Bulbuci spring (900)
42. Ponor of Vărăşoaia (1290) and V5 (Faţa Muncelului) pothole (1366,9)
43. Ponor of Cuţilor stream (1260m)
44. Ponor of Rengle stream (1235m)
45. Ponor of Arsurii stream (1245m)
46. Ponor of Trânghesti stream (1270m)
47. Spring of Poiana Ponor (1100m)
48. Ponor of Poiana Ponor (1060m)
49. Izvorul Rece spring (1075m)
50. Losses of Barsa Cohanului stream (1090m)
51. Groapa de la Barsa (1100-1150m)
52. Galbenei spring (815m)
53. Pauleasa spring (570m)
54. Losses of Ţiganului stream (820m)
55. Losses of Valea Seacă stream (1100m)
56. Losses of Crişanul stream (975m)
57. Pothole of Hoanca Urzicarului (1165m)

### Hydrografic basin of Arieş river

58. Gura Apei spring (1125)
59. Coliba Ghiobului spring (1110)
60. Coiba Mică cave (1015)
61. Vulturului spring (1040)
62. Peştera cu Apă cave (1095)
63. Hodobana cave (1000m)
64. Tăuz spring (850m)
65. Corobana cave (800m)
66. Pothole of Şesuri (1134m)
67. Gheţarul de la Scărişoara (1175)
68. Poliţa spring (920)
69. Feredeu spring (757)
70. Zgurăşti pothole (880) & Poarta lui Ioanele spring (810)
71. Izbucul Mic spring (730) and Izbucul Mare spring (725)
72. Losses of Ordâncuşa stream (745)
73. Troaca spring and ponor (1100)
74. Iapa spring (1230)
75. Ponor at Trei Cărări (1300)
76. Gheţarului spring (1190)
77. Dârninii cave (1260m)
78. Mătişeştilor spring

### Hydrografic basin of Someşu Cald river

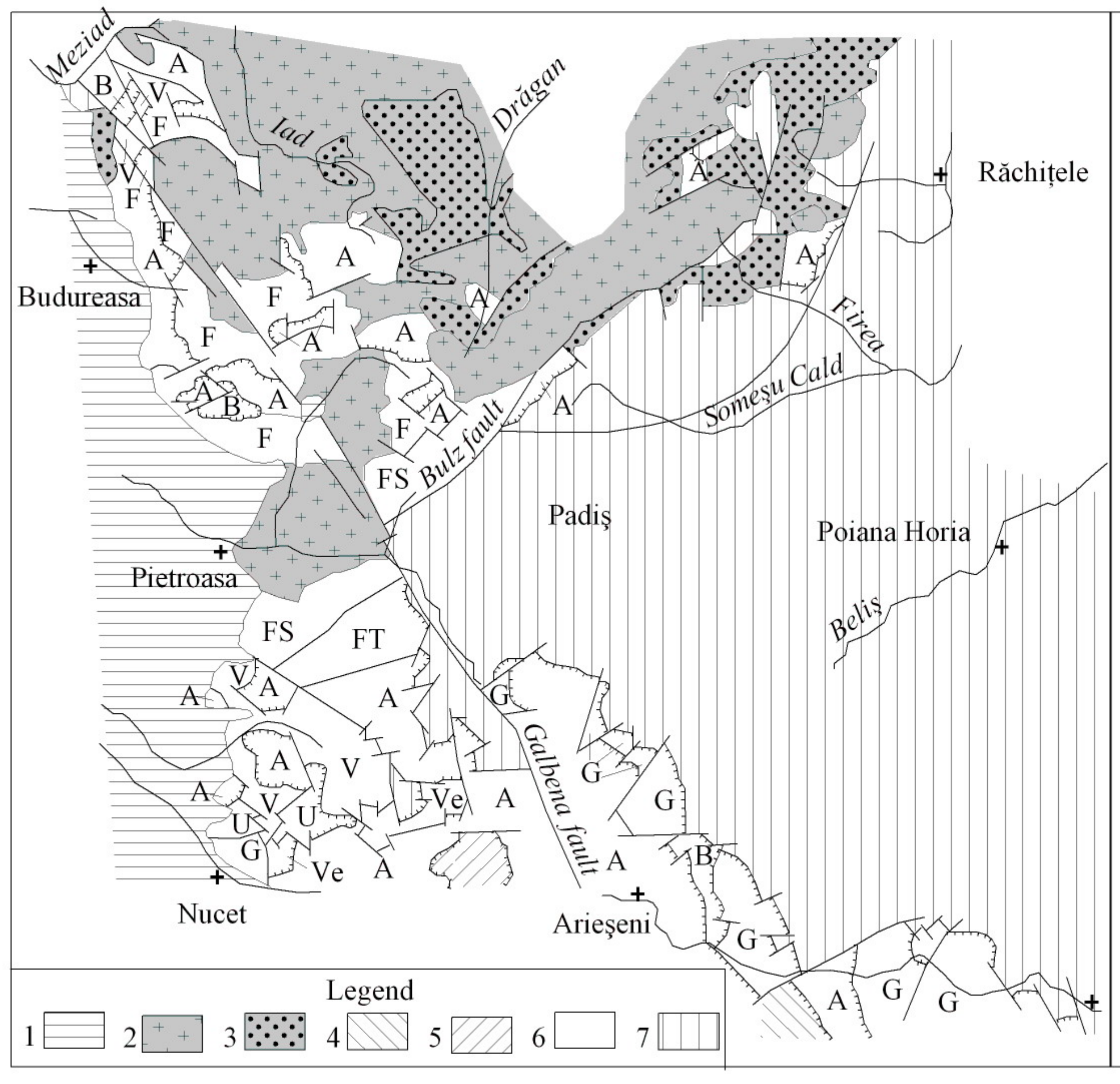
79. Apa Caldă spring (1120m)
80. Spring of Hoanca Seacă (1150m)
81. Losses of Beliş stream (1120-1160m)
82. Ponor (1305m) and spring(1170m) of Călineasa
83. Ponor in Cuciulata cave (1335)
84. Fisura Neagră cave (1210)
85. Moloh spring (1210m)
86. Cetăţile Rădesei
87. Izbucul cu Cascadă spring (1200)
88. Alunul Mare spring (1180)
89. Pepii cave (1125)
90. Spring in Someşu Cald-Pârâul Sec confluence (1095)
91. Alunul Mic spring (1100)
92. Warm spring in Alunu Mic stream (1065)
93. Diaclaza cave (1235)
94. Lucii pothole (1140)
95. Ponor of Poiana Vârtopului (1322)
96. Ponorul cu Pod ponor (1315)
97. Surile din Firea caves (1070)
98. Humpleu cave (1175)

### Hydrografic basin of Crişu Repede river

99. Lespezi spring (950m)
100. Răchiţele waterfall (1000m)
101. Springs of Preluca din Vale (1040)
102. Sărcerului spring (1070)
103. Vârfuraşu spring (1175), cave (1190) and Tăul Rogojanului ponor (1140m)
104. Tăul Negru ponor (1140)
105. Avenul cu Spinare pothole
106. La Divan spring
107. Ciripa spring
108. Păstrăvăriei spring(1100)
109. Rampei spring (1140)
110. Izvorul Minunilor Galery
111. Murgaşu spring (930m)

## B. S TRUCTURAL MAP OF THE BIHOR VLADEASA MOUNTAINS

(after geological maps of Romania, scale 1:50.000, edited by the Geological Institute of Romania)



1. Neogene and Quaternary sedimantary deposits
2. Banatitic magmatites
3. Senonian deposits
4. Muncel-Lupşa Nappe
5. Biharia Nappe
6. Codru Nappe system
   - A - Arieşeni Nappe
   - V - Vetre Nappe
   - U - Următ Nappe
   - B - Bătrânescu Nappe
   - F - Ferice Nappe
     - FS - Sebişel
     - FT - Tătăroaia
   - G - Gârda Nappe
   - V - Vălani Nappe
7. Bihor Unit

**Additional symbols**

| Mean annual spring flow, l/s | | | | |
|---|---|---|---|---|
| under 1 | 1-10 | 11-50 | 51-300 | 301-550 |
| • | ⊙ | ⊙ | ○ | ◯ |
| ▪ | ⊙ | ⊙ | ○ | ◯ |

**Geological data after:**

Bleahu M. et al., (1980), M. Bleahu et al., (1985), Bordea S. et al., (1984), Bordea S. et al., (1988), Bordea S. et al., (1992), Dumitrescu R.et al., (1970), Mantea Gh., (1986), Mantea Gh. et al., (1987), Istrate G., (1978), Stefan A., (1980)

## 3.1.5. Crișu Repede catchment basin

Within the section of the Crişu Repede catchment area that belongs to Vlădeasa Mountains, carbonate deposits outcrop in the upper catchment area of Stanciului brook (Valea Seacă karst area), and at Stâna de Vale, in the upper reaches of Iadului valley .

Valea Seacă collects its water from the eastern slopes of Vlădeasa Massif. In its fountain-head area, in a high energy environment, the stream crosses a succession of compartments risen and sunken along fault lines, with Triassic and Jurassic limestones and dolomites outcrops in the elevated blocks and Senonian deposits in the downthrown blocks. From a hydrologic point of view it is worth mentioning the presence of Vârfuraşul spring, of the temporary dry section of the Valea Seacă stream between the swallet "La Tău" and Nimoioasa springs, and the karstic stream piracy features along Valea Podurilor. Several caves and potholes have been explored, among which the outstanding 2250 m long Vârfuraşul cave (E. KÖMIVES and I. NAGY, 1976). A morphological description of Valea Seacă area were performed by P. COCEAN and CORINA BALC in 1987.

The presence close to Stâna de Vale of a little compartment consisting of limestones and dolomites resulted in shaping a karst topography of modest dimensions, yet including varied

| No. | Cavity (in brackets number in Figure 3.1) | Length (m) | Diference in level (m) | Bibliographic source |
|---|---|---|---|---|
| 1 | Poieniţă pothole - Humpleu cave (98) | 35600 | 347.6 | Papiu, Frăţilă |
| 2 | Pârâul Hodobanei cave (63) | 22142 | 181 (-121;+60) | Vălenaş, |
| 3 | Zăpodie cave - Peştera Neagră cave | 12048 | 178 (-162;+16) | Vălenaş, 1978 |
| 4 | Valea Rea cave (13) | 11718 | -264 | Damm |
| 5 | Cornilor cave (1) | 10140 | 112 | Brijan,1987 |
| 6 | Coiba Mare cave | 5680 | 121 (-76;+45) | Vălenaş, 1978 |
| 7 | Dârninii cave (77) | 5645 | -112 | Silvestru |
| 8 | Zgurăşti cave (70) | 5210 | -75 | Ciubotărăscu |
| 9 | Cerbului cave - Avenul cu Vacă | 5094 | -125 | Silvestru a.o., 1995 |
| 10 | Sesuri pothole (66) | 4010 | 240 (-220;+20) | Luduşan |
| 11 | Fântâna Roşie cave | 3550 | 129 (-40;+89) | Vălenaş, 1978 |
| 12 | Colţului cave | 3526 | 167 (-86, +81) | Silvestru a.o., 1995 |
| 13 | Lumea Pierdută cave network | 3322 | -137 | Vălenaş, 1984 |
| 14 | Cetăţile Ponorului | 3214 | -117 | Brijan,1978 |
| 15 | Ponorul din Cuciulata cave (83) | 3140 | 85 (-75;+10) | Vălenaş, 1978 |
| 16 | Gheţarul de la Barsa cave | 3010 | -112 | Vălenaş, 1978 |
| 17 | Peştera cu Peşti cave (Micula), (16) | 3000 (?) | | |
| 18 | Peştera de după Deluţ cave | 1480 | -142 | Vălenaş, 1976 |
| 19 | Cave in Dealul Secăturii | 1450 | -230 | Halasi |
| 20 | V5 pothole (Faţa Muncelului), (42) | 1446 | -645 | Damm, et al. 2005 |
| 21 | Hoanca Urzicarului pothole (57) | 1125 | 288 (-286;+2) | Vălenaş, 1982 |
| 22 | Cuciulata pothole | 925 | -186 | Vălenaş, 1978 |
| 23 | Ponorul Zăpodiei cave | 705 | 122 (-112;+10) | Vălenaş, 1978 |
| 24 | Sohodol 2 pothole | 507 | -193 | Vălenaş, et al., 1982 |
| 25 | Gaura care Suflă pothole (Petit Tibi,17) | 241 | 161 (-160;+1) | Kopacz, Lazar, 1996 |

**Table 3.1. Main cavities in the Bihor Vlădeasa Mountains.**
(After C. GORAN, 1981, P. MATOȘ, 1982-1988 and A. POSMOȘANU & P. DAMM, 1995-2005. In brackets number of cavities in figure 3.1)

landforms (sinkholes, dry valleys, swallets, caves and springs). Outstanding among them is Izvorul Minunilor, a source of still water of excellent quality, that emerges from a small cave excavated in Anisian dolomites, covered by a thick layer of senonian deposits and rhyolites.

