CONTEMPORARY BED ELEVATION CHANGES FROM THE EASTERN CARPATHIANS

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Abstract: The rivers that drain the Eastern Carpathians were studied under the aspect of the contemporary modifications of the bed elevation using a data base on 60 cross sections. The determination method of the bed elevations dynamics is based on the hydrometric measurements in the pre-established sections, calculating the height of the lowest point of the bed in comparison with the reference level represented by "0" graphic of the hydrometric measuring staff. Thus, it was possible the determination of the fluvial important processes: degradation, aggradation and stability of the river beds. The observation period was comprised between 30-50 years. The dominant fluvial process in our study area is that of degradation of the river beds (over 52%), followed by aggradation (29%) and the rest was represented by river beds with a stable elevation. The mobile layer of the river bed was frequently comprised between 50-100 cm, but the degradation of the river bed registered the biggest incisions, up to 3.5 m. The causality of this phenomenon was studied in this article in which concerns the variability of the discharges that are responsible for the phenomena of scour. The long time variations of the changes of bed elevations are in relation with the changes related to the sediment supply deficit or surplus of the rivers.

Key words: bed elevation, aggradation, degradation, channel mobile bed, Eastern Carpathians

1.Introduction

The modifications of the river beds thanks to the vertical instability along the longitudinal profile have numerous negative effects, such as: putting in danger bridges, dikes, and other hydro technical constructions, evacuations of large volumes of sediments; damage produced to the aquatic and riparian ecosystems, losses of the habitation diversity, effects on the relation between river and the groundwaters, damages brought to the riparian vegetation, the growth of the risk of flooding. That is why, we proposed to outline a wider image on this phenomenon in the case of the east-Carpathian river beds, in order to better understand the changes of the relief forms in the context of the actual dynamics of the Romanian relief. Even more, in order to offer a knowledge support of the fluvial processes for supporting the defence strategies against flooding, of guides with stabilization schemes and engineering intervention.

On the basis of a long expertise in the field of fluvial geomorphology and hydrology, we are preoccupied with knowing the contemporary modifications (in the last 50-80 years since there are systematic hydrological observations on the rivers) of the beds of river, in a horizontal and vertical plan. In this paper we draw the attention on the vertical changes over the bed elevations from the Eastern Carpathians.

The modifications of the bed elevations on vertical, in a positive or negative meaning in comparison with a reference level, are a direct answer to the surplus or deficit of the solid material transported by the river. Or, it is known that the load of sediment of the river is very sensitive to any change in the nature of the control factors from the basin, natural or anthropic (Pandi et al., 2004). The output from the fluvial geomorphologic system is calibrated at the level of the control section of the river bed. In this case, all the variables from the upstream of the basin and of the bed, influence the control section, from the flow regime, frequency and amplitude of the flow phases, the areal and linear

erosion, the land use type, geomorphologic processes, the basin geomorphometry, the anthropic impact and so on.

Preoccupations related to the identification and description of these fluvial processes are not very numerous in the specialty literature, at least comparatively with the second category of fluvial processes, the horizontal migration of the river beds. In our country, there are very well known the papers of the collective led by Diaconu (1962), the first ones to use the registrations from the hydrometrical stations in order to evaluate the dynamic state of the bed elevations. An important data base was collected by ourselves during the time for the East-Carpathians river beds (Ichim, Radoane, 1990; Radoane et al., 2008 a,b,c) and in collaboration with Pandi (1991) it was carried out a data base for the north-west river beds of Romania. Subsequently, our younger colleagues (Popa- Burdulea, 2007; Canciu 2008; Persoiu, 2008; Bidilita, 2009; Mureșan, 2009) worked by the same method on the main river beds of Siret, Danube, Crisul Negru.

In exchange, the foreign literature is characterized by numerous results under this aspect, the field of recent modifications of the river beds is a central preoccupation of the specialists in the countries with oceanic and temperate oceanic climate (Richards, 1982; Castaldini, Piacente, 1995; Paige, Hickin, 2000; Winterbottom, 2000; Stover, Montgomery, 2001; Rinaldi, 2003; Amsler et al., 2005) or even Mediterranean (Liebault, Piegay, 2002; Uribelarrea et al., 2003).

