Theoretical and Applied Karstology. Vol. 4 (1991). pp. 159 to 172.

TRACERS EXPERIMENTS IN THE KARST AREA OF BIHOR MOUNTAINS (ROMANIA)

BY

I. ORĂŞEANU, E. GAŞPAR, I. POP, T. TĂNASE

The complex geological evolution of Bihor Mountains led to the grooth of karstifiable and unkarstifiable rocks mosaic. This evolution is hydrogeologically reflected by the presence of numerous karstic aquifers having different extensions and being charged by precipitations and surface streams, karstically trapped either total of partial.

In order to find out the main running water directions of some karstic aquifers, the authors çarried out a number of 36 labellings with rhodamine, fluoresceine, stralex [1], radicactive tracers (I-131, Br-82) and activable tracers (In-EDTA, Dy-EDTA, I^-)

On the whole, the tracers labellings accomplished up to now in the karst area of Bihor Mountains showed an average running speed of the unoerground waters of 45 m/hour.

The longest course was found between the pothole of Hoanca Urzicarului and Păuleasa spring (4800 m), while the maximum level difference was between the Muncelu cave and Blidaru spring (665 m).

1. GEOGRAPHICAL AND GEOLOGICAL FRAME.

Bihor Mountains are considered on the first place in the hierarchy of karstic domains in Romania through the variety and amplitude of karstic phenomena and forms. The karstic terrains developed in the nort-hern half of Bihor Mountains, in the North Bihor, a massif characterised by the presence of the most important hydrographic knot of Apuseni Mountains. From here originate the hydrographic basins of Crişul Negru, Someşul Cald and Arieşul Mare rivers.

The endorheic basin Padiş—Cetăţile Ponorului is located at the intersection of the three great hydrographic basins. It is surrounded by a girdle of crests which prevent it from epigeal hydrographic affiliation to one of the three basins mentioned above.

The large majority of the carbonate deposits in Bihor Mountains belong from the structural standpoint, to the Bihor Autochton. This tectonic unit cro s out in the North-Eastern half of the massif, bordered northely by the faults system Bulz—Valea Rea and South-Westerly — between Gîrda and Între Ape—by the overthrust of Gîrda and Arieşeni nappes.

---

[1] Romanian optical brightener.

These tectonic units consist of sandstones, conglomerates and subordinatedly, of schists.

The carbonate deposits of Bihor Autochton have a thickness of about 1200 m and they generally form a monoclinal structure with South-West slopes, intensively fractured. These have at the basys Triassic limestones and dolomites, followed by Lower Jurassic detrital series and further on by Middle and Upper Jurassic limestones and Lower Cretaceous limestones. The practically impervious bed of the aquiferous accumulations located in the carbonate deposits of Bihor Autochton, consist of Permian-Werfenian detrital deposits and, locally, of cristalline schists.

On the terrains from the Western side of the massif, geologically and structurally assigned to the system of Codru Nappes, the limestones and dolomites crop out on quite limited areas (Ferice, Tătăroaia, Sighiştel, Crişul Băiţa).

The complex geological constitution as well as the intensive degree of tectonization — anterior, contemporary and posterior to the setting in place of Codru Nappes, led to the formation of a rocks mosaic, predominated by limestones and dolomites followed by sandstones, conglomerates, eruptive rocks and cristalline schists. This situation is reflected both in the relief configuration and in the surface and groundwater flow mode.

The ample development of carbonate deposits in Bihor Unit caused the forming of a wide karstic area with broken plateau aspect, extended on the alignment Vărăşoaia — Padiş — Bătrîna summit — Clujului summit — Apa Caldă. This zone is enclosed by steep slopes at the North and West towards the Bulz and Galbena valleys and cut Southward by Gîrda Seacă and Ordîncuşa Valleys. The last one has a remarkable gorge sector downstream.

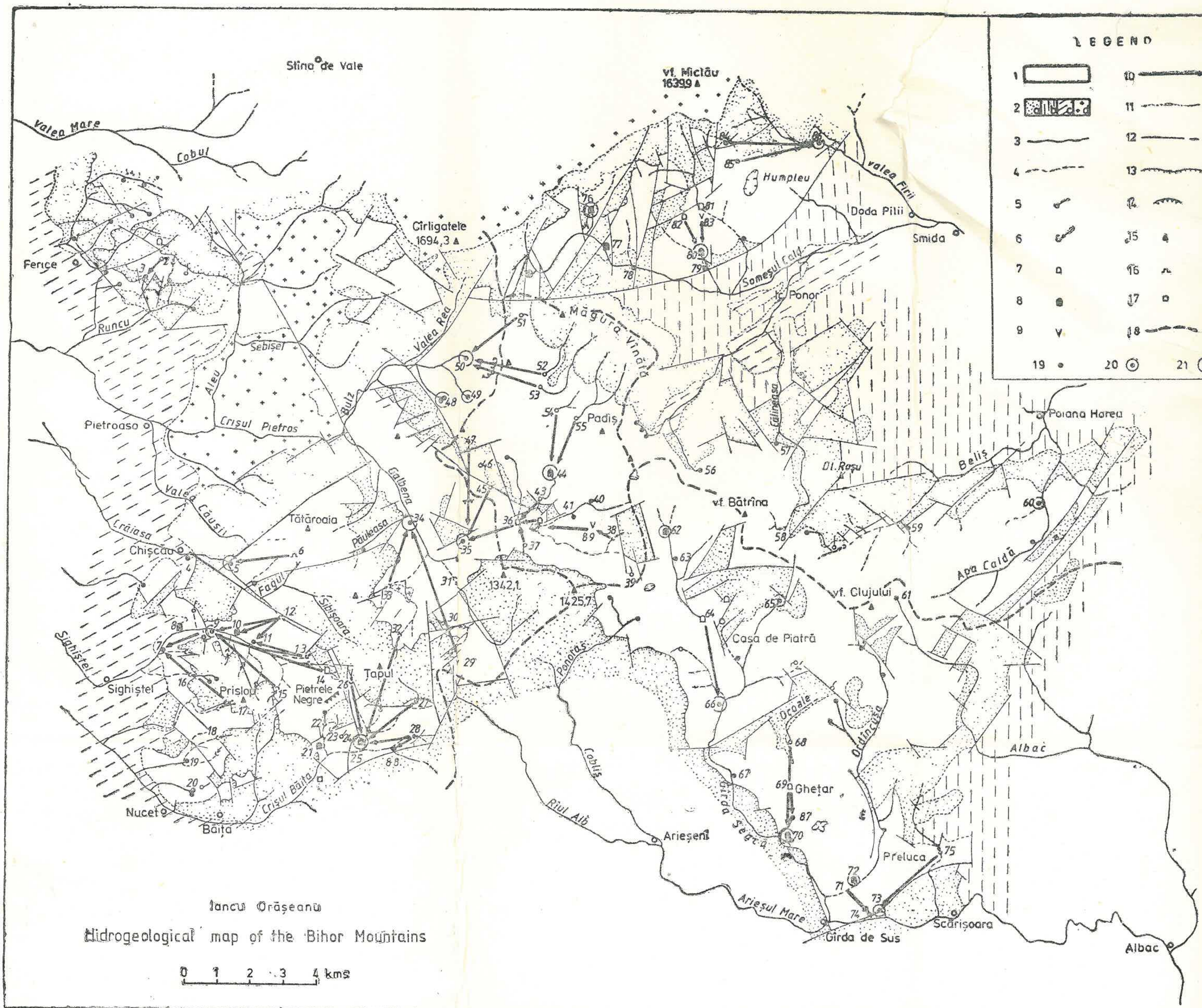
The morphology of the zone is individualised by the endorheic basins Padiş — Cetăţile Ponorului and Ocoale — Gheţar, the latter being shaped between Gîrda Seacă and Ordîncuşa Valleys.

The karstic terrains from the West Bihor Mountains as Well as those from Someşul Cald basin are characterised by the presence of particularly broken zones with deep valleys having a gorge aspect and by rare „plateau" zones, generally with small extension.

2. HISTORICAL DATA

Bibliographical references concerning the Bihor Mountains karst being with the well known work of Schmidl „Das Bihargebirge an der Grenze von Ungarn und Siebenbürge " published in Vienna in 1863. Since there up to the present there were published many works having generally a speologic character, signed among the other by : Jeannel and Racovitza (1929), Şerban a.o. (1957), Bleahu (1957), Rusu a.o. (1970), Bleahu and Bordea (1967, 1981), Vălenaş (1976, 1977, 1984), Vălenaş a.o. (1977), Bleahu a.o. (1976), Orghidan a.o. (1984).