The large number of karst cavities, their dimensions and their impressive beauty place Bihor Vlădeasa Mountains in the top position among Romania's karst areas. In Table no. 1 are indicated the largest caves and potholes surveyed in the area.

## 3.2. General hydro-meteorological data

Rainfall across Bihor Vlădeasa mountains area has an uneven distribution. Multiannual average values as well as records performed during hydrologic year October 1984-September 1985, display an increase of the annual amounts from the Beiuş basin (Budureasa - 941.3 mm, Pietroasa - 948.6 mm, Băiţa - 884.2 mm) eastward, up to the Stâna de Vale - Piatra Graitoare ridge area (Stâna de Vale - 1608.5 mm), while further east a decrease intervenes (Vlădeasa - 943 mm, Casa de Piatră - 836.5 mm, Smida - 952.3 mm, Poiana Horea - 714.5 mm, Scărişoara - 746.8 mm).

Within Bihor Vlădeasa Mountains are included a series of stations of the national stream gauging network, under the authority of the National Institute for Hydrology and Water Management (INHWM, a part of former INMH). They are generally located at the border of the mountain massifs and gauge runoff originating in catchment areas of varied lithologic constitution. The distribution of the multiannual specific discharge of those streams (Table 3.2) mirrors the rainfall dis-

| No. | River | Gauging station | | F km$^2$ | H m | Q m$^3$/s | q l/s/km$^2$ | Bf | ME, days | RT, days | TF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | Someşu Cald | Beliş | 1950-1967 | 320 | 1247 | 6.22 | 19.4 | 0.24 | 48 | 37.1 | 0.196 |
| 2 | Someşu Cald | Smida | | 110 | 1293 | 2.35 | 21.4 | 0.25 | | | |
| 3 | Beliş | Beliş | | 119 | 1249 | 2.32 | 19.5 | 0.27 | 47 | 34.2 | 0.208 |
| 4 | Beliş | Poiana Horea | | 83 | 1259 | 1.69 | 20.4 | 0.28 | | | |
| 5 | Drăgan | P. Crucii am. | | 119 | 1228 | 3.74 | 31.4 | 0.25 | | | |
| 6 | Sebişel | P. Crucii | | 39.4 | 1172 | 1.19 | 30.2 | 0.25 | 123 | 81 | 0.092 |
| 7 | Iad | Leşu | | 101 | 979 | 2.83 | 28.0 | 0.20 | | | |
| 8 | Iad | Stâna de Vale | | 27 | 1210 | 1.10 | 40.9 | 0.25 | 24 | 24.7 | 0.192 |
| 9 | Crişu Pietros | Pietroasa | | 123 | 956 | 4.15 | 33.7 | 0.21 | 15 | 21.4 | 0.208 |
| 10 | Crişu Băiţa | Băiţa | | 36 | 892 | 0.86 | 23.9 | 0.19 | | | |
| 11 | Arieş | Scărişoara | | 200 | 1099 | 5.45 | 27.25 | 0.27 | 35 | 29.8 | 0.232 |
| 12 | Crişu Pietros | Pietroasa | X.1984-IX.1985 | | | 4.28 | 34.8 | 0.30 | | | |
| 13 | Crişu Băiţa | Băiţa | | | | 0.80 | 22.2 | 0.27 | | | |
| 14 | Sighiştel | Sighiştel | | | | 0.46 | | 0.26 | | | |
| 15 | Crăiasa | Giuleşti upstream | | | | 0.41 | | 0.18 | | | |
| 16 | Galbena | Intre Ape | | | | 1.92 | | 0.29 | | | |
| 17 | Bulz | Canton silvic | | | | 0.92 | | 0.25 | | | |
| 18 | Arieş | Scărişoara | | | | 5.34 | 26.7 | 0.28 | | | |
| 19 | Beliş | Poiana Horea | | | | 1.83 | 22.0 | 0.30 | | | |
| 20 | Someşu Cald | Smida | | | | 3.34 | 30.4 | 0.28 | | | |

F - surface of hydrographic basin (h.b.); H - mean altitude of h.b.; Q - mean multiannual discharge;
q - mean multiannual specific discharge; Bf - base flow index; EM - memory effect. TR - Regulation time;
FT - truncation frequency (EM, TR and FT computed for 1971-1975 period).
Note: Data in columns 5-9 after "Râurile României". 1950-1967 time period
**Table 3.2. Morphometric and hydrometric data for main rivers.**

tribution and geological constitution, ranging from 40.9 l/s/km$^2$ in the case of Iad river, at the gauging station Stâna de Vale (Murgaşu), with a high altitude catchment basin, to 19.4 l/s/km$^2$ in the case of Someşu Cald river, at the gauging station Beliş, in the eastern part of the mountains (Anuare hidrologice INMH, C. MOCIORNIŢĂ Editor, 1967, 1968).

## 3.3. Short hystorical review of the Bihor Vlădeasa Mountains karst hydrology investigation

In the 1950-1970 period, the first fluorescein tracing experiments in Bihor Mountains have been performed by M. SERBAN et al., 1957, I. VIEHMANN, 1966, T. RUSU et al., 1970, the flow connections between Ocoale closed catchment area and the springs at Coteţul Dobreştilor, respectively the existence of the underground flows along the Padiş - Poiana Ponor - Cetăţile Ponorului - Galbenei spring lineament being outlined as a result.

During 1976-1985 L. VALENAS - alone or in co-operation, publishes in a series of papers the results of speleological investigations, which assumed a definite hydrologic character too, conducted in the karst of Bihor Vlădeasa Mountains and which have brought important contributions in this domain, as an outcome of the exploration of Groapa de la Barsa cave system (1977-1978), of Coiba Mică - Coiba Mare cave system (1978), of the cave in Pârâul Hodobanei (1982), of the karst at Casa de Piatră (1976), in the upper reaches of Someşu Cald (1978), Lumea Pierdută (1982) and in other areas.

The hydrogeologic investigations in Bihor Vlădeasa mountains have been initiated in 1983 through the activities conducted by I. ORĂŞEANU and NICOLLE ORĂŞEANU. During 1983-1985 they perform the first hydrogeologic map of the karst areas, as well as the groundwater reserves evaluation, and done some 30 new tracer experiments. The hydro-meteorological data acquisition has been performed in cooperation with PARASCHIVA and GH. HOŢOLEANU and LUMINIŢA TIBACU from NIHWM, while E. GAŞPAR and T. TĂNASE from Istitute of Physics and Nuclear Engineering (IFIN) and I. POP from the University in Baia Mare have taken part in the completion of the tracer tests, the results of which have been published in 1991.

## 3.4. Geologic-structural framework of Bihor Vlădeasa Mountains

Within the overall structural setting of Bihor Mountains the lowest position is occupied by the Bihor Unit, that is usually called the “Bihor Autochtonous”. It includes metamorphic formations and a sedimentary stack consisting of Mesozoic pre-Senonian formations, locally with detritic Permian deposits at their bottom. Deposits ascribed to the Codru overthrust system prevalent outcrops in the western part of the mountain area (Fig. 3.1). The Table 1.2 in first part of the paper indicates the stratigraphic correlation of the Bihor Unit formations and of the Codru overthrusts.

The geologic base of the hydrogeological map (Fig. 3.1) is draw according to the works of BLEAHU et al., 1981, BORDEA & BORDEA, 1973, and to the sheets Avram Iancu (DUMITRESCU et al., 1977), Poiana Horia (BLEAHU et al., 1980), Pietroasa (BLEAHU et al., 1985), Răchiţele (MANTEA et a., 1987) and Biharia (BORDEA et al., 1988) of the geologic map of Romania, scale 1:50,000.

At the end of the Cretaceous, three major geologic events have taken place: a) the overthrusting of the Codru nappes, during the Turonian; b) the formation of fracture systems, along which the subsidence of sedimentary basins of epicontinental facies took place, with associated accumulation of Gosau type Senonian formations; c) intense subsequent volcanic activity.

The Senonian deposits featuring a Gosau facies form the Late Cretaceous post-tectonic cover of the Bihor Unit and of the Codru Nappes System. Such deposits outcrop over relatively restricted areas in the Someşu Cald graben, as well as on the terrains covered by the Vlădeasa igneous formations.

The succession of the Senonian deposits in the Someş Cald graben begins with conglomerates with arenitic matrix and well rolled embedded gravel, that includes crystalline schists, limestones and sandstones. Dark grey - reddish argillaceous marls and micaferous yellow - green sandstones follow. The reef facies of the Senonian consists of limestones with many corals, while the volcanic-sedimentary formation includes alternating volcanic ashes, tuffs, tuffites, sandstones, micro-conglomerates, breccia and conglomerates with terrigenous-volcanic matrix (G. MANTEA, 1985).

G. ISTRATE (1978), in a paper dedicated to the petrographic study of Vlădeasa Mountains (the western part), distinguishes within the Senonian series a lower, sedimentary complex and a volcanic-sedimentary formation. The lower sedimentary complex (the Gosau formation) includes a succession consisting of three sections: a bottom, conglomeratic one, a median, marly, sandy, micaferous one, and an upper, micro-conglomeratic one.

### 3.4.1. Alpine subsequent igneous rocks and associated products

The alpine subsequent (banatitic) magmatic activity is documented in the western part of northern Bihor Mountains and along the northern border of this unit, by means of a large variety of rocks.

Within the Pietroasa - Aleului valley area, and further north, up to Budureasa, granodiorites outcrop. They are part of a single batholitic body, that within Bihor Mountains extends, both at the surface and in the underground, up to the Galbena fault. An exception is recorded in the Bulz valley area, where an igneuos body having penetrated along the previously mentioned fault outcrops. A multitude of veins of andesitic or basaltic composition, that have been identified especially in the upper reaches of Crişu Băiţa long the valleys Hoanca Moţului, Corlatu and Fleşcuţa, as well as in the Valea Seacă catchment area, are of hypoabissal origin, being associated to the indicated banatitic intrusion.

Vlădeasa Mountains are built up of rhyolitic rocks of different facieses, ranging from massive to vitrophyres, as a function of the place where the rhyolitic magma solidification has occured (i.e. under the Senonian sedimentary cover or at the surface). In the evolution of the magmatic activity of this area there have been two outstanding events, namely the setting of the ignimbritic rhyolites formations and the setting of the intrusive bodies.

The intrusion of the banatites has resulted in contact processes that concerned the sedimentary deposits being traversed. At the contact of the banatites with the limestones, marbles and various types of calcic skarns have been formed, while at the contact with the detritic and pelitic rocks, hornfels, garnet skarns, etc. are met.

### 3.4.2. Neogene formations

On the western rim of Bihor Mountains, Pannonian (Malvensian) deposits consisting of clays with coal interbeddings, sands and gravel from the Beiuş Neogene Basin filling outcrop. In the close neighbourhood of the mountains border coarse deposits prevail, that are however rapidly substituted by a pelitic facies, of wide occurence across the entire Beiuş Basin.

Quaternary formations consist of sands, gravel, boulders and, subordinately, clays. They occur in the terraces of Crişu Pietros and of the other streams that originate on the western slopes of Bihor Mountains, in the present day streams alluvia, in the ancient and the recent deluvial and colluvial deposits. A noteworthy extent have the deposits on the karstic platforms Padiş - Cetăţile Ponorului, Bătrâna and Apa Caldă - Beliş divide. They consist prevalently of sands with quartzite sandstone fragments, which have been carried away by runoff originating on the nearby slopes, then left in place, once the surface streamlets had taken an underground course through the carbonate substratum.

## 3.5. Hydrogeology of carbonate terrains

Karst systems in Bihor Vlădeasa Mountains are generally of binary type. They display a wide variety of dimensions, lithologic constitutions and dynamics, that are mirrored by the physical, chemical and hydrogeological characteristics of the springs.

The karst springs are situated at different elevations, as a result of the pronounced dissection of the carbonate deposits and of the rugged topography. At the scale of the entire karst region a general base level cannot be outlined, each specific karst area having its own base level. The karst springs flow rates extend over a very wide range, with a 550 l/s maximum annual average value.

### 3.5.1. Tracer tests

So far, in Bihor Vlădeasa Mountains there have been conducted 59 tracer tests which resulted in outlining 75 underground flow paths (Table 3.3). The average elevation of the sinking points is 1084 m, while that of the outlets is 812 m, the distance between a sinking point and an outlet being 2098 m on the average, while tracers flowed at an average velocity of 65.5 m/hour (computed by considering the first tracer arrival). The longest distance between a sinking point and an outlet (4600 m) is that which separates the pothole in Hoanca Urzicarului from Păuleasa spring, while the maximum elevation drop (665 m) is that recorded between the underground stream sinking point in Muncelul cave (the cave in Dosul Broscoiului) and Blidaru spring in Sighiştel Valley.