In this general context, the objectives followed in the paper are the following:

a) Which is the average state of the above defined fluvial processes, at the level of the 60 analyzed hydrometric stations afferent to the rivers from the Eastern Carpathians?

b) Can the effects of some control factors in the behaviour of the river beds be identified according to the data base that we have?

c) Are there common tendencies in the evolution of the east-Carpathians river beds with the one reported in different areas from Europe?
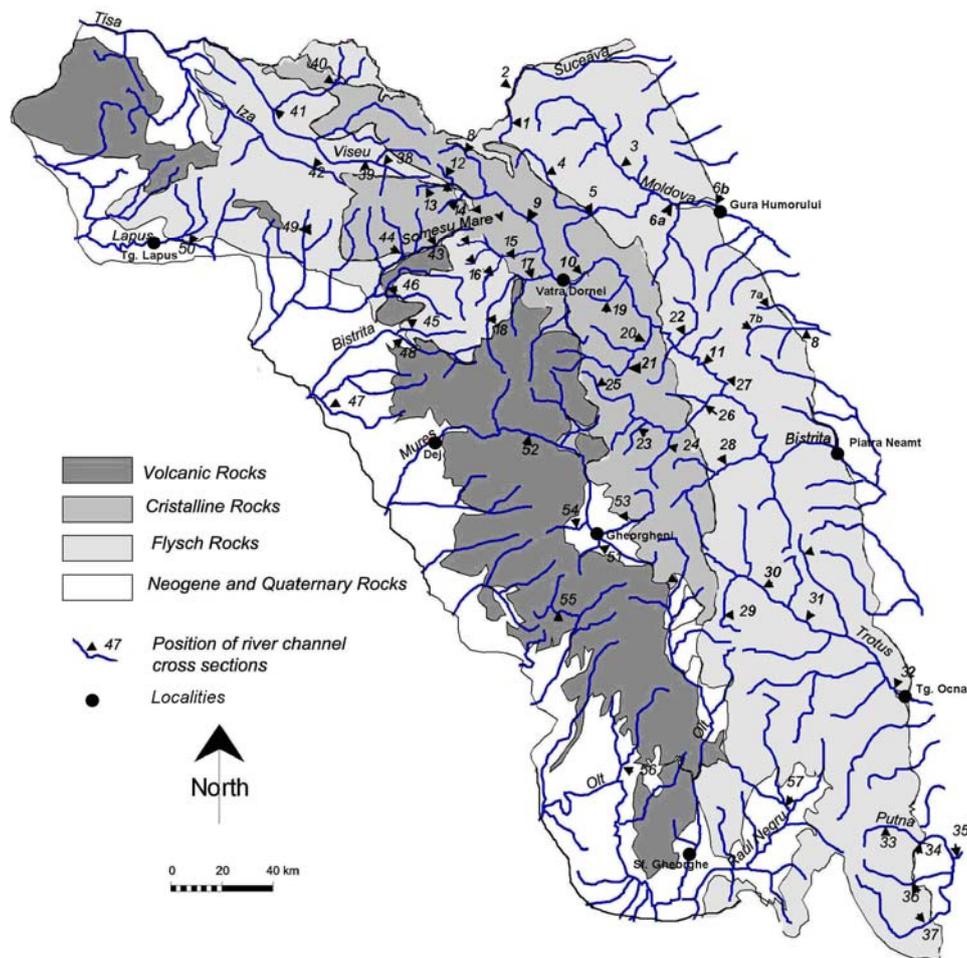

Figure 1. Localization of the study area and the sections of the hydrometric stations used in the study.

2. The study area and the work method

For the argumentation of our own observations, our research were based on the data registered at 60 hydrometric stations from the Viseu, Somes, Mures and Olt drainage basins on the western side and Siret on the eastern side of the Eastern Carpathians (Tab. 1). The raw data was obtained thanks to the kindness and courtesy "Romanian Waters" Autonomous Administration, to whom we are deeply grateful. Their processing needed a lot of time, but in the present we have outlined the first synthetic observations.