Despite the great number of karstic morphology works, there are very few ones with hydrologic character, concerning the research of the groundwaters dynamics by means of tracer labelling. They lead to the



Hidrogeological map of the Bihor Mountains

Fig. 1 — Legend: 1 — Karstic deposits; 2 — Nonkarstic deposits (a — sandstones, conglomerates, shales; b — crystalline schists; c — sands, gravels, clays; d — banatites); 3 — Peremial course; 4 — Temporary course; 5 — Ponor; 6 — Losses in flow along the riverbed; 7 — Inflow cave; 8 — Outflow cave; 9 — Pothole; 10 — Underground flow direction established by tracer experiments; 11 — Geological boundary; 12 — Fault; 13 — Overthrust front; 14 — Quarry; 15 — Summit; 16 — Mine galery; 17 — Mine snaft; 18 — Surficial watershed between Crișul Negru, Someșul Cald and Arieșul Mare rivers; 19 — Spring with flow from 1 to 5 l/s; 20 — Spring with flow from 50 to 100 l/s; 21 — Spring with flow from 100 to 600 l/s.

Denomination of points numbered on the map: 1 — Spring and cave of Ferice; 2 — Groapa Budeștilor ponor; 3 — Cerbasca spring; 4 — Spring of Peștera Urșilor cave; 5 — Spring of Giulești and Micula cave; 6 — Fagul galery; 7 — Hidra spring; 8 — Spring of Camenița; 9 — Blidaru spring; 10 — Pișolca cave; 11 — Spring of Coliboaia cave; 12 — Losses of Pietrele Roșii brook; 13 — Losses of Secătura brook; 14 — Muncelul cave; 15 — Losses of Preluca Nesului brook; 16 — Losses of Sodolul Tomeștilor brook; 17 — Losses of Crăciune brook; 18 — Losses of Sodolul Ghețarului brook; 19 — Spring of Fînațe; 20 — Springs of Toplița (bulz) brook; 21 — Poarta Bihorului cave; 22 — Losses of Hoanca Codreanului brook; 23 — Losses of Coșuri brook; 24 — Elena ponor; 25 — Izvorul Crișului spring; 26 — Losses of Corlatu brook; 27 — Losses of Fleșcuța brook; 28 — Losses of Hoanca Moțului brook; 29 — Pothole of Hoanca Urzicarului; 30 — Losses of Crișanu brook under Tîrnicioara; 31 — Losses of Lincșoara brook; 32 — Losses of Valea Seacă brook; 33 — Losses of Tiganu brook; 34 — Păruleasa spring; 35 — Galbena s
36 — Cetățile Ponorului; 37 — Losses of Barsa Cohanului; 38 — Losses of Pîrîul Sec brook; 39 —
of Iezere; 40 — Izbucul Ursului spring; 41 — Izvorul Rece spring; 42 — Căput cave; 43 — Losses of I
Ponor; 44 — Izbucul Ponorului spring; 45 — Ponor of Stevia Lupii; 46 — Ponor near Tăul Negru;
Ghețarul de la Barsa cave; 48 — Springs of Bulbuci Valley; 49 — Oșelu spring; 50 — Boga s
51 — Ponor of Vărășoaia; 52 — Ponor of Cuților Valley; 53 — Ponor of Renghii Valley; 54 — Po
Arsura Valley; 55 — Ponor of Tringhești Valley; 56 — Izbucul Mic spring; 57 — Călineasa spring;
Ponor of Călineasa; 59 — Spring of Hoanca Seacă; 60 — Apa Caldă spring; 61 — Spring of Măr
62 — Gura Apei spring; 63 — Spring of Coliba Ghiobului; 64 — Coiba Mică cave; 65 — Spr
Vulturul brook; 66 — Tăuz spring (spring of Moara lui Filea); 67 — Corobana spring; 68 — Losses of (
brook; 69 — Pothole of Sesuri; 70 — Cave of Cotețul Dobreștilor and Izvorul Morii spring; 71 —
of Ordîncușa brook; 72 — Spring of Poarta lui Ioanel; 73 — Izbucul Mare spring; 74 — Izbucul Mic s
75 — Losses of Pleșa brook; 76 — Alunu Mare spring; 77 — Pepi (Gordan) cave; 78 — Spring near
Sec river mouth; 79 — Subthermal spring from Alunu Mic brook (°C); 80 — Alunu Mic spring; 81 —
of Ponorul Valley; 82 — Diaclază cave; 83 — Lucii pothole; 84 — Ponotul cu Pod ponor; 85 —
of Vîrtop; 86 — Springs of Surile din Firea; 87 — Pojaru Poliței spring; 88 — Trei izvoare
89 — Gemănata pothole.

ascertain of only 6 flow direction of these waters, two of them being assigned to Viehman a.o. (1958, 1961), and one to each of the folowing authors: Şerban a.o. (1957), Rusu a.o. (1970), Vălenaş (1974), Halaşi and Ponta (1984)

Since 1983 there were made by the authors 36 experiments with rhodamine B, fluoresceine, stralex, radioactive tracers (I-131, Br-82) and activable tracers (In-EDTA, Dy-EDTA) — in the frame of a complex hydrogeological research programme of Bihor Mountains karst, initiated by Enterprise for Geological and Geophisical Prospecting.

During the accomplishment of different labelling works we've benefited by the aid of Brijan P., Catilina R., Stanca C., Matoş P., Popa C. and Onac B. At some injection of tracers we were helped by Matyaşi S., Baboş R. and by the members of „Politehnica" Spologic Club from Cluj-Napoca. The water samples processing and measurement in view of detecting the activable tracer was carried out by Stănescu P. from IFIN Bucureşti.

As a basis for the hydrogeological maps annexed we have used the following: the geologic map of Romania on a scale of 1 : 50,000, the sheets of Pietroasa, Poiana Horea and Avram Iancu drafted by Bleahu a.o. (1985, 1980), respectively by Dumitrescu a.o. (1977) as well as the geologic map of Someşul Cald graben drew up by Mantea (1986) and the structural map of West Bihor Mountains made by Bordea a.o. (1975).

3. THE RESULTS OF THE TRACER EXPERIMENTS

The results of tracers labelling, performed up to the present in Bihor Mountains karst, are synthetized in table 1, while the ideal flow directions of groundwaters, as resulted from these experiments, are found on the hydrogeological maps annexed.

3.1. TĂTĂROAIA ZONE

This area is shaped in Anissian dolomites and Ladinian limestones, developping in the form of a strip between Crăiasa and Galbena Valleys. The karstic area of Tătăroaia is mostly superposed to the hydrogeological karst system of Giuleşti spring (fig. 1, 5) charged almost exclusively by precipitations and deprived of an nonkarstic basin.

By digging a geological research gallery into the upper basin of Fagul brook (fig. 1, 6), an active cave was intercepted its underground stream drains through the spring from Giulesti, as proved by the rhodamine B experiment accomplished. In addition to this source, the system is probably charged too by the losses from Căuşii riverbed, as well as by the diffuse infiltrations, resulting from the precipitations in Tătăroaia peak zone. In case of great rainfalls the fisures and channels network of Giuleşti spring is inadequate for draining the whole quantity of water, so that, a part of it bails out through Micula cave entrance, which acts as the overflow of the system.