### 3.5.2. Hydrogeologic water budget

In order to evaluate the budget of surface water and groundwater in the Bihor Vlădeasa Muntains, during the hydrologic year October 1983 - September 1984 the national hydrological observations network has been filled in with discharge gauging sections, set up on the main streams, at sites where they left the carbonate terrains, and at the main karst springs. For filling in the national meteorological observations network, including Stâna de Vale, Ştei and Vlădeasa meteorological stations and rainfall device meter of the INHWM hidrological sections, temporary rainfall gauging devices have been installed at Runcu Ars and Vârtop. Additionally, a meteorological platform, provided with equipments for gauging rainfall, evaporation at the water surface and evapotranspiration by means of lysimeters has been built at Casa de Piatră (Fig. 3.2).

The discharge gauging stations located at the outskirts of the karst areas in Bihor mountains have provided control over a 527 km$^2$ surface area. For the considered area, the rainfall recorded over the hydrologic year October 1984 - September 1985 has amounted to 1220 mm. During the same period, the evapotranspiration value obtained by processing the meteorological data and the lysimetric data provided by the temporary meteorological station at Casa de Piatră, amounted to 374.6 mm. The available water amount (845.6 mm), distributed between runoff and infiltration, has been recovered at the discharge gauging sections at the outskirts of the karst areas, which indicates that within the range of error of the primary data, there are no significat water transfers from or toward ajoining structural units.

| Labelling no. | Drainage no. | Insurgence | H (m) | Resurgence | H, m | L, m | ΔH, m | Tracer | T, hours | V, m/h | Date of labelling | Author (s) of labelling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Ponor of Groapa Budeştilor | 875 | Cerbasca spring | 570 | 750 | 305 | In | 192 | 3.9 | 06.10.1985 | I. Orăşeanu et al. |
| 2 | 2 | Course of Fagului cave | 865 | Giuleşti spring | 505 | 1900 | 360 | R | 85 | 22.3 | 07.10.1984 | I. Orăşeanu |
| 3 | 3 | Losses of Pietrele Roşii brook | 800 | Pişolca cave | 500 | 1600 | 300 | In | 100 | 16.0 | 23.09.1987 | I. Orăşeanu et al. |
|  | 4 |  |  | Coliboaia spring | 513 | 1240 | 287 | “ | 100 | 12.4 | “ | “ |
|  | 5 |  |  | Blidaru spring | 435 | 2330 | 365 | “ | 100 | 23.3 | “ | “ |
|  | 6 |  |  | Hidrei spring | 390 | 3950 | 410 | “ | 100 | 39.5 | “ | “ |
| 4 | 7 | Losses of Secătura brook | 925 | Coliboaia spring | 513 | 2150 | 412 | R |  |  | 1984 | Halasi G., Ponta G. |
| 5 | 8 | Losses of Secătura brook | 925 | Coliboaia spring | 515 | 1700 | 410 | R | 168 | 10.1 | 21.09.1984 | I. Orăşeanu |
|  | 9 |  |  | Blidaru spring | 435 | 3070 | 490 | “ | 240 | 12.8 | “ | “ |
| 6 | 10 | Course of Muncelu cave | 1100 | Blidaru spring | 435 | 3880 | 665 | I | 147 | 26.3 | 17.05.1985 | I. Orăşeanu et al. |
| 7 | 11 | Losses of Preluca Neşului brook | 815 | Blidaru spring | 435 | 2770 | 380 | F | 96 | 28.9 | 21.09.1984 | I. Orăşeanu |
| 8 | 12 | Losses of Sodolul Tomeştilor | 550 | Hidrei spring | 390 | 1350 | 160 | F | 70 | 19.3 | 28.09.1984 | I.Orăşeanu, P.Brijan |
| 9 | 13 | Losses of Crăciune brook | 880 | Hidrei spring | 390 | 2550 | 490 | In | 310 | 8.2 | 24.09.1989 | I. Orăşeanu et al. |
| 10 | 14 | Losses of Hoanca Codreanu | 850 | Poarta Bihorului spring | 640 | 600 | 210 | Br | 48 | 12.5 | 17.05.1984 | I. Orăşeanu et al. |
| 11 | 15 | Losses of Coşuri brook | 750 | Molibden mine |  |  |  |  | 288 |  | 04.11.1983 | I. Orăşeanu et al. |
| 12 | 16 | Elena ponor | 845 | Poarta Bihorului spring | 640 | 850 | 205 | I | 96 | 14.1 | 18.05.1984 | I. Orăşeanu et al. |
| 13 | 17 | Losses of Corlatu brook | 1040 | Izvorul Crişului spring | 700 | 1750 | 340 | In | 20 | 87.5 | 03.11.1983 | I. Orăşeanu et al. |

| Labelling no. | Drainage no. | Insurgence | H (m) | Resurgence | H, m | L, m | ΔH, m | Tracer | T, hours | V, m/h | Date of labelling | Author (s) of labelling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 18 | Losses of Valea Seacă brook | 1100 | Izvorul Crişului spring | 700 | 3600 | 400 | In | 1340 | 2.7 | 07.08.1984 | I. Orăşeanu et al. |
| 15 | 19 | Losses of Fleşcuţa brook | 1150 | Izvorul Crişului spring | 700 | 2150 | 450 | F | 288 | 7.5 | 23.11.1983 | I. Orăşeanu |
| 16 | 20 | Losses of Hoanca Moţului brook | 925 | Izvorul Crişului spring | 700 | 1300 | 225 | I | 30 | 43.3 | 19.09.1985 | I. Orăşeanu et al. |
|  | 21 |  |  | “Trei Izvoare” source | 775 | 550 | 150 | “ | 10 | 55.0 | “ | “ |
| 17 | 22 | Losses of Sebişelul Sec brook | 1345 | Valea Rea spring | 920 | 1130 | 425 | F | 20 | 56.5 | 22.06.2004 | I.Orăşeanu, P.Damm |
| 18 | 23 | Losses of Ţiganu brook | 820 | Păuleasa spring | 570 | 2000 | 250 | In | 24 | 83.3 | 21.05.1985 | I. Orăşeanu et al. |
| 19 | 24 | Losses of Crişanu brook | 975 | Păuleasa spring | 570 | 3075 | 405 | B | 95 | 32.4 | 27.05.1985 | I. Orăşeanu |
| 20 | 25 | Hoanca Urzicarului pothole | 1165 | Păuleasa spring | 570 | 4600 | 595 | In | 300 | 15.3 | 17.12.1984 | I. Orăşeanu et al. |
| 21 | 26 | Losses of Luncşoara stream | 700 | Păuleasa spring | 570 | 1900 | 130 | S | 24 | 79.1 | 27.05.1985 | I. Orăşeanu et al. |
| 22 | 27 | Vărăşoaia ponor | 1290 | Boga spring | 675 | 2170 | 615 | B | 15 | 144.6 | 13.06.1985 | I. Orăşeanu et al. |
| 23 | 28 | Ponor of Cuţilor brook | 1260 | Boga spring | 675 | 2560 | 585 | S | 20 | 128.0 | 13.06.1985 | I. Orăşeanu et al. |
| 24 | 29 | Ponor of Renghii brook | 1235 | Boga spring | 675 | 2500 | 560 | In | 24 | 104.1 | 14.06.1985 | I. Orăşeanu et al. |
| 25 | 30 | Ponor of Arsurii brook | 1245 | Spring of Poiana Ponor | 1100 | 2100 | 145 | R | 15 | 140.0 | 22.09.1985 | I. Orăşeanu et al. |
|  | 31 |  |  | Galbenei spring | 815 | 5120 | 430 | “ | 30 | 171.0 | “ | “ |
| 26 | 32 | Ponor of Trângheşti brook | 1270 | Spring of Poiana Ponor | 1100 | 2000 | 170 | F | 66 | 38.0 | 1958 | I. Viehman et al. |
| 27 | 33 | Ponor of Poiana Ponor | 1060 | Galbenei spring | 815 | 3000 | 245 | F | 66 | 45.0 | 1961 | I. Viehman et al. |
| 28 | 34 | Ponor of Trângheşti brook | 1260 | Spring of Poiana Ponor | 1100 | 1950 | 160 | Dy | 12 | 162.5 | 22.09.1985 | I. Orăşeanu et al. |
|  | 35 | “ |  | Galbenei spring | 815 | 5320 | 145 | “ | 24 | 221.6 | “ | “ |
| 29 | 36 | Gheţarul de la Barsa Barsa cave | 1100 | Galbenei spring | 815 | 2775 | 285 | In | 190 | 14.6 | 10.07.1987 | I. Orăşeanuet al. |
| 30 | 37 | Ştevia Lupii ponor | 1125 | Galbenei spring | 815 | 1925 | 310 | KI | 40 | 48.1 | 06.09.1986 | I. Orăşeanuet al. |
| 31 | 38 | Losses of Valea Seacă brook |  | Gemănata pothole |  | 650 |  | R | 40 | 16.2 | 10.08.1986 | I.Orăşeanu, P.Matoş |
|  | 39 |  |  | Cetăţile Ponorului | 950 | 2950 | 255 | “ | 70 | 42.1 | “ | “ |
| 32 | 40 | Losses of Barsa Cohanului | 950 | Cetăţile Ponorului | 950 | 900 | 145 | F | 14 | 64.3 | 10.08.1986 | I.Orăşeanu, P.Matoş |
| 33 | 41 | Course of Fântana Rosie cave |  | Bulbuci spring |  |  |  |  |  |  | 12.1974 | L. Vălenaş |
| 34 | 42 | Course of Coiba Mică cave | 960 | Tăuz spring | 850 | 2650 | 110 | R | 322 | 8.2 | 19.10.1985 | I. Orăşeanu |
| 35 | 43 | Course of Şesuri pothole | 1134 | Poliţei spring | 920 | 880 | 214 | F |  |  | 1957 | M. Şerban et al. |
| 36 | 44 | Losses of Ocoale brook | 1160 | Coteţul Dobreştilor spring | 770 | 2800 | 390 | F | 38 | 73.7 | 04.1964 | T. Rusu et al. |
|  | 45 |  |  | Izbucul Morii | 760 | 2880 | 300 | “ | 38 | 75.0 | “ | “ |
| 37 | 46 | Vuiaga Veche ponor | 1145 | Poliţei spring | 920 | 1360 | 225 | R | 10 | 136 | 12.08.2001 | I. Orăşeanu |
| 38 | 47 | Losses of Troaca Hănăşeşti | 1110 | Coteţul Dobreştilor | 770 | 2430 | 340 | F | 42 | 57.9 | 29.10.2002 | I. Orăşeanu |
| 39 | 48 | Losses of Ordâncuşa stream | 745 | Izvorul Mic spring | 730 | 1000 | 15 | In | 36 | 27.8 | 26.08.1985 | I. Orăşeanu et al. |
| 40 | 49 | Losses of Ordâncuşa stream at Moara lui Ivan | 960 | Coteţul Dobreştilor spring | 770 | 2900 | 190 | F | 90 | 32.2 | 29.06.2003 | I. Orăşeanu |
|  | 50 |  |  | Morii spring | 760 |  |  | “ |  |  | “ | “ |
|  | 51 |  |  | Spring at Hoanca Morii | 761 |  |  | “ |  |  | “ | “ |
|  | 52 |  |  | Fredeu spring | 758 |  |  | “ |  |  | “ | “ |
| 41 | 52 | Trei Cărări (Aprozar) ponor | 1300 | Iapa spring | 1230 | 840 | 70 | F | 10.5 | 80 | 23.03.2002 | I. Orăşeanu |
| 42 | 53 | Losses of Pleşii brook | 875 | Izvorul Mare spring | 725 | 2620 | 150 | R | 65 | 40.3 | 26.08.1985 | I. Orăşeanu |
| 43 | 54 | Losses of Ponorul brook | 1130 | Alunul Mic spring | 1100 | 1400 | 30 | R | 108 | 13.0 | 27.10.1985 | I. Orăşeanu et al. |
| 44 | 55 | Course of Diaclază cave | 1230 | Alunul Mic spring | 1100 | 1200 | 130 | In | 230 | 5.2 | 27.10.1985 | I. Orăşeanu et al. |
| 45 | 56 | Course of Lucii pothole | 1160 | Alunul Mic spring | 1100 | 1100 | 60 | F | 44 | 25.0 | 27.10.1985 | I. Orăşeanu et al. |
| 46 | 57 | Ponor of Poiana Vârtopului | 1322 | Springs Şurile din Firea | 1070 | 2610 | 252 | In | 120 | 21.7 | 12.06.1988 | I. Orăşeanu et al. |
| 47 | 58 | Ponorul cu Pod ponor | 1315 | Springs Şurile din Firea | 1070 | 2920 | 245 | R | 90 | 32.4 | 12.06.1988 | I. Orăşeanu et al. |
| 48 | 59 | Course of Cuciulata cave | 1335 | Moloh spring | 1210 | 700 | 125 | F | 35 | 20 | 22.11.1994 | I. Orăşeanu et al. |
| 49 | 60 | Course of Fisura Neagră cave | 1210 | Izbucul cu Cascadă spring | 1200 | 450 | 10 | F | 12 | 37.5 | 21.03.1995 | I. Orăşeanu et al. |
| 50 | 61 | Pothole in Cuciulata | 1258 | Izbucul cu Cascadă spring | 1200 | 580 | 58 | F | 2.25 | 256.6 | 28.04.1995 | I. Orăşeanu et al. |
| 51 | 62 | Brebu’s ponor | 1200 | Păstrăvăriei spring | 1100 | 1000 | 100 | F | 11 | 90.9 | 24.09.1997 | I. Orăşeanu et al. |
| 52 | 63 | Losses of Rampei brook | 1200 | Rampei spring | 1140 | 370 | 60 | F | 1 | 370 | 16.06.1999 | I. Orăşeanu |