Table 1. Data on the position of the measuring sections of the river beds in the mountainous area of the Eastern Carpathians.

No.	Number on the map, fig. 1.	Drainage basin name	River	Hydrometric station	Altitude H, (m)	Drainage basin area km²	Mean annual discharge m³/s
1	38	Vişeu	Vişeu	Poiana Borşa	1268	131	3,60
2	39		Vişeu	Moisei	1215	280	6,47
3	40		Ruscova	Luhei	1188	187	5,52
4	41		Ruscova	Ruscova	1080	434	11,4
5	42	Iza	Iza	Sacel	898	68	1,39
6	43	Someş	Someş	Rodna	1118	290	5,47
7	44		Anieş	Anieş	1250	131	3,26
8	45		Straja	Mureşenii Bârgăului	997	71	0,41
9	46		Ilva	Poiana Ilvei	880	224	2,52
10	47		Şieu	Domneşti	590	151	1,14
11	48		Bistriţa	Bistriţa Bârgăului	1130	203	3,60
12	49		Sălăuţa	Romuli	939	39	0,67
13	50		Suciu	Suciu de Jos	715	223	3,64
14	51	Mureş	Mureş	Suseni	987	160	1,06
15	52		Mureş	Stânceni	967	1532	14,3
16	53		Belcina	Gheorgheni	1115	94	0,89
17	54		Remetea	Remetea	860	21	0,16
18	55		Târnava Mare	Vârşag	966	154	2,08
19	56	Olt	Olt	Tomeşti	1070	214	1,52
20	57		Caşin	Ruseni	828	482	3,10
21	58		Baraolt	Baraolt	734	221	1,57
22	1	Suceava	Suceava	Brodina	990	354	4,20
23	2		Brodina	Brodina	989	154	1,98
24	3	Moldova	Moldoviţa	Lunguleţ	977	149	2,00
25	4		Moldoviţa	Dragoşa	934	475	5,13
26	5		Moldova	F.Moldovei	1083	327	3,55
27	6		Moldova	P.Dornei		666	7,37
28	7		Moldova	Gura Humorului		1887	17,04
29	7a		Pluton	Pluton		27	0.38
30	7b		Ozana	Leghin		162	1,77
31	8	Bistriţa	Ozana	Dumbrava		390	3,07
32	9		Bistriţa	Dorna G.	1255	740	12,2
33	10		Bistriţa	Dorna Arini	1206	1656	24,7
34	11		Bistriţa	Frumosu		2901	32,00
35	12		Cârlibaba	Cârlibaba	1343	349	7,86
36	13		Tomnatic	Drăgoiasa	1408	33	0,642
37	14		Teşna	Coşna		216	2,65
38	15		Dorna	P.Stampei	1305	132	2,56
39	16		Dorna	Burcut	1378	100	
40	17		Dorna	D.Cîndreni	1138	566	7,22
41	18		Haita	Gura Haitii	1450	40	1.05
42	19		Bancu	Coşna	1185	101	1,70
43	20		Neagra	G.Negrii	1256	301	1,40
44	21		Neagra	Broşteni	1220	353	3,82
45	22		Sabasa	Sabasa	1070	84	0,923
46	23		Putna	Tulghes		173	1,324
47	24		Bistricioara	Tulgheş	1073	416	3,61
48	25		Bistricioara	Bilbor	1155	95	1,09
49	26		Bistricioara	Bistriciora		777	6,165
50	27		Bolatau	Poiana Largului		60	0,471
51	28	Trotus	Bicaz	Tasca		500	4,765
52	29		Trotus	Lunca de Sus		89	0,781
53	30		Trotus	Fagetel		331	3,487
54	31		Trotus	Goioasa		763	6,379
55	32		Trotus	Tg Ocna		1868	17,08
56	33	Putna	Putna	Lepşa	1022	143	1,828
57	34		Putna	Tulnici	990	362	4,471
58	35		Putna	Colacu	921	1100	11,802
59	36		Zăbala	Neregu	1171	143	1,828
60	37		Năruga	Herăstrău	1040	362	4,471