RESULTS OF TRACING OPERATIONS ON

No.	Insurgence (number on the map)	H (m)	Resurgence (number on the map)
1	2	3	4
1	Ponor of Groapa Budeştilor (2)	875	Cerbasca spring (3)
2	Fagului cave (6)	865	Giuleşti spring (5)
3	Losses of Pietrele Roşii brook (12)	800	Pişolca cave (10)
	,,	,,	Coliboaia spring (11)
	,,	,,	Blidaru spring (9)
	,,	,,	Hidra spring (7)
4*)	Losses of Secătura brook (13)		Coliboaia spring (11)
5	Losses of Secătura brook (13)	925	Coliboaia spring (11)
	,,	,,	Blidaru spring (9)
6	Muncelu cave (14)	1100	Blidaru spring (9)
7	Losses of Preluca Neşului brook (15)	815	Blidaru spring (9)
8	Losses of Sobodolul Tomeştilor br. (16)	550	Hidra spring (7)
9	Losses of Crăciune brook (17)	880	Hidra spring (7)
10**)	Losses of Hoanca Codreanului (22)	850	Poarta Bihorului cave (21)
11**)	Losses of Coşuri brook (23)	750	Underground works of Molibden mine
12**)	Elena ponor (24)	845	Poarta Bihorului cave (21)
13	Losses of Corlatu brook (26)	1040	Izvorul Crişului spring (25)
14	Losses of Valea Seacă brook (32)	1100	Izvorul Crişului spring (25)
15	Losses of Fleşcuţa brook (27)	1150	Izvorul Crişului spring (25)
16**)	Losses of Hoanca Moţilor brook (28)	925	Izvorul Crişului spring (25)
	,,	,,	Trei Izvoare spring (88)
17	Losses of Tiganu brook (33)	820	Păuleasa spring (34))
18**)	Losses of Crişanu brook (30)	975	Păuleasa spring (34)
19	Pothole of Hoanca Urzicarului (29)	1165	Păuleasa spring (34
20**)	Losses of Luncşoara brook (31)	700	Păuleasa spring (34)
21	Ponor of Vărăşoaia (51)	1290	Boga spring (50)
22	Ponor of Cutilor brook (52)	1260	Boga spring (50)
23	Ponor of Renghii brook (53)	1235	Boga spring (50)
24	Ponor of Arsura brook (54)	1245	Izbucul Ponor spring (44)
	,,	,,	Galbena spring (35)
25*)	Ponor of Trîngheşti brook (55)	1270	Izbucul Ponor spring (44)
26*)	Ponor of Poiana Ponor (45)	1060	Galbena spring (35)
27	Ponor of Trîngheşti brook (55)	1260	Izbucul Ponor spring (44)
	,,	,,	Galbena spring (35)
28	Course of Gheţarul de la Barsa cave (47)	1100	Galbena spring (35)
29	Ponor of Stevia Lupii (45)	1125	Galbena spring (35)
30	Losses of Pîrîul Sec brook (38)	1205	Gemănata pothole (fig. 3)
	,,	,,	Cetăţile Ponorului (36)
31	Ponor of Barsa Cohanului (37)	950	Cetăţile Ponorului (36)
32*)	Course of cave of Fîntîna Roşie (fig. 3)		Bulbuci spring (48)
33	Course of Coiba Mică (64)	960	Tăuz spring (66)
34*)	Pothole of Sesuri (69)	1134	Izbucul Poliţei spring (87)
35*)	Losses of Ocoale brook (68)	1160	Coteţul Dobreştilor spring (70)
	,,	,,	Izbucul Morii spring (70)
36	Losses of Ordîncuşa brook (71)	745	Izvorul Mic spring (74)
37	Losses of Pleşii brook (74)	875	Izvorul Mare spring (73)
38	Losses of Ponorul brook (81)	1130	Alunul Mic spring (80)

Table 1

BIHOR MOUNTAINS KARSTIC AREA

H (m)	L(m)	ΔH(m)	Tracer used	houts	V m/hour	Date of labelling
5	6	7	8	9	10	11
570	750	305	In-EDTA	192	3.9	6.10.1985
505	1900	360	Rhodamine B	85	22.3	7.10.1984
500	1600	300	in-EDTA	100	16.0	23.09.1987
513	1240	287	,,	100	12.4	,,
435	2330	365	,,	100	23.3	,,
390	3950	410	,,	100	39.5	,,
			Rhodamine B			1984
515	1700	410	Rhodamine-B	168	10.1	21.09.1984
435	3070	490	,,	240	12.8	,,
435	3880	665	I-131	147	26.3	17.05.1985
435	2770	380	Fluoresceine	96	28.9	21.09.1984
390	1350	160	Fluoresceine	70	19.3	28.09.1984
390	2550	490	In-EDTA	310	8.2	24.09.1989
640	600	210	Br-82	48	12.5	17.05.1984
			$K_2Cr_2O^3$	288		4.11.1983
640	850	205	I-131	96	14.1	18.05.1984
700	1750	340	In-EDTA	20	87.5	3.11.1983
700	3600	400	In-EDTA	1344	2.7	7.08.1984
700	2150	450	Fluoresceine	288	7.5	23.11.1983
700	1300	225	I-131	30	43.3	19.09.1985
775	550	300	,,	10	55.0	,,
570	2000	250	• In-EDTA	24	83.3	21.05.1985
570	3075	405	Rhodamine B	95	32.4	27.05.1985
570	4600	595	In-EDTA	300	15.3	17.12.1984
570	1900	130	Stralex	24	79.1	27.05.1985
675	2170	615	Rhodamine B	15	144.6	13.06.1985
675	2560	585	Stralex	20	128.0	13.06.1985
675	2500	560	In-EDTA	24	104.1	14.06.1985
1100	2100	145	Rhodamine B	15	140.0	22.09.1985
815	5120	430	,,	30	171.0	,,
1100	2000	170	Fluoresceine	66	38.0	1958
815	3000	245	Fluoresceine	66	45.0	1961
1100	1950	160	Dy-EDTA	12	162.5	22.09.1985
815	5320	445	,,	24	221.6	,,
815	2775	285	In-EDTA	190	14.6	10.07.1987
815	1925	310	KI	40	48.1	6.09.1986
	650		Rhodamine B	40	16.2	10.08.1986
950	2950	255	,,	70	42.1	,,
950	900	145	Fluoresceine	14	64.3	10.08.1986
						12.1974
850	2650	110	Rhodamine B	322	8.2	19.10.1985
920	880	214	Fluoresceine			1957
770	2800	390	Fluoresceine	38	73.7	04.1964
760	2880	300	,,	38	75.0	,,
730	1000	15	In-EDTA	36	27.8	26.08.1985
725	2620	150	Rhodamine B	65	40.3	26.08.1985
1100	1400	30	Rhodamine B	108	13.0	27.10.1985

1	2	3	4
39	Course of Diaclază cave (82)	1230	Alunul Mic spring (80)
40	Course of Pothole of Lucii (83)	1160	Alunul Mic spring (80)
41	Ponor of Poiana Vîrtopului (85)	1322	Surile din Firea spring (86)
42	Ponorul cu Pod ponor (84)	1315	Surile din Firea spring (86)

H = Elevation above the mean sea level ; L = Horizontal distance between losses and springs ;
*) Tracer operations performed by other authors: Halasi, Ponta (nr. 4), Viehman et al.
**) Drainage direction is not drown on the hydrogeological map (fig. 1) ;
Note 1 : The following tracer operations were performed by the authors in cooperation with : Stanca C. (nr. 6, 10, 12, 16), Popa C., Onac B. (nr. 41, 42).
Note 2 : In the following tracer operations, the injection of tracer were performed with parti-Napoca speological club (nr. 38, 39, 40).
Note 3 : In tracer operations nr. 10, 12, 13, 14, 16, the tracers were identified also in waters

3.2. SIGHIŞTEL ZONE

Sighiştel hydrographic basin represent the karstic area with the greatest density of caves in the country. This is due to the tithonic-oxfordian limestones propitions to an intensive karsting and (mostly) to the presence of the detrital deposits on the limitrophe crest, deposits which facilitate the concentration and the conduct of surface flows towards the karstic fields.

In table 1 we present the result obtained in the six labellings carried out in this zone. Among these we mention two. Thus, the surface waters infiltrated through the thalweg of Secătura brook (fig. 1, 13) had mostly abandoned their old point of discharge through Coliboaia cave (fig. 1, 11) in favor of Blidaru spring (fig. 1, 9).

By labelling the waters of Pietrele Roşii brook from the hydrographic basin of Crăiasa Valley, it was shown their participation to the supply of all the main sources from Sighiştel brook (the spring beneath Coliboaia cave, Pişolca cave, Blidaru and Hidra spring), with an increased weight on Blidaru spring (fig. 2). We mention that systematic gauging accomplished in the whole path of Sighiştel brook did not reveal the presence of any infiltration in riverbed – therefore the impossibility of contaminating the downstream sources by the tracers reaching the brook water through the upstream sources.

Considering the groundwater circulation in the Sighiştel basin on a whole, one may assert that we find in the presence of a well developed karstic aquifer, supplied by precipitations and by numerous surface courses with reduced water discharge. The discharge of the aquifer is mainly accomplished through Blidaru spring, with the fossilization tendency of the upstream discharge points (caves of Coliboaia and Pişolca) as well as the activation of Hidra spring placed downstream.

The results show a typical example as regards the karstic drainages evolution, the downstream migration of the aquifers discharge points with the abandoning of old upstream sources.