| Labelling no. | Drainage no. | Insurgence | H (m) | Resurgence | H, m | L, m | ΔH, m | Tracer | T, hours | V, m/h | Date of labelling | Author (s) of labelling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | 64 | Avenul cu Spinare pothole | 1370 | Vârfuraşul spring | 1175 | 1900 | 195 | F | 15.5 | 122.6 | 19.06.1997 | I. Orăşeanu |
| | 65 | Tăul Rogojanului ponor | 1140 | Sping of Sărcerului brook | 1070 | 1450 | 70 | “ | 4 | 362.5 | “ | “ |
| | 66 | “ | “ | Spring of Preluca din Vale | 1040 | 2180 | 100 | “ | 10 | 218.0 | “ | “ |
| 54 | 67 | Ponor of Cetăţuia brook | 1450 | Spring of Preluca din Vale | 1040 | 3540 | 410 | R | < 300 | >10.4 | 20.08.1997 | I. Orăşeanu |
| | 68 | “ | 1450 | Sping of Sărcerului brook | 1070 | 3130 | 380 | R | < 300 | >10.4 | “ | |
| 55 | 69 | Tăul Negru ponor | 1330 | Vârfuraşul spring | 1175 | 1200 | 155 | F | < 11 | >109 | 18.07.1998 | I. Orăşeanu |
| | 70 | Tăul Rogojanului ponor | 1140 | Spring of Sărcerului brook | 1070 | 1450 | 70 | F | < 4 | >362 | 19.07.1998 | “ |
| | 71 | “ | “ | Spring of Preluca din Vale | 1040 | 2180 | 100 | “ | < 13 | >168 | “ | “ |
| 56 | 72 | Dârnini cave | | Mătişeşti spring | | | | | | | 1984 | A. Moldovan |
| 57 | 73 | Bălileasa | 1150 | Oşelu spring | 910 | 1250 | 245 | F | | | 2005 | P.Damm, I.Orăşeanu |
| 58 | 74 | Miron pothole | 1275 | Ursului spring | 1095 | 1850 | 180 | F | | | 2007 | I. Orăşeanu et al. |
| 59 | 75 | R2 pothole | 1220 | Boga spring | 675 | 2000 | 545 | F | 15 | 133 | 10.10.2009 | I. Orăşeanu et al. |

H - elevation, in meters a.s.l., L - horizontal distance between losses and springs, ΔH - vertical drop; T - time of first arrivel of tracer; V - apparent velocity. Used tracers: F = Fluoresceine, R = Rhodamine B, I = I-131, Br = Br-82, In = In-EDTA, Dy = Dy-EDTA, S = Stralex;

Note 1: The following labellings were performed by the author in cooperation with E. Gașpar, I. Pop and T. Tănase: 3, 6, 10, 11, 12, 16, 18, 21, 22, 23, 24, 25, 28; E. Gașpar and T. Tănase: 1, 9, 14, 20, 29, 30, 39, 44, 46; R. Catilina and C. Stanca: 10, 11, 12; P. Brijan: 3 and 6; B. Onac and C. Popa: 46 and 47; P. Brijan and S. Matyasi: 20; R. Baboș: 30; “Politehnica” Cluj Napoca speological club: 45, 46, 47; Brebu and I. Varga: 51; P. Damm, Kondacs A., J. Zih., Katalin Zih-Perenyi: 58. Underground course in R2 pothole (Seșul Padișului) was labelled by O. Pop, M. Bădescu and V. Baciu in 08.08.2009 and by J. Zih., Katalin Zih-Perenyi and G. Losonczi in 10.10.2009.

Note 2: In labellings no. 10, 12, 13, 14 and 16, the tracers were identified also in waters of undergrounds works of Molibden mine.

**Table 3.3. Results of tracing operations in Bihor Vlădeasa Mountains.**

## 3.6. Hydrogeology of karst areas

The puzzle-like distribution of the domains occupied by carbonate deposits in Bihor Vlădeasa Mountains had as a result the occurence of several distinct karst areas, each one characterised by its own groundwater dynamics regime, and including, as a general rule, several karstic systems.

The hydrologic regime of 6 outlets has been continously monitored over the hydrologic year October 1984 - September 1985. Table 3.4 indicates average, minimum and maximum annual flow rate, flow rates variability index and results of correlative and spectral analysis of daily average recorded flow rates series, while Table 3.5 indicates the main parameters that characterize the flow rates recession period.

Some of those springs collect their water from karst systems which display feeble inertia and which are concerned by intense karst processes, being hence highly conductive and subject to a poor capacity of storage. The rainfall input is filtered only to a small extent, heavy rainfall being immediately followed by significant flood pulses. Subsequently to rain-stops the discharge of those springs rapidly declines, while prolonged periods of draught result in severe reductions of their flow rates, occasionally even in a complete cessation of flow (ex. the spring at Giuleşti). Other outlets discharge from karst systems that display totally opposite characteristics (ex. Izvorul Minunilor at Stâna de Vale).

For some sources, the proportion of rapid flow in the volume of water discharged in recession time is important (38.2% at Coteţul Dobreştilor spring and 37.4% at Tăuz), while for some of them is very low (4% at Alunul Mic spring) or rather not important (0.8% at Izvorul Minunilor).

The average cumulated debit of karstic sources systematically monitored in X.1984-IX.1985, was about 3 m$^3$/s, with 1 m$^3$/s added for an average cumulated debit of other springs in this mountain.

### 3.6.1. Ferice karst area

To the north and south of the Măgura Ferice summit, in Valea Mare a Buduresei and in Runcu streams catchment areas, carbonate deposits occur in the Codru facies, while in structural terms they are ascribed to the Ferice and Bătrânescu nappes. The frequent clay sequences that occur in the Late Triassic series of Ferice nappe prohibit the development of major karst systems in the Valea Mare a Buduresei catchment area. The most important outlet in that area is Cuciului spring (Fig.3.1, no. 4), which is mainly supplied by groundwater accumulations stored within the Vlădeasa rhyolites.

The Anisian dolomites of the Bătrânescu nappe, located to the south of the quartzite sandstone body which outcrops in Măgura Ferice, host the karst systems that discharge via the springs Cerbasca (no. 8) and Troscău (no. 9), whose yearly average flow rates are about 10 l/s.

### 3.6.2. Tătăroaia karst area

Tataroaia karst area is developed in Anisian dolomites and Ladinian limestones that occur as a strip extending between Crăiasa and Galbena valleys. Most of this karst area overlies the karst system of Giuleşti spring, that is supplied almost exclusively by rainfall and does not include a non-karstic catchment basin.

The relatively scarce exokarst landforms are restricted to the sinkholes in the Vârcioroagele plateau, aroun Tătăroaia pick; in contrast, there are several significant cavities, among which it should be mentioned the "Gaura care suflă" pothole (Fig. 3.1, no. 15) and two major stream caves, Micula (no. 16) and Fagului (no. 15), the latter being discovered ensuing to the excavation of a geological exploration mining gallery.

The stream in Fagului cave emerges in Giuleşti spring (no. 16), as indicated by the rhodamine tracing experiment. Some additional supply to the system might also originate in the sinking stream of Valea Căuşii. During heavy rainfall periods the water transfer capacity of the cracks and channels network of Giuleşti spring is exceeded, so that part of the flow is discharged through the entrance of Micula cave, that behaves as an overflow to the system.

The global interpretation of the data concerning Giuleşti spring contained in Table no. 3.3 indicates that its discharge is derived from a karst system of very poor inertia, subject to intense karst development, prevalently conductively and much less in what concerns its storage capacity. The reserves of the system are small, the weight of the fraction dis-

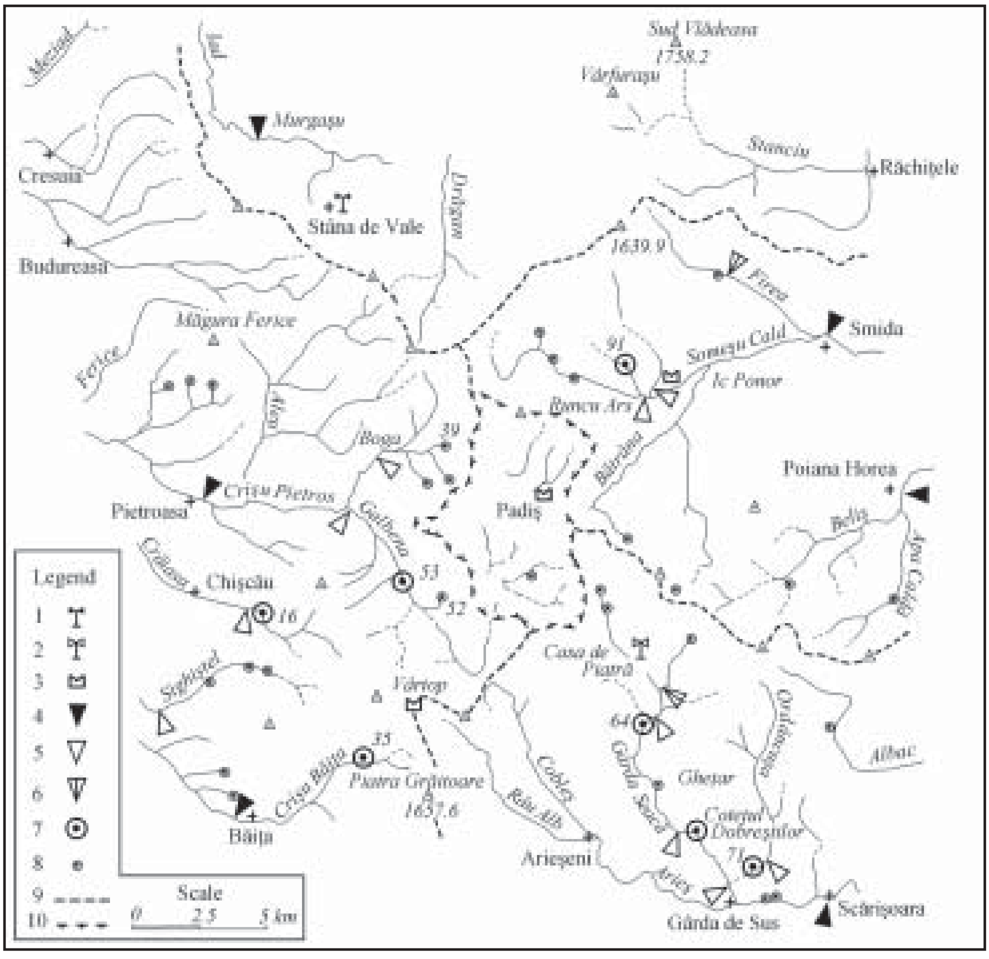


**Figure 3.2. Hydrometeorological network in Bihor Vlădeasa Mountains in X.1984-IX.1985 (T period).**
Legend:
1. Meteorologic station in national network;
2. Meteorologic station in T period;
3. Rainfall device recorder in T period;
4. Hydrometric station in national network;
5. Hydrometric section in T period;
6. Monthly hydrometric measurements in T period;
7. Source with discharge device recorder in T period;
8. Source with expeditionary discharge measurements;
9. Watershed;
10. Limit of Padiș internal drainage basin.

charged by the fast flow amounting to 13 %. There is no significant filtering of the rainfall induced information, so that heavy rainfall is immediately followed by intense floods. The discharge of the springs quickly declines after the rains stop, and as a consequence the prolonged draught periods result in a drastic reduction of the flow rate, occasionally till the discharge ceases completely.

### 3.6.3. Chișcău - Sighiștel - Fânațe karst area

This karst area, that extends between Crăiasa and Crişu Băiţa valleys and is traversed along its main axis by the Sighiştel valley, is dominated by the central position of the Arieşeni nappe thrust outlier located on Prislop peak, marked by a multitude of swallets through which the runoff water sinks in the underground at its entrance on carbonate domains. When additionally considering the aquifer concentrated supplies originating on the western slopes of the Ţapu peak, a realistic image is obtained on the multitude of the impact points between surface water and limestones, that over the ages resulted in the excavation of an impressive number of caves.