The localization of the hydrometric station sections is given in figure 1, the drainage network being placed on a background represented by the geological structure of the substratum. In this research phase, the information coverage degree is higher on the Suceava, Moldova, Bistrita, Trotus and Putna rivers, than the rivers from the western and southern part. As it can be noticed, the analyzed sections of river beds are controlled by drainage basins under 1000 km², the average being of 406 km², from an altitudinal point of view, these are positioned between 600 m and 1450 m. It is known that at the level of the years 1950 the hydrometrical monitoring of the Romanian rivers was standardized and modernized, so that in our study area there is a consistent base of information. Beginning with 1956-1960 at numerous stations there has been a continuity of measurements.

The method used and promoted by us in numerous works has its origin in a simple model of calculation of bed elevation in comparison with the set reference level, represented by "0" graphic of the hydrometric measuring staff. The graphic expression from figure 2 clarifies the way in which the maximum depth of the river bed can be used for obtaining the position of the bed height (that is thalweg position) at a certain moment of time. These data can be found in the standardized tables, named discharge centralizers, of which we present an extract (Tab. 2).

In the exemplified extract there are included a part of the complete measurements in the sections of the hydrometric stations in a certain day of the month for the calculation of the liquid flows, but especially for the control and adjustment of the watermark post key. The last column of the table is the one that can be used for obtaining a series of time with a uniform step of one calendar month. The monthly average value is obtained through the mediation of the 3-12 measurements, as many as carried out in a calendar month, if the measurement is made on the same transversal profile and if the river is free of ice bridge.

Table 2. An extract from the *Discharge centralizer* at a hydrometric station. The last column is added by us and exemplifies the calculation method of the bed-elevation.

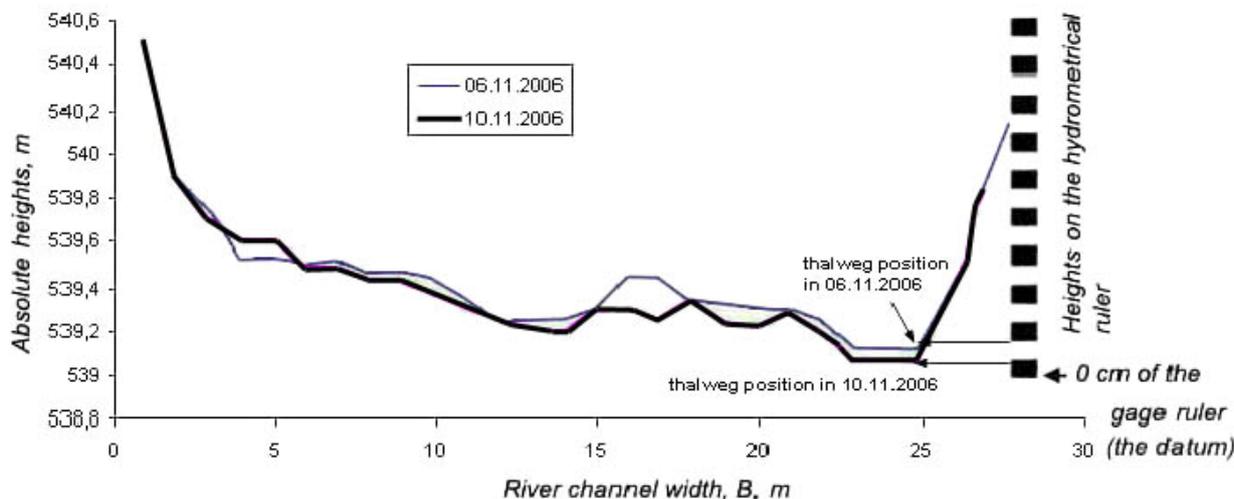| N0	Date	No. of gauge measurement profile	River state	Gauge height, H, cm	Discharge, Q, m³/s	Channel maximum depth, hmax, cm	Bed elevation, H - hmax, cm
1	9.01. 1982	1	open channel	132	0.410	20	112
2	14.01	1	"	131	0.510	20	111
3	21.01	2	bank ice	168	0.480	56	112
4	11.02	1	"	149	0.601	33	116
5	17.02	1	open channel	133	0.513	21	112
6	2.03	1	"	138	1.240	28	110
7	11.03	1	"	147	1.830	31	116
8	27.03	1	"	136	0.695	21	115
9	31.03	1	"	148	1.560	34	114
10	2.04	1	"	150	2.390	38	112

Figure 2. Presentation of the determination method of the bed elevation, using the thalweg position to "0" graphic of the gage ruler.