Table 1 (continuation)

5	6	7	8	9	10	11
1100	1200	130	In-EDTA	230	5.2	27.10.1985
1100	1100	60	Fluoresceine	44	25.0	27.10.1985
1070	2610	252	In-EDTA	120	21.7	12.06.1988
1070	2920	245	Rhodamine B	90	32.4	12.06.1988

ΔH = Vertical drop ; t = Time of first arrival of tracer ; v = Apparent velocity (nr. 25, 26), Şerban et al. (nr. 34), Rusu et al. (nr. 35) and Vălenaş (32)

Brijan P. (nr. 3, 8, 9), Mateş P. (nr. 30, 31), Matyasi S. (nr. 28), Catilina R.,

cipation of : Brijan P., Matyasi S. (nr. 19), Baboş R. (nr. 29), „Politehnica" Cluj-

of underground works of Molibden mine.

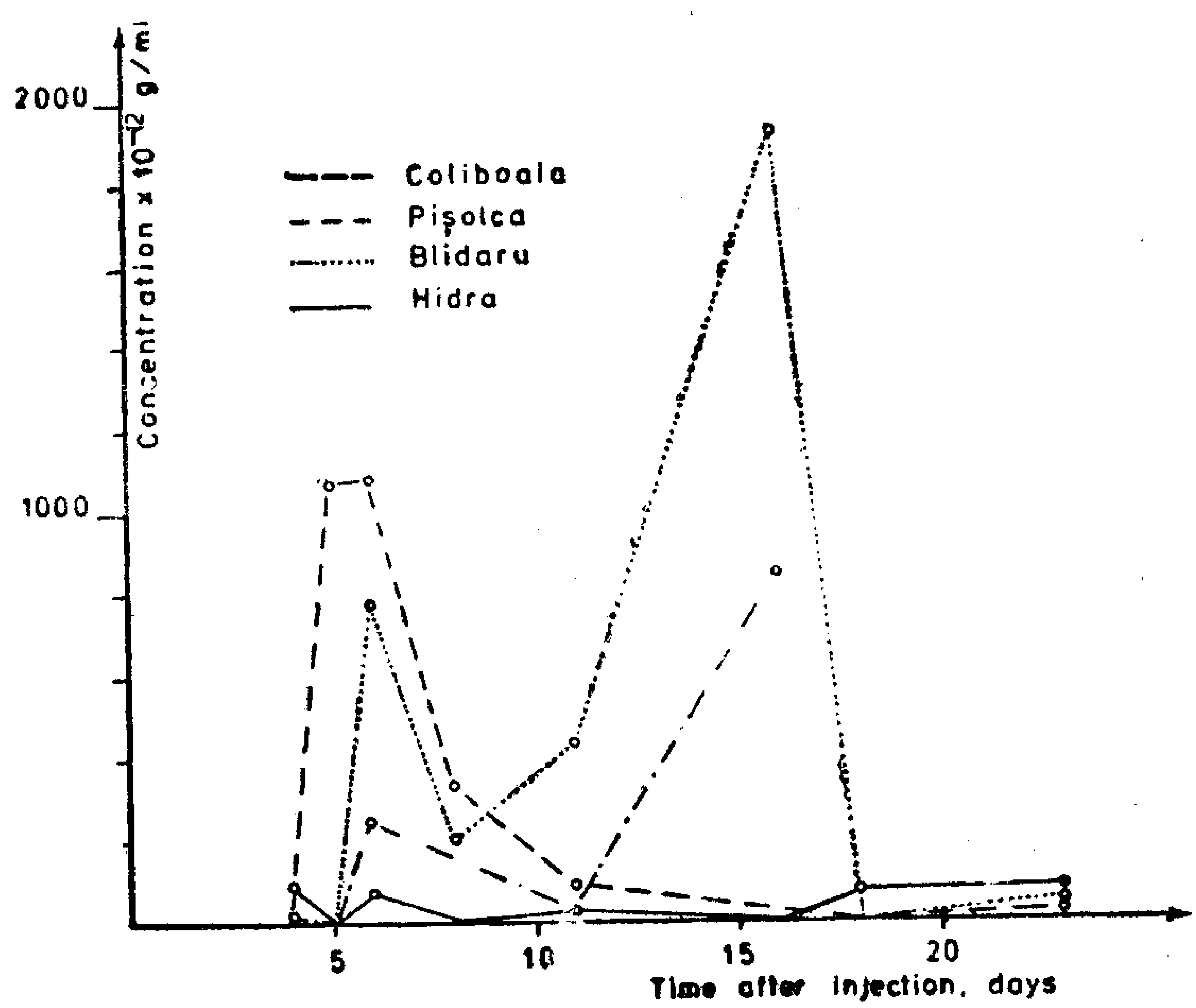


Fig. 2 — The time behaviour of In-EDTA used as a tracer in Pietrele Roşii experiment Data of labelling : 23.09 1987.

3.3. THE UPPER BASIN OF CRIŞUL BĂIŢA BROOK

This basin develope mostly on karstic terrains, the area which overlaps the polimetallic sulfides ore „Molibden". The ore is horizontally and vertically open through numerous workings (Stoici, 1983), and its exploit is particularly difficult because of the karstic waters.

The tracer labelling carried out indicate a redistribution of groundwaters from their natural escape points represented by the effluent caves of Izvorul Crişului (fig. 1, 25) and Poarta Bihorului (fig. 1, 2) towards the underground workings of „Molibde " mine. Conducting the groundwaters to these, caused a substantial diminution of Izvorul Crişului flow as well as a transition of Poarta Bihorului spring to a temporary flow regime.

Among the numerous labellings accomplished in this area, we mention the one made in the diffuse losses in riverbed of Valea Seacă brook, downstream of Groapa Ruginoasă (fig. 1, 32). The In-EDTA tracer used for this experiment was detected in the Izvorul Crişului spring as in the waters inflows from the underground workings of „Molibden" mine. This proves a continuity of carbonate deposits under the detrital deposits of Arieşeni Nappe from Tapu crest (Gaşpar and Orăşeanu, 1987).

3.4. THE UPPER BASIN OF GALBENA VALLEY

The karstic aquiferous from the upper basin of Galbena brook discharge mostly through Păuleasa spring (fig. 1, 34 and fig. 3), excepting the waters infiltrated from the upper course of Valea Seacă brook which are Southerly led in Crişul Băiţa basin.

Most of Luncşoara brook waters, diffusely infiltrated through the limestone fissures and holes in thalweg (fig. 1, 31), participate to the charge of Păuleasa spring. In addition to these there are the waters of Ţiganul (fig. 1, 33) and Crişanul (fig. 1, 30) brooks, as well as the groundwaters from the deepest pothole in Bihor Mountains (280 m) — Hoanca Urzicarului (fig. 1, 29). The underground course was labelled in Jderilor gallery with the aid of Brijan P. and Matyaşi S.

3.5. THE PADIŞ — CETĂŢILE PONORULUI BASIN

The endorheic basin Padiş—Cetăţile Ponorului has an area of 37.2 km² Its genesis is closely connected with the geological constitution of the zone, with the alternation of karstifyable and nonkarstifyable beds. The werfenian detrital deposits from Măgura Vînătă, the hettangian-sinemurian ones from the alignment Valea Plaiului — Groapa de la Barsa — Izvorul Ursului brook and the permian ones from Borţigu — Glăvoiu crest, favour the forming of a surface flow, which infiltrate underground, when entering in carbonate terraines and contributes to the supply of some wide aquifers.

In tracers labellings made for detecting the affiliation of the waters infiltrated through numerous ponors from Padiş — Cetăţile Ponorului basin (table 1 and fig. 3) pointed out the underground conduct of the waters belonging to Vărăşoaia sub-basin and to Cuţilor and Renghii brooks from the Northern part of Padiş sub-basin towards to Boga spring (fig. 1, 50). The reduced transit time of the tracers through the carbonate deposits mass show the presence of a preferential circulation on the karstic holes widely developed, and implicitely the possible existence of a cavernament accessible to speologists. The difference of level between Vărăşoaia ponor and Boga spring is of 615 m, the second in value among the hydrogeological connections established by our experiments carried out in Bihor Mountains. The greatest difference of level of 665 m appears in the drainage Muncelu cave — Blidaru spring.