Ensuing to the intense tectonic dislocation of the area, one karst aquifer occurs, the resources of which are subject to competition between many large flow rates springs. In the Sighiştel valley upper reaches, on its right hand side, are located the caves Pişolca (Figure 3.1, no. 22) and Coliboaia (no. 23). The most important karst spring along Sighiştel valley is Blidaru (no. 21). It has 70 l/s average annual flow rate and during flood periods the cave Răsuflătoarea Blidarului, located 5 m upslope, acts as an overflow to the karst system.

Tracer tests (Table 3.3) have indicated that Blidaru spring discharges the entire amount of water derived from the north-western slopes of Prislop peak and from the western slopes of Ţapu - Pietrele Negre ridge. They have also outlined the fact that the main springs in the Sighiştel stream catchment area extend their radius of influence up to Pietrele Roşii brook, a tributary of Crăiasa stream.

Hidrei spring (no. 20) is the second largest outlet (25 l/s average flowrate). It is impenetrable and occurs at the bottom of a 15 m high Tithonic limestones cliff, discharging mainly the water originating on the western slopes of Prislop peak. Considered as a whole, the karst springs in Sighiştel catchment basin are supplied by a single karst aquifer that is subject to an intense contemporary evolution of the karst processes. The large number of completed tracer tests (Orăşeanu et al., 1991) indicate that groundwater flow currently concentrates toward Blidaru spring, with an obvious tendency to abandon outlets situated upstream (Coliboaia and Pişolca) and to augment of the flow rates discharged by Hidrei spring, located at the bottom of the erosional level of the considered karst area.

During the previously indicated observation period, Sighiştel stream had an average flow rate of 456.5 l/s, with the extreme values ranging between 2130 and 110 l/s.

The most outstanding underground feature on the western water divide between Crăiasa and Sighiştel valleys is Urşilor cave at Chişcau, with a small stream running along its bottom level.

| No | Source | Period | Q mean | Q min | Q max | nv | Bf | Cv | ME | RT | TF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | l/s | | | | | | day | | |
| 1 | Tăuz | 1984-85 | 529.0 | 68.0 | 4640.0 | 62.2 | 0.38 | 0.8 | 18.0 | 24.6 | 0.208 |
| 2 | Păuleasa | | 477.0 | 180.0 | 1920.0 | 39273.0 | 0.52 | 0.53 | 31.0 | 42.0 | 0.092 |
| 3 | Alunu Mic | | 306.0 | 2.0 | 3160.0 | 1580.0 | 0.10 | 0.96 | 16.0 | 23.8 | 0.112 |
| 4 | Coteţul Dobreştilor | | 274.7 | 0.0 | 2120.0 | | 0.03 | 0.96 | 31.0 | 34.5 | 0.160 |
| 5 | Izvorul Crişului | | 217.9 | 58.0 | 826.0 | 39127.0 | 0.37 | 0.58 | 37.0 | 42.7 | 0.172 |
| 6 | Gilueşti | | 77.7 | 3.0 | 571.0 | 190.3 | 0.37 | 0.71 | 7.0 | 12.3 | 0.420 |

nv - index of discharge variability; Bf - base flow index; Cv - the discharge time series variation coefficient, the ratio between average deviation and the annual average of an hydrologic annual series of mean daily discharges values (october-september); ME - memory effect; TR - Regulation time; TF - truncation frequency.

**Table 3.4. Main characteristic of the larges karstic springs in Bihor Vlădeasa Mountains.**

### 3.6.4. Padiș - Galbena - Bulz karst area

The karst piracy phenomena that developed in the Triassic - Early Cretaceous carbonate area located westward of the Early Triassic non-karst terrains from Măgura Vânătă have had as a consequence the dislocation of the network of streams (with the latter sinking as a result in the underground), a dissection of the topography and finally, the development of a widespread internal drainage basin, the Padiş Plateau, extending over 37.2 km$^2$, with a mean altitude of 1265 m, and being surrounded by a continuous belt of ridges which prevent any epigean hydrological connection with the surrounding catchment areas.

The plateau genesis is closely related to the geological setting of that area. The argillaceous sandstones molasse deposits of Early Triassic age on the south-western slopes of Magura Vânată Mountain favor the development of surface flows, primarily including the large and permanent discharge streams Cuţilor, Renghii, Arsurii and Tringheşti. When entering Triassic carbonate terrains, the surface streams sink in the underground, either diffusely, across alluvia in their streambeds, or in a concentrated manner, through swallets discernible as morphology steps (Figure 3.3).

Water sunk through the swallets at the northern border of the plateau flows rapidly underground across the Triassic limestone, being collected by Boga spring (Figure 3.3, no. 1). In the case of water-courses sinking farther to the south, beginning with the swallet of Arsurii valley, the underground flow path is broken as a result of the occurrence, in the Triassic - Early Cretaceous karst deposits body, of an insoluble horizon of Early Jurassic age formations, developed along the lineament Plaiului valley - Izbucul Ursului stream. This hydrogeological barrier prevents the extension of the Triassic karst aquifer toward the southwest, imposing at the same time the emergence of the corresponding groundwater flow in the springs from Valea Cetăţilor, in the spring in Poiana Ponor (no. 11), in Ursului spring (no. 16), in the spring Izvorul Rece (no. 15), so that eventually the barrier is "by-passed" by means of the surface flow (Valea Cetăţilor, Vraniţa stream, Izbucul Ursului stream). Subsequently to flowing along those short-length surface flow paths, streams sink in the underground once more, to emerge again through springs located close to the porch of Cetăţile Ponorului, then, after flowing along the underground stream course of Cetăţi, water finally emerges in Izbucul Galbenei (no. 7).

To the supply of this latter spring also contribute, directly or via the underground course in Cetăţile Ponorului, the water collected by the subordinate internally drainage basins Paragina, Groapa de la Barsa, Barsa Cohanului (no. 14), Lumea Pierdută and Cetăţilor valley. Lumea Pierdută having a significant impact due to the contribution of Pârâul Sec and of Izvorul Ursului brooks, that sink in Căput cave (no. 13). The average flow rate of Galbenei spring, during the considered hydrologic year has been 550 l/s (expeditionary measurements).

| Source Parametre | Tăuz | Păuleasa | Alunul Mic | Coteţul Dobreştilor | Izvorul Crişului | Giuleşti | Izvorul Minunilor |
|---|---|---|---|---|---|---|---|
| Period of the recession | 06.06.85<br>30.09.85 | 24.01.85<br>04.03.85 | 22.06.85<br>06.08.85 | 06.10.84<br>19.11.84 | 09.08.85<br>30.09.85 | 20.11.84<br>19.12.84 | 31.12.95<br>04.06.96 |
| $\alpha$ | 0.0116 | 0.0093 | 0.0231 | 0.0495 | 0.0078 | 0.0549 | 0.0034 |
| $\eta$ | 0.0313 | 0.0769 | 0.0667 | 0.0714 | 0.0588 | 0.1111 | 0.0313 |
| $\varepsilon$ | 0.114 | 0.339 | 0.046 | 0.446 | 0.394 | 0.025 | 0.042 |
| Vdyn, $10^6 m^3$ | 21.8 | 1.55 | 1.06 | 0.194 | 1.25 |  | 0.547 |
| V0, $10^6 m^3$ | 3.48 | 1.626 | 1.104 | 0.314 | 1.311 |  | 0.551 |
| Vdyn/V0, % | 62.6 | 95.3 | 96.0 | 61.8 | 95.3 |  | 99.2 |
| v inf/V0, % | 37.4 | 4.7 | 4.0 | 38.2 | 4.7 |  | 0.8 |

$\alpha$ (day $^{-1}$) - baseflow (recession) coefficient coefficient; $\eta$ and $\varepsilon$ (day$^{-1}$) - parameters adopted for the curves of the quickflow; Vdyn, dynamic volume; V0, total volume, (V0=Vdyn+v.inf); v inf, volume evacuated from aquifer in falling period.

**Table 3.5. Parameters of flow recession.**

Boga karst system is developed in the northern part of Padiş Plateau, including the western slopes of Măgura Vânătă, up to the water divide between the streams Arsurii and Renghii. It includes Vărăşoaia depression and Seşul Padişului, a flat-land extending around Padiş forestry hut. In the area between Padiş forestry hut and Răchita peak, the groundwater divide between the karst systems Boga and Izbucul Galbenei has an uncertain position.

Tracer tests performed in the swallet in Vărăşoaia and in the swallets of the streams Cuţilor and Renghii (Table 3.3) have indicated groundwater flow velocities as high as 140 m/hour, as water follows the corresponding flow-paths toward Boga outlet in 24 hours at maximum. The spring water emerges from a boulders accumulation at the foot of Piatra Boghii escarpment. Expeditionary discharge measurement performed during the year X.1984-IX.1985, slown the spring has discharged on the average 300 l/s of water with an average temperature of 6.8°C and an average mineralization amounting to 258 mg/l.

Speleological exploration performed in the pothole V5 (Figure 3.3, no. 8 and Figure 3.4) has intercepted water inflows sunk through the swallets in Vărăşoaia, the corresponding underground stream-course developing at first almost vertically, down to about 205 m depth. Farther on, the underground stream-course dips more gently, by about 50°, then by about 10°. The total depth of the pothole is 653 m (Fig. 3.4), and its downstream end is located about 600 m away from Boga spring and +52 m above it (P. E. DAMM , J. ZIH, KATALIN ZIH-PERENY, C. POP, 2004-2005).

Between the junction of Galbena spring stream with Luncşoara valley and Păuleasa spring occurred important inflow of water in river bed directed to the Păuleasa spring along the Galbena fault. Between Păuleasa spring and the junction with Bulz stream the flow rates of Galbena have a normal evolution, no significant inflows or outflows being recorded within the error range of the gauging methods.

The left side of Galbena valley, upstream of the junction with Păuleasa stream, displays ad-

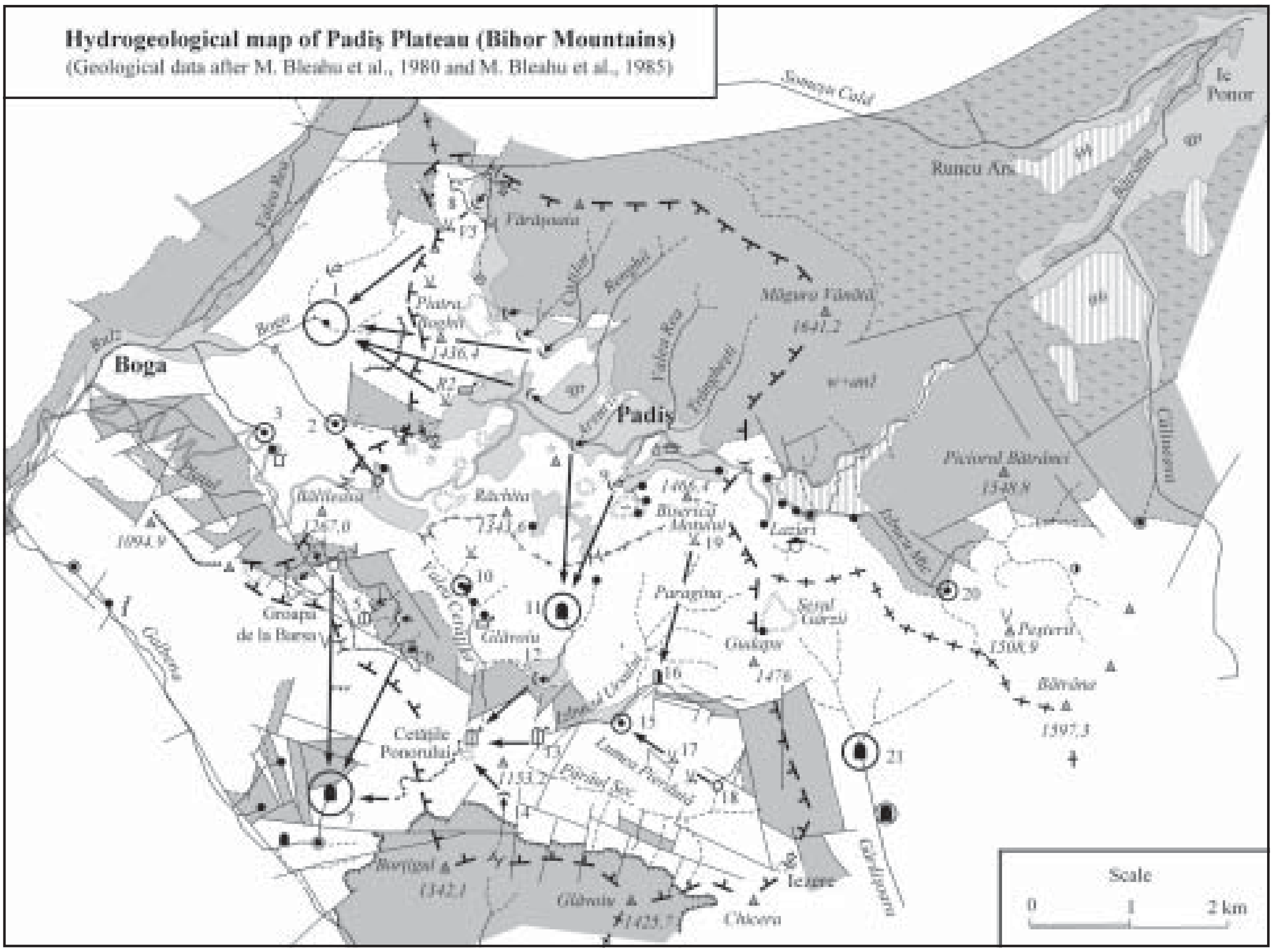


Figure 3.3. Hydrogeological map of Padiş Plateau (Legend as in Figure 1.6).

vanced karstic stream piracy phenomena, especially in the catchment areas of Valea Seacă and Crişanu brooks. Subsequently to diffuse sinking in a swlallet of Ţiganului valley, a tributary of Valea Seacă, emerges in Păuleasa spring, as indicated by an In-EDTA tracing experiment.