In this way there were obtained values of the thalweg altitude in comparison with "0" of the measuring staff, with lengths of 40-60 years and that allowed their processing in the context of series of time analysis.

In the specialty literature there are presented similar ways for obtaining the information regarding the vertical dynamics of the bed elevations. For example, the Skokomish River, Washington (a drainage basin area of 622 km^2, Q = 200 m^3/s) was investigated in the same way as we did for a period comprised between 1932-2000 (Stover and Montgomery, 2001). For the Tully River, northern Australia (A = 1475 km^2, Q = 900 m^3/s), the authors (Neil and Yu, 1999) proposed another calculation formula of the average bed elevation height and that is:

$$BE = H- (A/B)$$

where BE is the bed elevation height, H is the measured level on the hydrometric measuring staff, A is the cross-sections area, and B is the width of the river channel. The comparison of this calculation method with the one used by us showed that the series of time obtained by the Australian authors contains numerous oscillations given by the influence of the discharge, much more than this factor has effect in reality on the bed elevation.

Another problem that must be presented from the beginning is related to the terminology of the fluvial processes used in the paper. The hydraulic adjustment of the river channel sections at the action of the control factors is a complex one, but we focused on two types of fluvial processes from the level of the bed elevation whose terminology is related to the period of time in which they are produced.
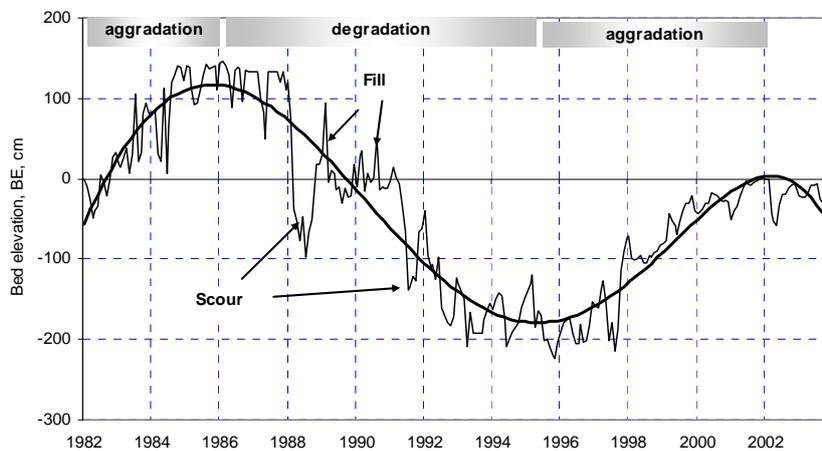

Figure 3 Graphic explanation of the terminology of the fluvial processes approached in the paper, using the registrations from the Brodina hydrometric station of the Suceava River.
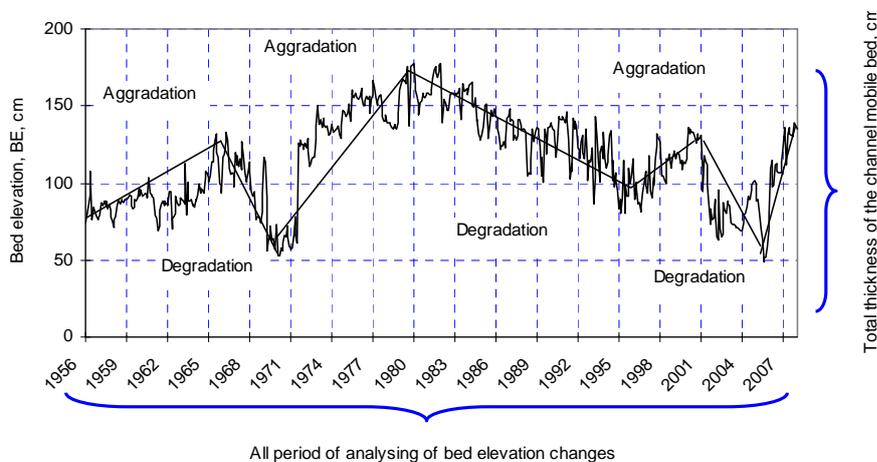