The surface waters from the Southern half of Padiş sub-basin (Arsura, Trîngheşti and Gîrjoaba brooks) are drained underground in a first stage up to the Ponorului spring (fig. 1, 44), from where following an epigeal

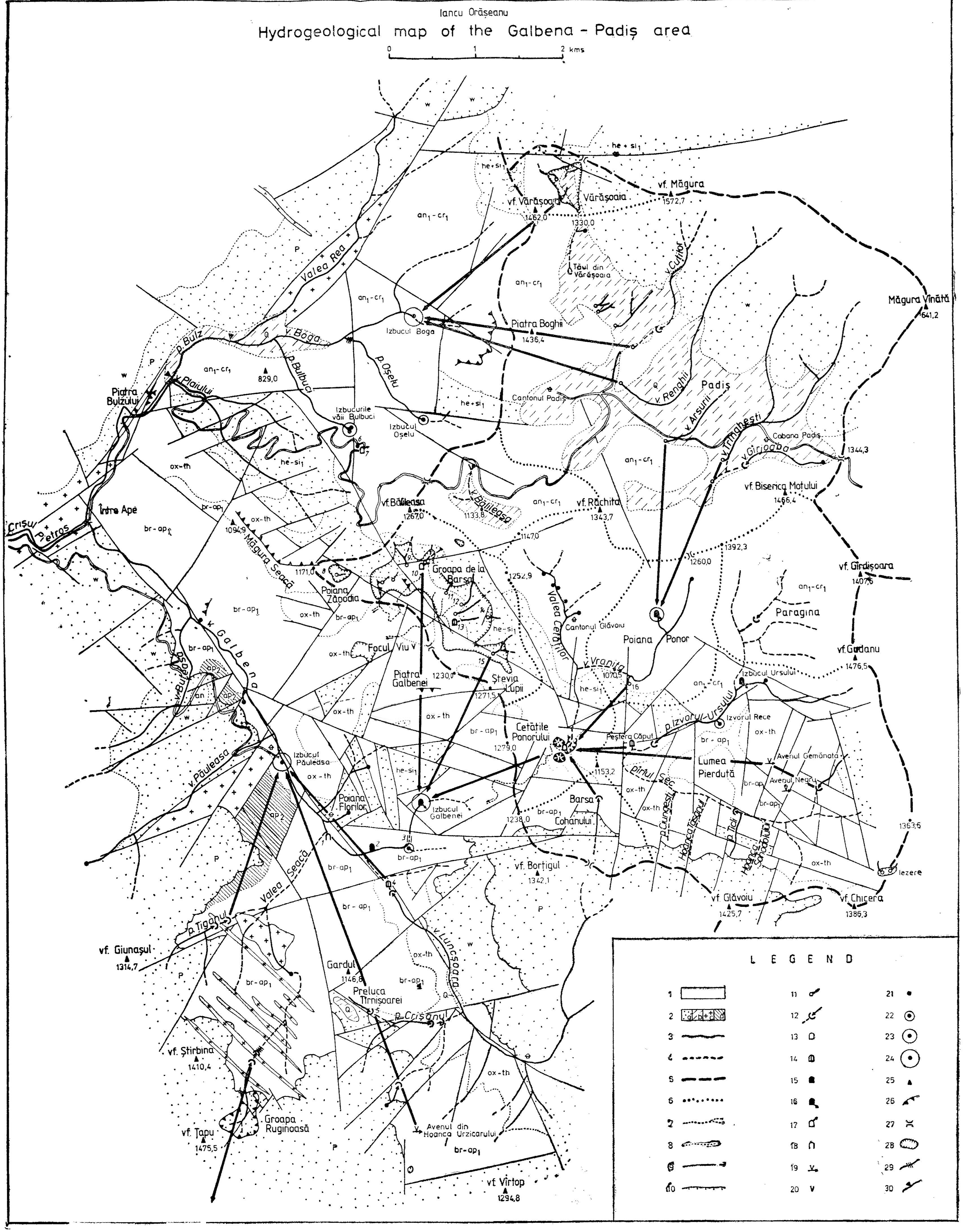


Fig. 3 — Legend : 1 — Karstic deposits ; 2 — Nonkarstic deposits (a — sandstones, conglomerates, shales ; b — sands, gravels, clays ; c — banalites ; d — marls) ; 3 — Perennial course ; 4 — Temporary course ; 5 — Limit of Padiș-Cetățile Ponorului endorheic basin ; 6 — Limit of sub-basins ; 7 — Clave passage ; 8 — Geological boundary ; 9 — Fault ; 10 — Overthrust front ; 11 — Ponor ; 12 — Losses in flow along the riverbed ; 13 — Perennial inflow cave ; 14 — Temporary inflow cave ; 15 — Perennial cutflow cave ; 16 — Outflow cave accesible by diving ; 17 — Cave tapping an underground stream ; 18 — Fossil cave ; 19 — Pothole tapping un underground stream ; 20 — Fossil pothole ; 21 — Spring with flow from 1 to 10 l/s ; 22 — Spring with flow form 10 to 100 l/s ; 23 — Spring with flow from 100 to 300 l/s ; 24 — Spring with flow from 300 to 600 l/s ; 25 — Summit ; 26 — Abrupt ; 27 — Saddle ; 28 — Karst depression ; 29 — Waterfall ; 30 — Hydrometric gauging section.

Denomination of points numbered on the map : 1 — Peștera Seacă cave ; 2 — Peștera cu Apă ; 3 — Tunnel from Galbena Valley ; 4 — Ponor cave from Luncșoara Valley ; 5 — Losses of Crișanu brook under Tîrnicioara ; 6 — Fîntîna Rece spring ; 7 — Cave of Fîntîna Rece ; 8 — Ponor of Poiana Zăpodie ; 9 — Ponor of Zăpodie Valley ; 10 — Ponor and cave Ghețarul de la Barsa ; 11 — Ponor near Tăul Negru : 12 — Ponor „D" of Groapa de la Barsa ; 13 — Peștera Neagră cave ; 14 — Ponorul Argilei ponor ; 15 — Ponor of Stevia Lupii ; 16 — Ponor of Poiana Ponor. Note ; Cave passages of Groare de la Parsa after Vălenas (1977) and of Cetățile Ponorului after Viehman et al. (1978).

path of about 1 km they re-enter underground through a ponor, unaccessible for man. They re-appear at Cetățile Ponorului through the spring near the Northern sinkhole [2] (Viehman, 1966) in order to appear again in the Galbena spring (fig. 1, 35) after another underground passage.

Lumea Pierdută sub-basin consist of a homonimous little karstic plateau and of hydrographic basin of the brooks Pîrîul Sec and Izvorul Ursului enclosing it Northely and Southerly. The former brook has a temporar character while the latter is permanent on the most of its course, being mainly charged by the waters of Izvorul Ursului spring (fig. 1, 40) and Fîntîna Rece (fig. 1, 41) springs. Both of them comfluence before penetrating in the cave from Căput (fig. 1, 42).

In order to reveal the running direction of groundwaters from Lumea Pierdută plateau, a rhodamine B labelling was performed in the water of the Northern affluent of Pîrîul Sec, which infiltrate diffusely into the riverbed when leaving the Liassic sandstones (fig. 1, 38). The tracer was detected in the underground course from Gemănata pothole (fig. 3) and in the water which emerges from Căput gallery at Cetățile Ponorului.

The waters infiltrating through the ponor from the Barsa Cohanului sub-basin (fig. 1, 37) participate also to the flow of Căput gallery, which was proved by a fluoresceine experiment.

The speologic researches carried out in Groapa de la Barsa by Vălenaș (1977) pointed out the presence of a cavernament which a remarkable lenght (14,880 m) named Zăpodie — Barsa System. It centres itself broadly along the two underground courses, Northern Course and Southern Course, both of them ending by siphons. In addition to these there are some independent courses charged by the ponors from Poiana Zăpodie, Zăpodie Valley, Argila Valley and that from Stevia Lupii (fig. 3). The ponors and the underground courses are charged by numerous small brooks arising on the Liassic terrains at the North and East of Groapa de la Barsa.

Northern Course was coloured with fluoresceine by „Focul Viu" Spological Club, the authors indicating the appearance of the tracer in some weak springs from Liassic sandstones of Poiana Florilor (Vălenaș, 1977). Our works did not confirm that.

On 6th of september 1986, the water of the ponor from Stevia Lupii was labelled with KI, the presence of I^- activable tracer being detected in Galbena spring, two days after launching (fig. 4).

On 10th Julli 1987 the course from Sala Mare in Ghețarul de la Barsa cave, belonging to the Northern Course was labelled with In-EDTA. The tracer was drawn into the Galbena spring, crossing this point from 18. 07 till 28.07.1987 (fig. 5). The samples taken from Boga (10—26.07. 1987) and Oșelu (10—20.07.1987) springs had not indium. We mention

[2] In Cetățile Ponorului, right in the proximity of the entrance, there are two water supplies which join the temporary course of Valea Cetăților brook in order to form the ground course. The first source is situated upstream the portal on the left side and appears from a siphon lake placed at the end of a 90 m long asceding cave passage. The second one appears through two close channels situated at about 1 m above the minimum water level, in the right wall of Cetățile Ponorului cave, upstream the inlier facing the Northern sinkhole.