Păuleasa spring has a 477 l/s average flow rate, with a 25% contribution of the fast flow to the water volume discharged during recession period. The relatively long duration of the rain unitary impulse influence (42 days regulating time) and the significant memory effect (31 days), indicate Păuleasa system to have important groundwater reserves, while the small values of the cut frequency (0.092) mirror the influence of the surface runoff in the spring supply.

The tracing experiment performed in Valea Seacă brook, downstream of Groapa Ruginoasă, has proven underground hydraulic connexion with Izvorul Crişului spring and substantiating by means of a hydrogeologic investigation method the continuity of the Tithonic limestones of the Bihor Autochtonous beneath the Permian quartzite sandstones of Arieşeni Nappe.

Along a section between the junction with Valea Rea and with Plaiului valley, Boga valley displays significant sinking into the streambed, amounting to about 20% of the entire flow rate. The topography of this specific zone appears as a wide valley section, abundantly covered with alluvial deposits, where Boga cottages settlement is located. The abundance of the alluvia is the result of the deposition of part of the suspended solids carried by the stream, which occurred when the latter diminished its flow ensuing to underground sinking. The sinking is related to the presence of the major draining fault of Bulz, along which the valley is incised. Except for this specific section, the hydrogeological role of the Bulz fault is not known; it can be only stated that gauging performed down to the site called “Între Ape” has indicated that the flow which sinks upstream is not recovered along this section.

### 3.6.5. Izvorul Crișului karst system

Izvorul Crişului karst system is located in the upper reaches of Crişu Băiţa stream, in an extremely rough topography area, that had been also subject to intense tectonic dislocation and where carbonate deposits outcrop in the streambed and on the right side of the previously mentioned streamcourse, being overthrusted in their northern, southern and eastern parts by the Permian deposits of the Arieşeni nappe (S. D. STOICI, 1983).

The outcrop area of the carbonate deposits does not have a permanent surface runoff: the multitude of streams running down the adjoining non karstic mountain slopes (Corlatul, Corlăţelul, Fleşcuţa, etc) sink diffusely, at their entrance on carbonate terrains. Before the excavation of the underground mining works, those groundwater flows ran to Izvorul Crişului spring (Figure 3.1, no. 35), but currently a significant part of the flow

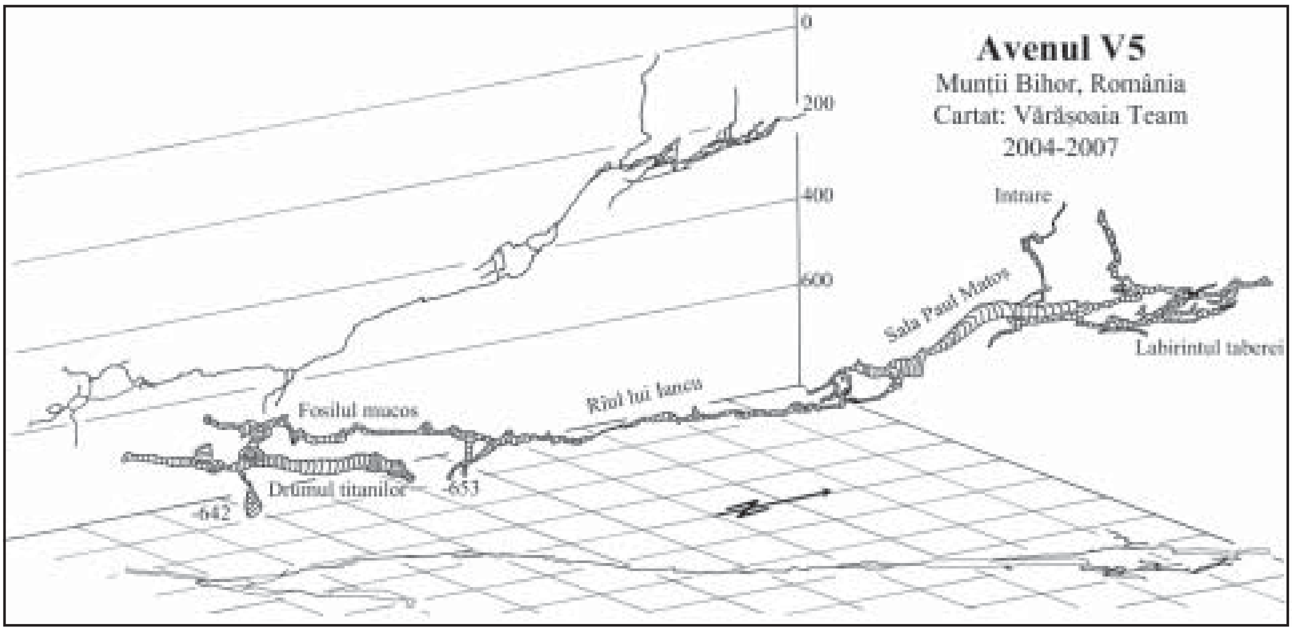


Figure 3.4. V5 pothole in Vărășoaia.

is drained by the galleries of Băiţa Molibden mine. The tracer tests have indicated that the radius of influence of those mining works has extended over the entire Crişu Băiţa upper catchment basin, as well as in the upper reaches of Valea Seacă, a tributary of Galbena stream. The spring ensuingly underwent a drastic decline of its discharge, to such an extent that during draught periods it isn't able to meet the drinking water supply demand of Nucet town, located downstream.

In period X.1984-IX.1985, Izvorul Crişului spring has 217.9 l/s mean annual flow rate, with fluctuation between 58 and 826 l/s. The karst system has a strong inertia, a significant regulating capacity and important water reserves, 95% of the goundwater flow during recession periods being provided by the base flow.

### 3.6.6. Gârdișoara - Tăuz karst area

The geologic structure in Gârda Seacă upper reaches, that includes extensive carbonate terrains occurring as a monoclinal structure, subject to intense tectonic dislocation and covered by the detritic deposits of the Arieşeni overthrust, favoured the occurence of several large flow rate karst springs (Gura Apei, Figure 3.1, no. 58, Coliba Ghiobului, no. 59 etc.). The discharge of those systems supplies Gârdişoara, the most upstream section of Gârda Seacă stream, that sinks in the cave Coiba Mică (no. 60), to eventually emerge in Tăuz spring (no. 64), after a 2650 m long underground course, across 110 m elevation range.

Starting from Casa de Piatră hamlet, Gârda Seacă valley carries water a new and additionally receives a strong left hand tributary, Vulturului valley (75 l/s average flow rate)., supplied mainly by the spring with the same name.

The Tăuz spring has an annual average flow rate of 529 l/s and a 68.2 ratio between the extreme daily average flow rates recorded over the observation period (October 1984 - September 1985). When all described springs are considered, it can be observed that the fast flow of Tauz has the highest weight (29%) with respect to the water volume discharged by the spring during the considered period of flow rates recession, which is normal if the prevalent supply of the aquifer via Gârdişoara stream is taken into account, and which is also corroborated by the large cut frequency (0.208), characteristic to systems that are highly inertial and that have undergone intense karst development. The relatively small value of the memory effect (18 days) indicates relatively small groundwater reserves, compared to the very large surface area of the system. The rain has a smaller influence period (26.4 days) than in the case of the other springs (Table 3.4 and 3.5).

### 3.6.7. Gârda Seacă - Ordâncușa water divide territory

The water divide between Gârda Seacă and Ordâncuşa valleys, dominated by the Ocoale - Gheţar interrnal drainage area, was the object of many speleological investigations, stimulated by the presence of the Scărişoara glacier, the largest cave glacier in Romania. Those investigations have been paralleled by observations concerning the groundwater flow directions (ŞERBAN M., COMAN D., VIEHMANN I. 1957, RUSU T., RACOVIŢĂ GH., COMAN D.,1970, RUSU T., COCEAN P.,1992), the datailed hydrogeological (ORĂŞEANU I. 1996, 2008, ORĂŞEANU et al., 2005) and meteorological studies (ORĂŞEANU I., VARGA I., 2004, 2005) and by intrinsec vulnerability of Coteţul Dobreştilor aquifer evaluation (I. ORĂŞEANU, M. PARICHI, D. SCRĂDEANU, 2005).

In the watershed between the streams Gârda Seacă and Ordâncuşa there is developed one of the largest karst systems in Bihor Mountains, the karst system of the spring at Coteţul Dobreştilor. In spring area, the carbonate deposits of Bihor Unit exhibit a tectonic contact with the Werfenian sandstone of Gârda Nappe, that overthrusts them.

Coteţul Dobreştilor karst system (Figure 3.5) extends over an area of 19.4 km$^2$. It includes the internal drainage area Ocoale-Gheţar-Tarniţa (8.2 km$^2$) and the Ordâncuşa-Coteţul Dobreştilor difluence surface (10.3 km$^2$), located in the upper catchment area of Ordâncuşa stream, upstream from the karst piracy spot at Moara lui Ivan.

The average flow rate of Coteţul Dobreştilor spring recorded over the previously indicated hydrologic year has been 280 l/s, while the maximum monthly flow rate has been 1.06 m$^3$/s. During draught periods the spring flow rate declines progressively to complete dry out, the outlet being actually an overflow of the system. The perennial outlet is Morii, Hoanca Morii (Topliţa) and submerged springs that occur along the left side of Gârda Seacă valley, over the specified 100 m distance, at stream level or below. The cummulated flow rate of those springs and of Morii spring has been occasionally gauged during periods when Dobreştilor spring had dried out, resulting a value of 85 l/s.

The base flow of Coteţul Dobreştilor spring displays large values of the recession coefficients ($\alpha$ = 0.017 and $\alpha$ = 0.085), that indicate a fast drainage of the aquifer. The karst system displays large values of the discharge time series variation coefficient, Cv, indicate a well developed underground flow organization, quite probably along large cavities. The aquifer discharging through the outlets at Coteţul Dobreştilor is well structured and organized, with a functional main flow axis that facilitates to the water sunk in Ocoale area and Moara lui Ivan swallet a fast arrival to the springs.

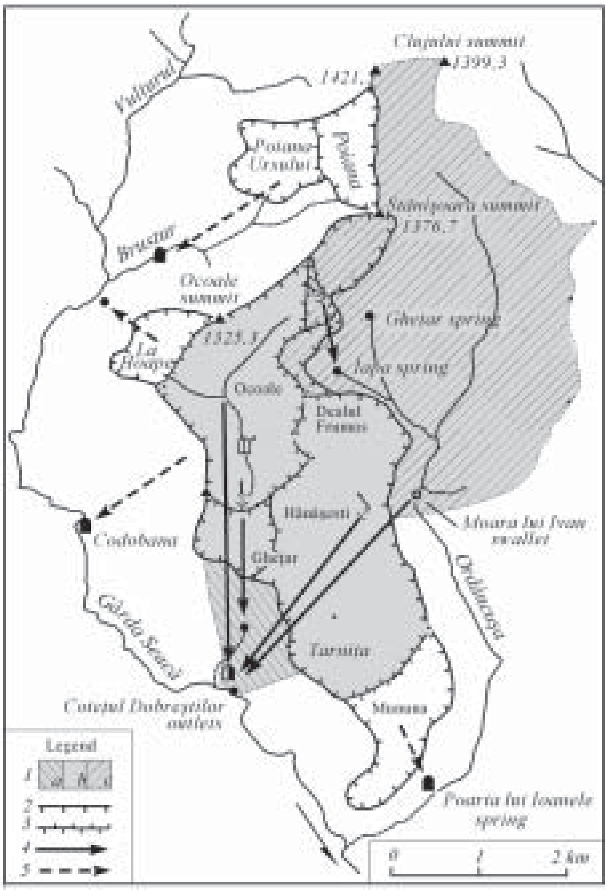


**Figure 3.5. The Coteţul Dobreştilor karst system.** Legend: 1 - Extension of the karst system: a - Karstic slope basin; b - Internal drainage area; c - Diffluence surface; 2 - Boundary of internal drainage area; 3 - Boundary inside intenal drainage areas; 4 - Proven groundwater flow connexion; 5 - Inferred groundwater flow connexion.