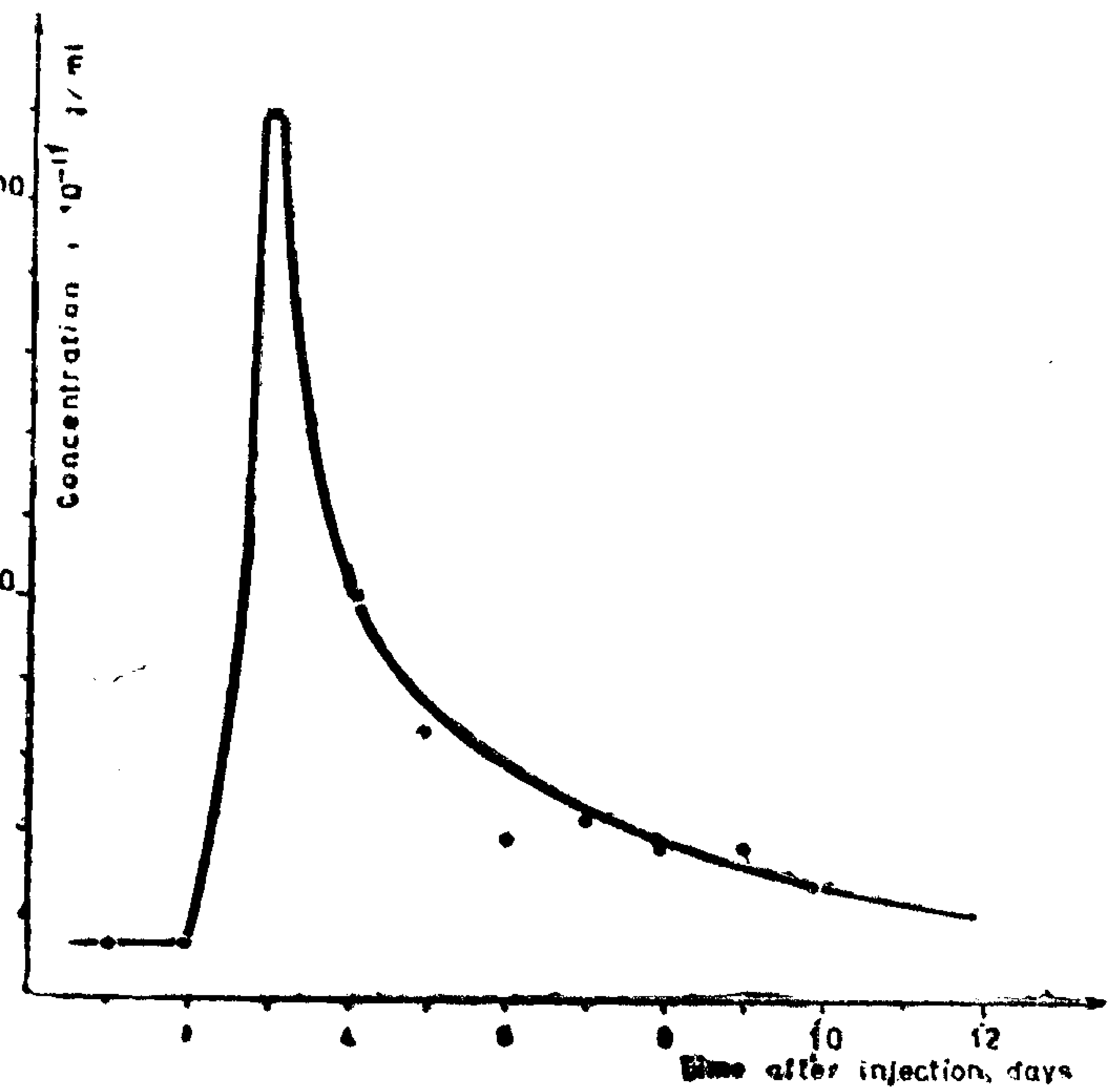


Fig. 4 — The output curve of a I^- tracer after labelling Stevia Lupii — Izbucul Galbenei spring underground route at 6.09.1986.

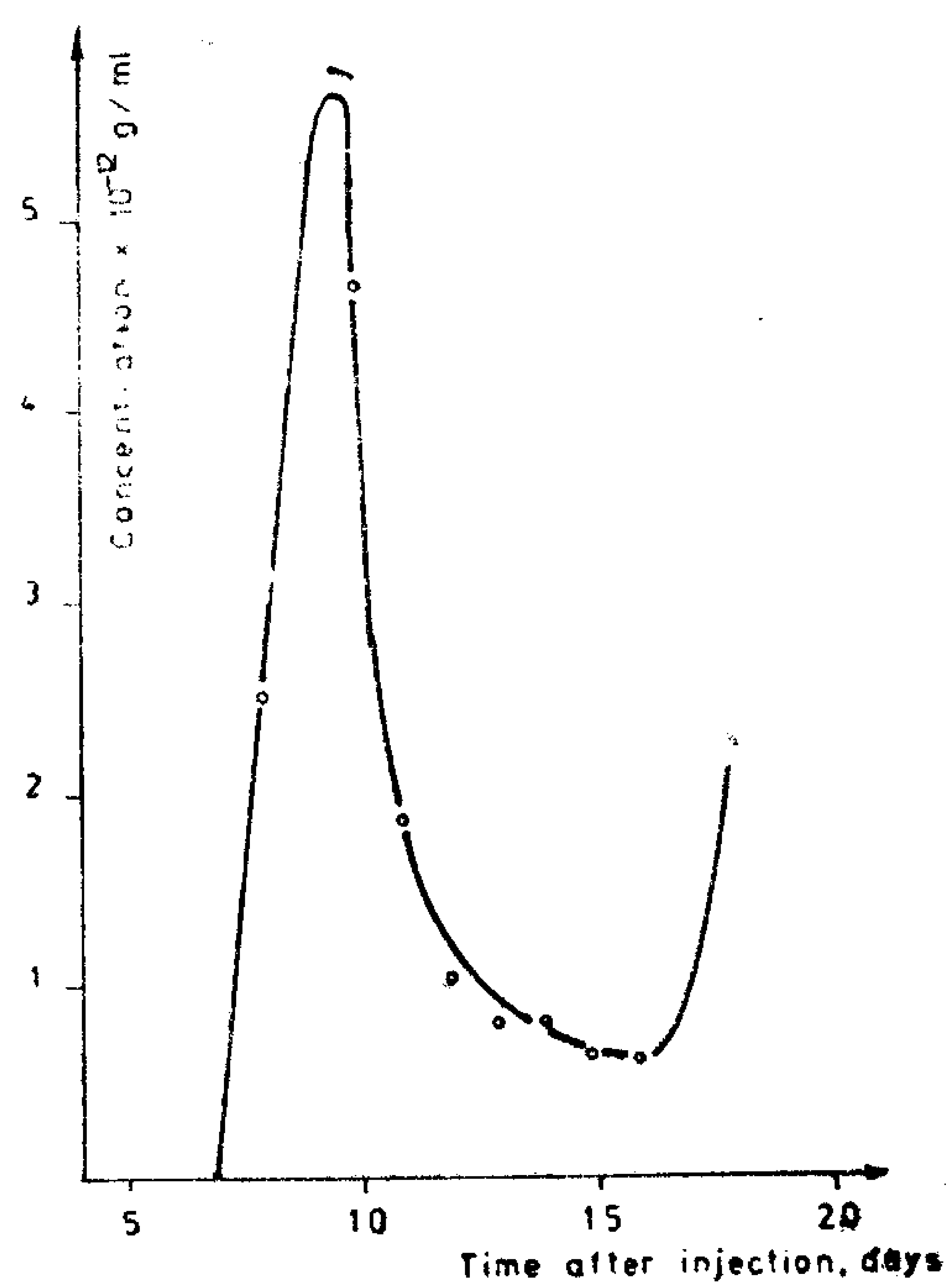


Fig. 5 — Concentration-time variation of In-EDTA as a tracer in Gheţarul de la Barsa — Izbucul Galbenei spring experiment.

that in all our experiments the samples from Galbena spring were taken from its brook at the bridge situated at the confluence with Luncșoara Valley.

At the previous labelling considerable quantities of In-EDTA were noted in Galbena brook water at the point Între Ape. We may not state whether the tracer cames exclusively from Galbena spring or from the springs below Măgura Seacă too, because we lack both systematic discharge measurements and short-period samples taking over-i.e. the basic data for calculating the quantities of retrieved tracer.

As a preliminary conclusion of the labellings now proceeding, it may be hold that the karstic aquifer from Groapa de la Barsa discharges mainly through Galbena spring. In the hydrogeological regional context, it is posible that a part of waters that infiltrated through the ponors belonging to this zone, to be directly drawn, without a immediate local reappearing, into a ground flow by means of the drain constitued by Bulz — Valea Rea and Galbena faults systems. This may be explained by considering a karstic aquifer developed in the whole stack of limestones, the Northern Course and the Southern Course representing the major drains which are placed at the upper side of the aquifer and have the role of rapid relievsing the high floods.

We mention that on hydrogeological map presented in fig. 3, the outline of Groapa de la Barsa was plotted on the contour line of 1150 m.

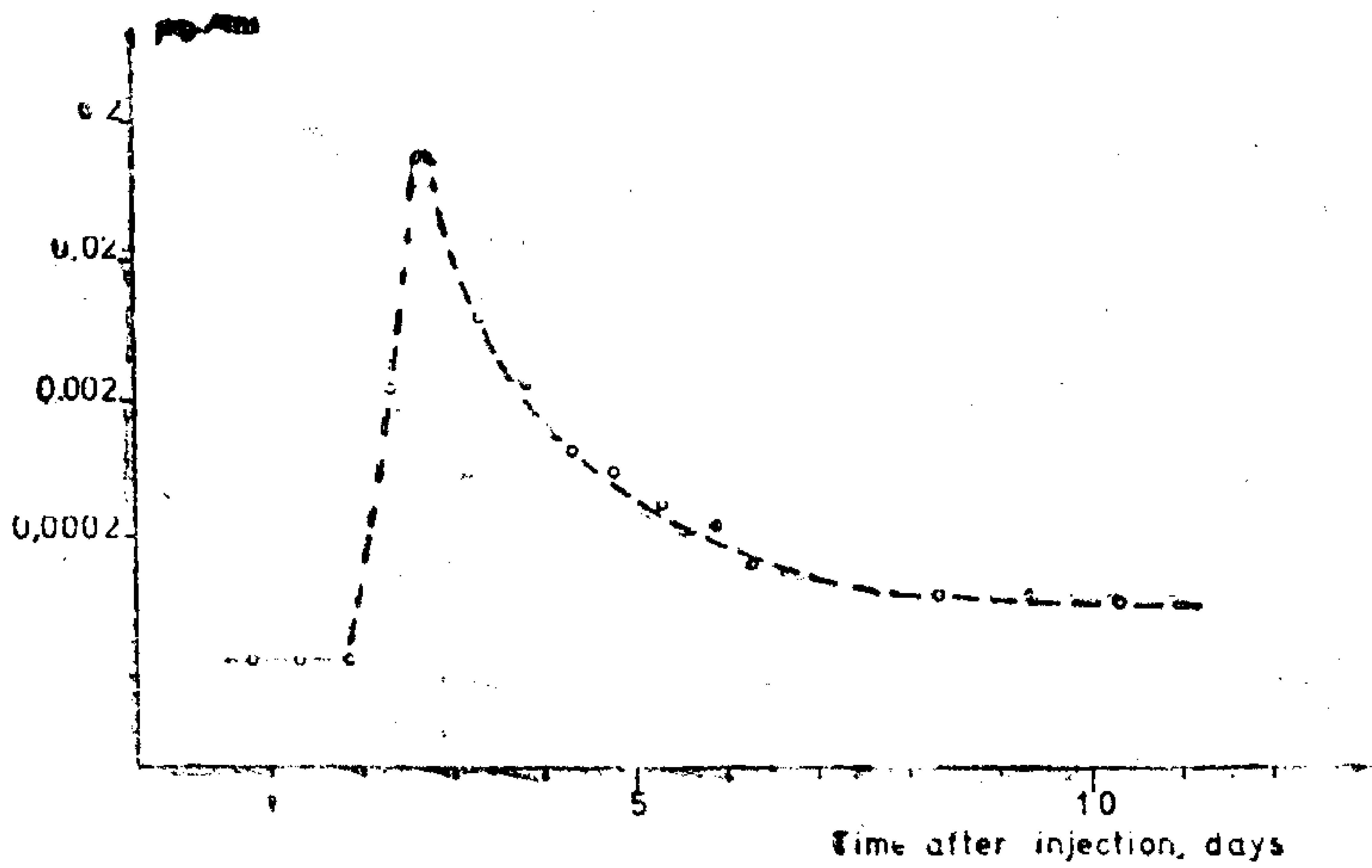
3.6. THE BASIN OF GÎRDA SEACĂ VALLEY

By labelling with rhodamine B of Gîrdișoara brook it was mean to specify the dynamics of the groundwaters between Coiba Mică inlet cave (fig. 1, 64) and Tăuz spring (fig. 1, 66). These points are situated at an aerial distance of 2650 m having a level difference of 110 m. The tracer crossed the underground passage in 12 days travelling through the control section 7 days long under a unique classical maximum specific to a „piston type" flow (Gașpar, Orășeanu, 1987).

The interstream area between the Valleys of Gîrda Seacă and Ordîncușa, dominated by Ocoale-Ghețar endorheic basin, was the object of numerous speological researches, stimulated by the presence of Scărișoara Glacier. There were simultaneously accomplished studies about the running direction of groundwaters, which pointed out the hydrological relationship between the underground stream of Sesuri pothole (fig. 1, 69) and Pojarul Poliției spring (fig. 1, 87, Șerban a.o., 1957) and the one between the losses of Ocoale Valley (fig. 1, 68) and the springs from Cotețul Dobreștilor (fig. 1, 70) and Izvorul Morii (Rusu a.o., 1970), by means of fluoresceine labellings.

The Southern terminal of the limestones of Gîrda Seacă Valley basin is dominated by the presence of temporary total losses from the lower basin of Ordîncușa brook. The waters diffusely infiltrated through the talweg of the valley are partially found in Izbucul Mic (fig. 1, 74). They probably join the waters of Preluca (fig. 1, 75) in order to supply Izvorul Mare spring (fig. 1, 73, fig. 6) too. This hypothesis is not yet conffirmed by the experiment carried out.

Fig. 6 — Transfer curve of In-EDTA in the Pleşa Valley — Izvorul Mare spring experiment