## The vulnerability of Coteţul Dobreştilor karst aquifer

The soil in the internal drainage area provides a weak protection to the karst aquifer, being easily and frequently by-passed by the permanent or temporary superficial flow, while the karst network is very well developed. Over most of the considered area, the vulnerability of the karst aquifer is extremely high (ORĂŞEANU I., PARICHI M., SCRĂDEANU D., 2005).

In the Gheţar Plateau, intrinsic vulnerability mapping has been carried out using PI method (GOLDSCHEIDER N., 2003), one of the proposed methods developed within the framework of COST Action 620 (ZWAHLEN, 2003). In our exercise to assessing the intrinsic vulnerability of the karst aquifer from Coteţul Dobreştilor we considered the internal drainage area and the mountainside karstic catchment (Fig. 3.5), without take into account the Ordâncuşa-Coteţul Dobreştilor diffluence surface, a part of karst system with insufficient hydrogeological and soil data.

Protective cover. The soil develop has a thin thickness, beneath a meter. For assessing the protective capacity of the soil cover we considered the field capacity of the soil, multiplied with its thickness (Figure 3.6). The field capacity of the soil cover ranks in a 4 classes: very low (under 10 %), medium (21-25 %), medium-high (21-30 %) and high (26-30 %), while its thickness has been ranked in 5 classes (0-10, 11-20, 21-50, 51-75, 76-100 cm). The product obtained by integrating the two maps (n = 4×5=20 values) has been distributed in 4 vulnerability classes: P=1, very low protection, for n=1-5; P=2, low protection degree, for n=6-10; P=3, moderate protection degree, for n=11-15 and P=4, for n=16-20, medium protection degree.

Determination of I parameter. The I parameter shown the degree to witch the protective cover is being bypassed by the water, and has two components:

- The I’ parameter estimates the occurring seepage, being controlled by the permeability of the soil, the land slope and the vegetation. The integration of these factors is shown in Table 1 in Fig. 3.6. Permeability of the soil has been estimated on the basis of satured hydraulic conductivity;
- The surface catchments map. The protective cover are bypassed as a result of lateral surface and subsurface flow in the catchments area of

shallow holes and sinking streams. Surface catching map show components which by-pass the protective cover. The later has been drown-up on base of the hydrogeological mapping that indicated the presence of the swallow holes and the sinking streams. The 10 m and 100 m „buffer zones" around these features are inducted (Table 2 in Fig. 3.6).

The PI vulnerability map is obtaining by intersecting the P map with the I map. Legend of the P-map, I-map and vulnerability map is presented in Table 3 in Fig. 3.6. The PI map shows many areas of extreme and high groundwater vulnerability.

On base of of the available geological and hydrogeological data (tracer tests, spring hydrograph, water electroconductivity time series), soil data (thickness, field capacity and saturated hydraulic conductivity soil maps), vegetation and slope maps, there were drown up the effectiveness of protective cover map (P map) and bypassing of protective cover map (I map) and finally the intrinsic vulnerability of the Coteţul Dobreştilor karst aquifer map. The soil provides a weak protection to the karst aquifer, being easily and frequently by-passed by the permanent or temporary flows, while the karst network is very well developed. Over most of the considered area, the vulnerability of the karst aquifer is extremely high.

On the right side of Gârda Seacă stream, opposite to its junction with the streamlet flowing out of Coteţul Dobrestilor spring, a hypothermal spring Feredeu (Figure 3.1, no. 69) emerges from the flood plain alluvia. Its temperature is 15.8 - 16.2°C and it is accompanied by strong outflows of free gas. The simultaneous arrival of the tracer in Izbucul Feredeu and in Coteţul Dobreştilor outlets in the tracer test performed in Ordâncuşa losses at Moara lui Ivan, indicates that water mixing takes place close to the surface and it involves a thermal component, that flows up the Gârda Nappe thrust plane which covers the Bihor Unit, and a cold component that originates in Coteţul Dobreştilor karst system.

The southern part of the Ocoale - Gheţar-Mununa internal drainage area discharges via Poarta lui Ioanel cave (no. 70, 810 m elevation). The cave is situated on the right side of Ordâncuşa stream, about 30 m above the streambed The spring has a permanent character and diffusely emerges through the limestone boulders that build the floor of the impressive entrance of the cave that bears the same name. From the cave entrance downstream, there occurs a succession of small waterfalls, built by the travertine deposited from the spring water.

Sideways from the cave Poarta lui Ioanele, at 880 m elevation, it is gaping the impressing entrance of Peştera de sub Zgurăşti cave (Gheţarul de sub Zgurăşti, Zgurăşti pothole), that has a total length of 5210 m, extending across a total elevation range of 75 m (-45;+30 m, with respect to the entrance) and over 640m horizontal straight line distance (P. E. DAMM et al., 1999).

In terms of hydrology the main characteristic of Zgurăşti cave is provided by 4 lakes altogether represent a reservoir of about 50.000 m$^3$ storage capacity, with a water level occurring at 860-865 m elevation, some 100 m above the streambed of the nearby Ordâncuşa stream. The lakes are interconnected via an underground stream that emerge in Poarta lui Ioanele spring. During high water stages, the lakes overflows through the Spillway Tunnel passage, to form an impressive waterfall on the right side of Ordâncuşa stream (P. E. DAMM et al, 1999).

Over the period X.2001-IX.2003, the spring at Poarta lui Ioanele had an average flow rate of 24.0 l/s, with daily fluctuations between 6 and 615 l/s, with 0,58 value of the discharge time series variation coefficient, Cv. The spring water temperature displayed minor oscillations, in the range 7.4-7.8°C. The flow rate recesion diagrams constructed for 3 time intervals within the investigation period exhibit low values, in the 0.002-0.008 range, that indicate a slow discharge of the karst aquifer.

### 3.6.8. Preluca karst area

This name has been used to designate the limestones water divide between Ordâncuşa and Arieşu Mare valleys, the topography of which is marked by the sinkhole plain in the area of Preluca hamlet and by the gorge of Ordâncuşa. The dominating hydrogeological feature of this area is the massive diffuse, temporary complete sinking of Ordâncuşa stream along its last 2 km section before the junction with Gârda Seacă stream. The water is recovered in Izbucul Mic and Izbucul Mare springs, on the left side of Arieşu Mare.

Izbucul Mare (no. 71) emerges at the contact of the Wetterstein limestones with the Permian deposits of the Gârda overthrust, and discharges an

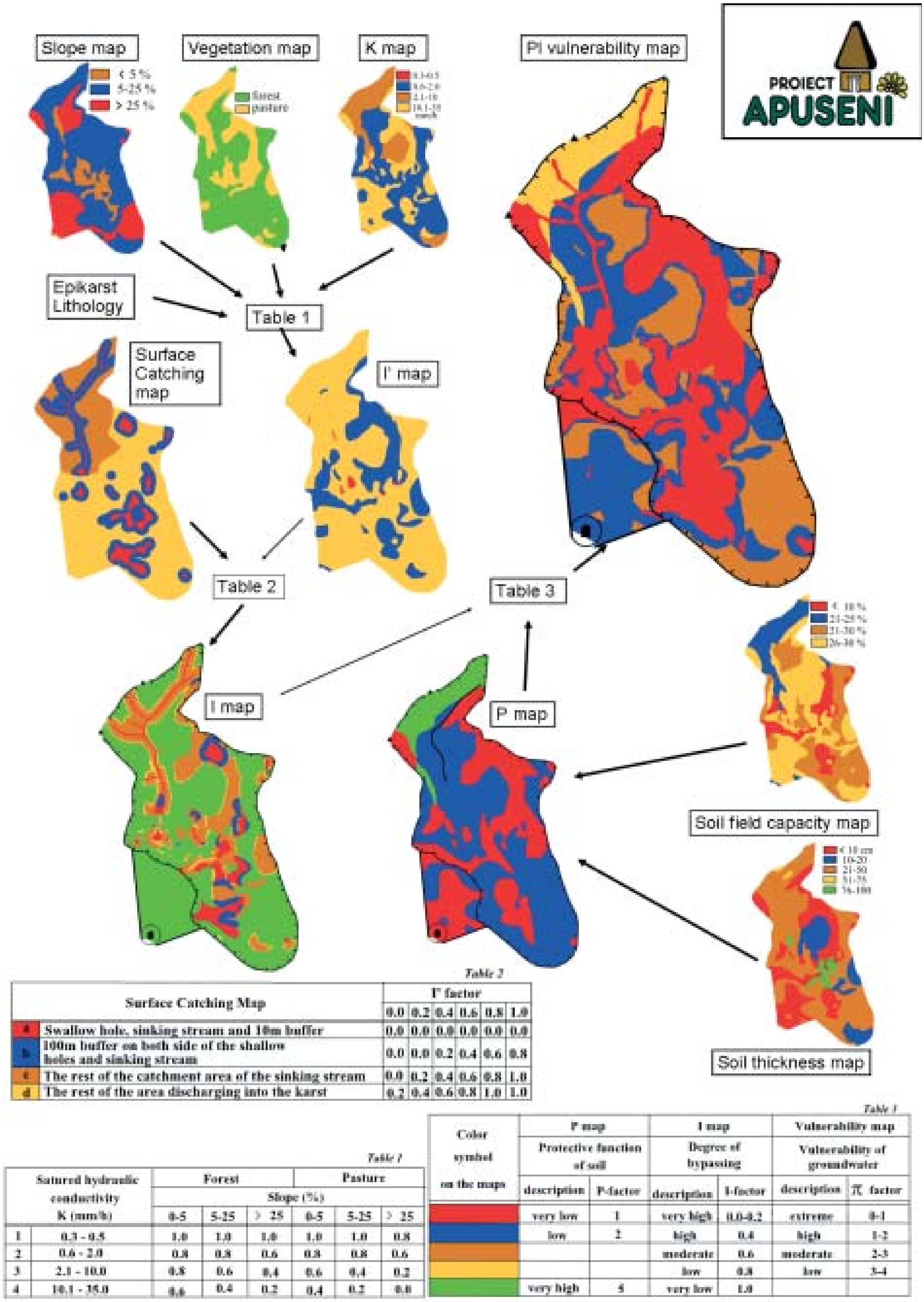


*Table 2*

| Surface Catching Map | I' factor | | | | | |
|---|---|---|---|---|---|---|
| | 0.0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 |
| 🟥 a Swallow hole, sinking stream and 10m buffer | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 🟦 b 100m buffer on both side of the shallow holes and sinking stream | 0.0 | 0.0 | 0.2 | 0.4 | 0.6 | 0.8 |
| 🟧 c The rest of the catchment area of the sinking stream | 0.0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 |
| 🟨 d The rest of the area discharging into the karst | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.0 |

*Table 1*

| Satured hydraulic conductivity K (mm/h) | | Forest | | | Pasture | | |
|---|---|---|---|---|---|---|---|
| | | Slope (%) | | | | | |
| | | 0-5 | 5-25 | > 25 | 0-5 | 5-25 | > 25 |
| 1 | 0.3 - 0.5 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.8 |
| 2 | 0.6 - 2.0 | 0.8 | 0.8 | 0.6 | 0.8 | 0.8 | 0.6 |
| 3 | 2.1 - 10.0 | 0.8 | 0.6 | 0.4 | 0.6 | 0.4 | 0.2 |
| 4 | 10.1 - 35.0 | 0.6 | 0.4 | 0.2 | 0.4 | 0.2 | 0.0 |

*Table 3*

| Color symbol on the maps | P map | | I map | | Vulnerability map | |
|---|---|---|---|---|---|---|
| | Protective function of soil | | Degree of bypassing | | Vulnerability of groundwater | |
| | description | P-factor | description | I-factor | description | π factor |
| 🟥 | very low | 1 | very high | 0.0-0.2 | extreme | 0-1 |
| 🟦 | low | 2 | high | 0.4 | high | 1-2 |
| 🟧 | | | moderate | 0.6 | moderate | 2-3 |
| 🟨 | | | low | 0.8 | low | 3-4 |
| 🟩 | very high | 5 | very low | 1.0 | | |

**Figure 3.6. Steps in processing the vulnerability map of Cotețul Dobreștilor karst aquifer** (after ORĂȘEANU, PARICHI, SCRĂDEANU, 2005).

average flow rate of 45 l/s, derived from seepage across Preluca sinkhole plateau and from diffuse sinking, that occurs along the median course of Preluca stream at crossing the above mentioned limestone area.

### 3.6.9. Beliș - Apa Caldă karst area

The easternmost occurences of carbonate deposits in Bihor mountains are located in Belis - Apa Caldă area. They consist of Triassic dolomites and limestones, that occupy a synclinal structure with quartzite sandstones at the bottom. The supply of the structure is derived from rainfall and its discharge is directed eastward, mainly toward Apa Caldă, a 50 l/s and 7°C spring (no. 79). In the catchment basin of Beliş stream, the only significant karst springs are that in Poiana brook, upstream of Vâltaie hamlet and spring in Hoanca Seacă brook (no. 80). The springs discharges a 10 l/s average flow rate, derived from water accumulations in the northern part of Clujului summit.