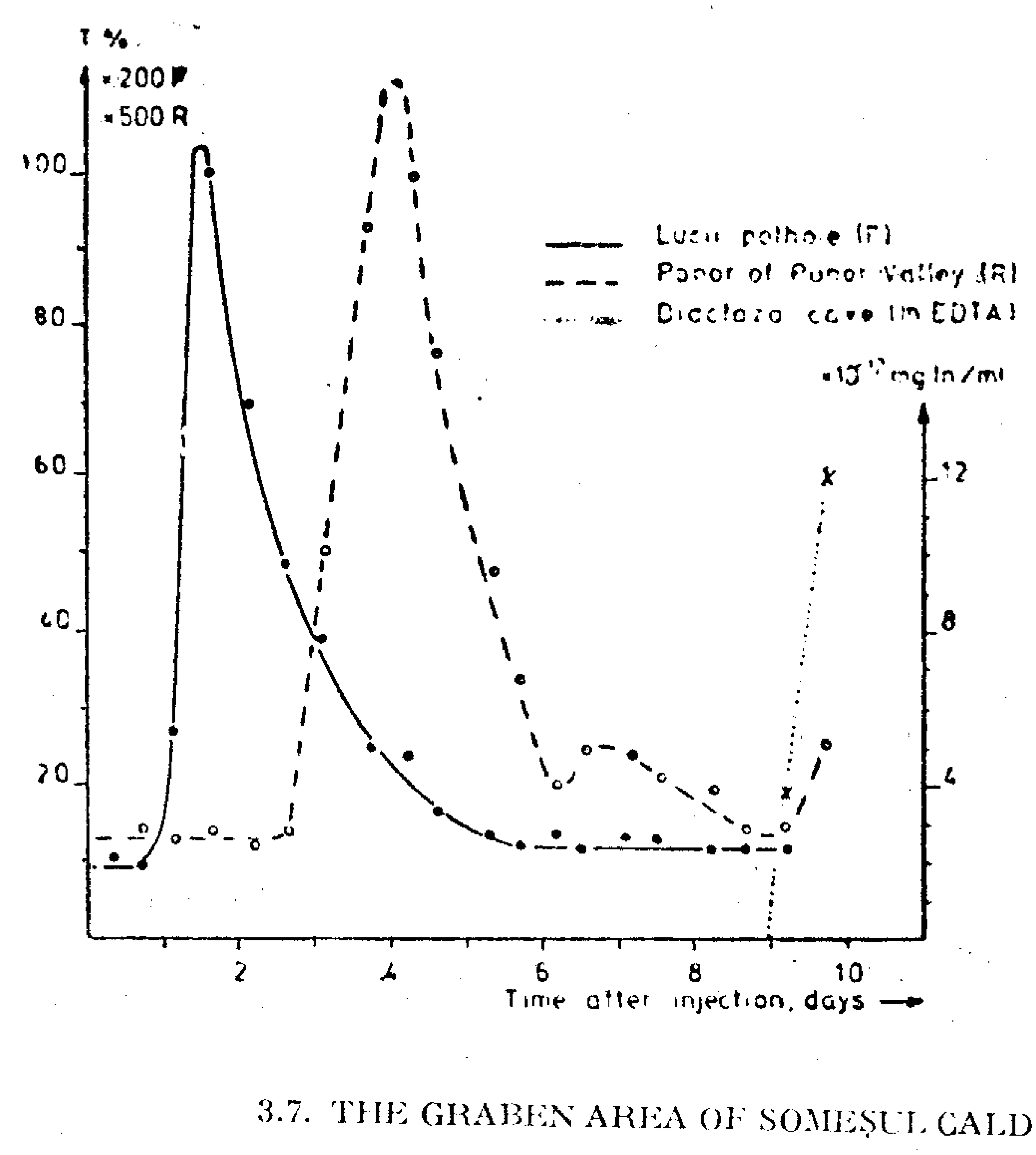


Fig. 7 — Multitracing experiment in Someşul Cald area.

3.7. THE GRABEN AREA OF SOMEŞUL CALD RIVER

The tracer labellings were made in this zone in order to ascertain the hydrogeologic basin extension of Alunul Mic spring, as well as the source of Humpleu cave stream (Peştera Mare din valea Firii).

The explored cavernament of this cave develops in lower Cretaceous limestones of the homonymous plateau, starting from the springs from Surile din Firea (fig. 1, 86) up to the proximity of Ponorului Valley.

In a first stage three tracer labellings were carried out in the total losses of Ponorului Valley (fig. 1, 81) and in ground streams from Diaclaza cave (fig. 1, 82) and Lucii pothole (fig. 1, 83). The tracers were exclusively directed towards the Alunul Mic spring (fig. 7).

The tracer labelling of the waters infiltrated through Ponorul cu Pod ponor (fig. 1, 84) and the ponor from Poiana Vîrtop (fig. 1, 85), that were made in collaboration of Popa C. and Onac B., pointed out the affiliation of these streams to the groundwaters of Humpleu cave.

In all 42 tracer labellings accomplished up to the present in the karst of Bihor Mountains, an average running speed of the groundwater about 45 m/hour was recorded. The longest path was found between the pothole from Hoanca Urzicarului and Păuleasa spring (4600 m) and the maximum level difference (665 m) between Muncelu cave and Blidaru spring.

REFERENCES

BLEAHU M. (1957), *Captarea carstică și importanța ei pentru evoluția morfologică a regiunilor carstice.* Probleme de geografie, vol. V, pp. 55–99, București.

BLEAHU M., DECU V., NEGREA S., PLEȘA C., POVARĂ I., VIEHMAN I. (1976), *Peșteri din România.* Ed. Științifică și Enciclopedică, 409 pp. București.

BLEAHU M., DUMITRESCU R., BORDEA S., BORDEA JOSEFINA, MANTEA G. (1980), *Harta geologică a României, scara 1:50,000, foaia Poiana Horea.* Ed. IGG București.

BLEAHU M., BORDEA S. (1981), *Munții Bihor-Vlădeasa.* Ed. Sport-Turism, 496 pp. București.

BLEAHU M., BORDEA S., BORDEA JOSEFINA, MANTEA G., POPESCU AGAPIA, MARINESCU Fl., CIOFLICĂ G., ȘTEFAN A. (1985), *Harta geologică a României, scara 1:50,000, foaia Pietroasa.* Ed. IGG București.

BRIJAN P. (1978), *Avenul Independența din Hoanca Urzicarului.* Bul. Informativ 2, pp. 20–23, FRTA-CCSS, București.

BRIJAN P. (1982), *Fenomene endocarstice în zona Valea Bulzului – Fînațe (Bihor).* Carst 2, pp. 54–60, Cluj-Napoca.

BORDEA JOSEFINA, BORDEA S., POP Gr. (1975), *Date noi stratigrafice și structurale asupra Bihorului de vest: Unitatea de Următ și Unitatea de Vetre.* D.S. IGG, LXI/5, București.

DUMITRESCU R., BLEAHU M., LUPU M. (1977), *Harta geologică a României, scara 1:50,000, foaia Avram Iancu.* Ed. IGG București.

GAȘPAR E. (1987), *Modern Trends in Tracer Hydrology.* vol. 2, CRC-Press, Boca Raton, Florida, USA.

GAȘPAR E., ORĂȘEANU I. (1987), *Natural and artificial tracers in the study of the hydrodynamics of karst.* Theoretical and Applied Karstology, vol. 3, pp. 31–107, București.

GLIGAN M. (1987), *Drenaje subterane în zona de izvoare a Someșului Cald.* Bul. Speologic, 11, pp. 25–32, FRTA-CCSS., București.

GORAN C. (1981), *Catalogul sistematic al peșterilor din România.* CNEFS, 496 pp., București,

HALASI G., PONTA Gh. (1984), *Subterranean drainage in the upper part of the Sighiște l Valley (Apuseni Mountains).* Theoretical and Applied Karstology, vol. 1, pp. 239–242. București.

MANTEA Gh. (1985), *Geological studies in the upper basin of the Someșul Cald Valley and the Valea Seacă Valley region (Bihor – Vlădeasa Mountains).* An. IGG, 66, pp. 5–90, București.

ORGHIDAN T., NEGREA St., RACOVIȚĂ Gh., LASCU C. (1984), *Peșteri din România. Ghid turistic,* 454 pp. Ed. Sport-Turism, București.

RUSU T., RACOVIȚĂ G., COMAN D. (1970), *Contribution à l'étude du complexe karstique de Scărișoara.* Ann. Speol., tome 25, fasc. 2, pp. 383–408, Moulis-Ariege, France.

ŞERBAN M., COMAN D., VIEHMANN I. (1957), *Recherches spéologiques dans les Monts Apuseni*. Zvlastni otisk z cesopis Ceskoslovensky Kras, Rocnik 10, cislo 1, pp. 11—25.
STOICI S. D. (1984), *Districtul metalogenetic Băiţa Bihorului*. 189 pp. Ed. Academiei Bucureşti. vol. IV, pp. 21—58, Oradea.
VALENAŞ L. (1976), *Privire de ansamblu asupra carstului din Munţii Bihorului*. Nymphaea, vol. IV, pp. 21—58, Oradea.
VALENAŞ L. (1977), *Probleme de morfologie carstică în Groapa de la Barsa (Munţii Bihorului)*. Nymphaea, V, pp. 157—199, Oradea.
VALENAŞ L. (1984), *Studiu complex al carstului din zona Izvorul Ursului — Pîrîul Sec*. Crisia, pp. 559—580, Oradea.
VALENAŞ L., BLEAHU M., BRIJAN P., HALASI G. (1977), *Inventarul speologic al Munţilor Bihor*. Nimphaea, V, pp. 209—335, Oradea.
VIEHMANN I. (1966), *Colorările cu fluoresceină în cunoaşterea hidrografiei carstului*. Hidrotehnica, Gospodărirea apelor, Meteorologia, 11, 1, pp. 37—42, 2, pp. 92—96, Bucureşti.

Manuscript received 27 October 1989

Addresses of the authors : Iancu ORĂŞEANU — „Prospecţiuni S.A.", Str. Caransebeş 1, 78768 Bucureşti, Romania. Dr. Emilian GAŞPAR and Tudor TĂNASE. — Institutul de Fizică şi Inginerie Nucleară, 5206, Măgurele, Romania. Dr. Iuliu POP — Institutul de Învăţămînt Superior Baia Mare, Str. Dr. V. Babeş 62/A, Baia Mare, Romania.