The upper section of Beliş streamcourse displays a temporary flow regime, while its left side tributaries, running on non karstic terrains, are sinking in the streambed when penetrating in the karst domains.

### 3.6.10. Someșu Cald graben karst area

Runoff originating on terrains consisting of igneous rocks of Vlădeasa massif and of Werfenian and Senonian deposits existing in the northern part of Someşu Cald graben, supplies a widely developed karst aquifer that discharges through important flow rate springs. An outstanding position among them occupy, as a result of their significant flow rates, the springs Alunul Mic, Alunul Mare and the sprigs in the area Şurile din Firea.

Alunul Mic spring (Figure 3.1, no. 91) has a karstic system that extends northward to the upper reaches of Ponorului valley, an area that for most of the time of the year supplies the system via the swallet of Ponorului valley. The tracer tests performed by injecting In-EDTA in the streamway of Diaclaza cave (no. 93), fluorescein in that in Lucii pothole (no. 94) and rhodamine in the swallet of Ponorului valley have indicated an active karst flow. Alunul Mic spring has a flow rate that fluctuates over a very wide range (2-3160 l/s), with an average of 180 l/s. The base flow is prevalent (88%) in the water volume discharged by the spring during recession periods. The system has undergone intense karst development, it has a very poor inertia and small groundwater reserves.

Alunul Mare spring (no. 88) is the second largest in the graben area in terms of discharge. The average, computed according to discharge gauging performed on different occasions, amounts to 110 l/s.

Between Ponorului valley to the west and Firii valley to the east stretches Humpleu karst plateau. The plateau is built up in Barremian-Aptian limestones and has as an outstanding speleological mark the presence of the cave with the same name, one of the largest in Romania (no. 98). The cave extends from Firii valley up to the environs of the swallet in Ponorului valley, and provides a major drainage path for the water accumulations in the plateau. The tracer experiments we performed have indicated that the surface streams running down the southern slopes of Miclău peak, which sink through the swallets Poiana Vârtopului (no. 95) and Ponorul cu Pod (no. 96), also belong to this system. The system discharges through the springs and the cave at Şurile lui Firea (no. 97), of about 80 l/s average flow rate.

### 3.6.11. Valea Seacă karst area

The upper reaches of Stanciului stream, a tributary of Henţ (Săcuieu) stream in Răchiţele area, includes one of the karst areas that in terms of groundwater hydrology ranges among the most interesting in Vlădeasa Mountains. Cavers designate that area as Valea Seacă, after the name of the brook that runs across it, or alternatively as Pietrele Albe, after the name of the limestone mountain which dominates the landscape by its tall vertical cliffs. A detailed description of the physiography of that area has been provided by COCEAN P. & BALC CORINA (1987).

In the proximity of the karst area there is located Vlădeasa meteorological station, where during the time interval 1896-1975, the recorded multiannual average of the air temperature was 1.4°C, while that of the amount of rainfall was 1058.3 mm.

The geological structure of the Valea Seacă catchment area includes a very thick stack of compact and bedded limestones of Late Jurassic - Early

Cretaceous age, that has been subject to intense thermal metamorphism induced by the Vlădeasa igneous body. The limestones are transgressively covered by Senonian deposits that occur in the Gosau formation facies and, less frequently, in the volcano-sedimentary formation facies (G. MANTEA, 1985; G. MANTEA et al., 1987).

A multitude of landforms occur, which highlight the presence of limestones in the Valea Seacă catchment area: topographically well defined ridges (Pietrele Albe, Piatra Arsă), canyon type valleys (Valea Seacă, Boaica, valea Arsă), largely developed surface karst landforms (sinkholes) and underground cavities (potholes and caves), outstanding among the latter being Vârfuraşul cave (Fig. 3.7).

The streams network in the Valea Seacă catchment area is severely dislocated as a result of the limestones occurrence. The surface stream water collected on non-karst mountain slopes that consist of igneous rocks and of sedimentary formations diffusely sinks in the underground when reaching limestone terrains (Boaica, Valea Seacă upstream of Vârfuraşul spring), or it sinks through actual swallets, downstream of which long sections of valleys are left where water runs only temporarily: the pothole Cu Spinare (Figure 3.7, no. 1), the swallet Tăul Negru (no. 2). By the impressive swallet at Firezul Rogojanului (no. 3), also known as the swallet La Tău (20 m depth, 30 m in diameter), water discharged by Vârfuraşul spring (no. 4) sinks once more in the underground, a circumstance

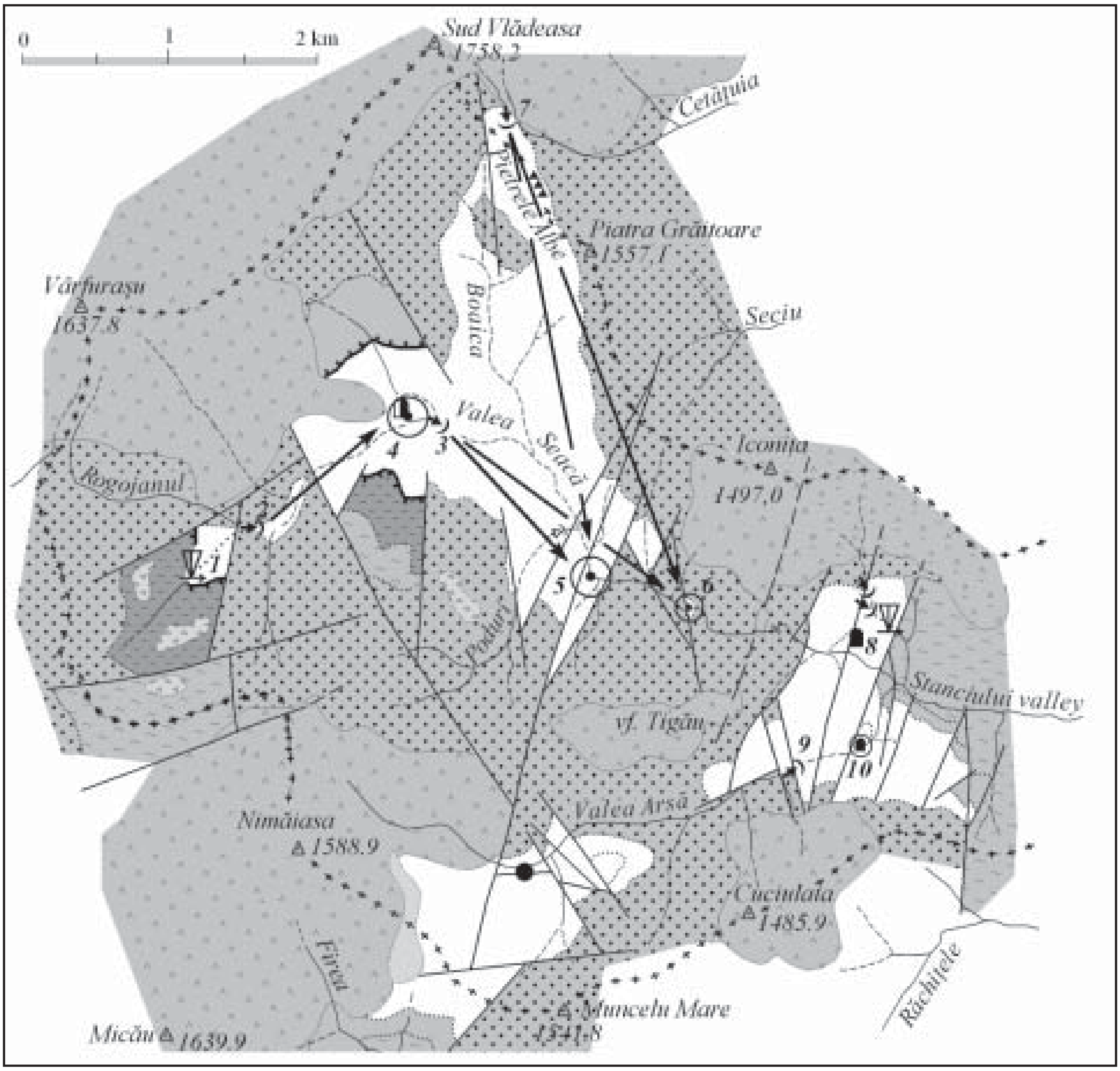


**Figure 3.7. Hydrogeological map of the Valea Seacă area.** (Geological data after G. Mantea, 1985. Legend as in Figure 1.6)

which results in Valea Seacă carrying a permanent flow only for about 200 m. The valley starts carrying permanently water again only downstream from the inflow provided by the springs at Sărcerului brook (also called Nimăiasa springs, or the springs at the Gorges, no. 5), that are located some 1.4 km further downstream (I. ORĂŞEANU, 1998).

Vârfuraşul spring is the outlet of the underground stream that runs through a cave with a total length of the surveyed passages amounting to 2250 m (E. KOMIVES & I. NAGY, 1976). The spring provides the discharge to the karst groundwater accumulations in the upper catchment area of Valea Seacă, the corresponding karst system being developed at an average elevation of 1445 m and occupying an area of 6.75 km$^2$, most of which (97%) is developed within non-karst formations.

Flow rate measurements have been performed at Vârfuraşul spring in june-october period of 1996 and 1997 years, recorded values ranging between 90 and 208 l/s. The chemical character of Vârfuraşu spring water is calcium bicarbonate, with a very low o mineralization (166.5 mg/l). Observations and measurements performed occasionally have indicated spring water temperature values which ranged between 6,4-7°C, and a narrow fluctuation range of the electrical conductivity (112-137 µS/cm), a circumstance that mirrors a relatively constant water mineralization.

Water that sinks through the swallet at Firezul Rogojanului follows an underground flow path toward the springs in Sărcerului brook and toward the spring at Preluca din Vale (Fig. 3.7, no. 6), the cumulated discharge of the first springs being similar to that of Vârfuraşul spring, while the second mentioned spring discharges only about half this value. By the same springs, water sunken in Boaica valley and in Cetăţuia ponor (no. 7), discharges as well.

## 3.7. Groundwater quality

Observations, measurements and analyses performed at the main springs of Bihor Vlădeasa mountains result in the following considerations concerning the groundwater quality:

- the temperature of the karst springs ranges between 5.4 and 10°C, directly related to the elevation of the supplying karst system. Some springs discharge higher temperature flows, as a result of deeper underground circulations along overthrust or fault planes (Table 3. 6)
- the pH of the discharged water is slightly alkaline, ranging between 7.15 and 7.86;
- the computed saturation indexes indicate that the water of most karst springs in Bihor Vlădeasa mountains is undersaturated, to a larger or smaller extent, with respect to both calcite and dolomite. The warm and cold springs at Valea Neagră, the stream emerging from Pepii cave (no. 89), Izvorul Mic and the spring Poarta lui Ioanel are supersaturated with respect to calcite, the latter spring having large associated travertine deposits.
- the water of the springs in the noncarbonate catchment areas of the binary karst systems is strongly undersaturated with respect to calcite and dolomite, inducing as a result of its agressivity an intense dissolution of the carbonate deposits. Quite typical in this respect is the water of the springs originating in igneous formations, with slightly acid pH value, which explains the intense development of the karst within the carbonate deposits in the Someşu Cald graben, induced by runoff water originating on the southern and southeastern slopes of the Cornul-Miclău-Vlădeasa ridge.

| No | Source* | Q l/s | T °C | T.D.S. | $CO_2$ | $O_2$ | $N_2$ | Ar |
|---|---|---|---|---|---|---|---|---|
|  |  |  |  | mg/l | % vol |  |  |  |
| 1 | Warm spring in Valea Neagră (19) | 1.5 | 17.2 | 415.4 | 6.9 | 19.42 | 72.80 | 0.86 |
| 2 | Spring at conflence Someşul Cald -Pârâul Sec (90) | 15.0 | 8.8 | 171.4 | 1.27 | 20.2 | 77.59 | 0.89 |
| 3 | Warm spring in Alunul Mic stream (92) | 5.0 | 14.4 | 206.2 | 0.31 | 20.26 | 78.15 | 0.91 |
| 4 | Feredeu spring in Coteţul Dobreştilor hamlet (69) | 2.5 | 16.2 | 252.3 | 0.54 | 17.83 | 80.81 | 0.79 |

Note: *In brackets number of spring on hydrogeological map in Figure 3.1.
Other comounds for which the gases were analysed, $C_2H_2$ , $C_3H_8$ , $C_4H_{10}$ , He and $H_2$, are lacking.

**Table 3.6. Chemical composition of gas associated with water in gaseous spring.**

- the water of the karst systems is of calcium bicarbonate, calcium-magnesium bicarbonate and magnesium-calcium bicarbonate type, depending on the chemical composition of the traversed formations (limestones and/or dolomites), with TDS values ranging between 125 - 529.7 mg/l.

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