Figure 4. Model for obtaining the data base regarding the dynamics of the investigated bed elevations.

The geomorphologic processes of the sudden deepening or the sudden clogging of the river bed type (during days, hours, months, sometimes even 1 year) bears the name in *scour*, usually followed by the river bed refilling, clogging (*fill*). The two processes succeed one another in time, creating the image of some oscillations with reduced amplitude and high frequency (Fig. 3). As it will be seen, the *scour-fill* oscillations answered directly in case of flood (usually, the scour at the beginning of the flood and fill of the scour to the end of the flood).

The modifications of the bed elevation for a long period of time (years or tens of years) bears the name of *aggradation* (the rising of the bed elevation) and *degradation* (the lowering of the bed elevation) (Fig. 3). Both processes take place in much slower rhythms than the previous ones, but also phases of much higher amplitudes.

That is why, for the 60 channel sections was obtained the same number of series of time regarding the position of the bed elevation at a certain level. The information was synthesized in a centralizer table in which it was put a stress on the length of the period of observation, on the thickness of the mobile layer of the bed of river subjected to the aggradation – degradation processes, on the amplitude and length of the instability phases. The way in which all these variables were determined is exemplified in fig. 4. The database was processed with the help of statistical methods and there was obtained a series of synthetic indexes regarding the state of the bed elevations from this region.

3. The analysis of the bed elevation changes in the last decades

The database synthesized by us for the rivers that drain a good part of the Eastern Carpathians was carefully processed for extracting as much information as possible.

A first observation was related to the **period of registration of the bed changes**. In the case of the series of time it is important that the length of the analysis period of the studied phenomenon variation to be as large as possible. Regarding the phenomenon studied in this article, the obtaining of certain series of time with reasonable length and for a pretty vast area, it can be considered a real success, being known how rare the quantitative information are, regarding the vertical changes of the bed elevations. As it can be seen from the histogram built according to the data that we have (Fig. 5), the modal class of the observations period regarding the dynamics in a vertical plan of the Eastern Carpathians beds is comprised between 30-40 years.
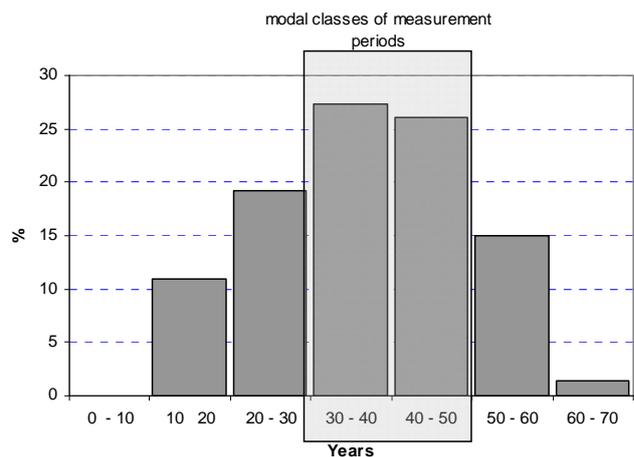

Figure 5. The histogram of the analysis period of the bed processes in the Eastern Carpathians.

An important value is also given to the class comprised between 40 and 50 years. It can be appreciated that more than 50% from the river sections studied by us are analyzed on the basis of some long registration of over 30 years. It is interesting to show that the arithmetic mean is placed around the value of 30 years, or, this fact opens an encouraging perspective over the consistency o the work conclusions.

The next observation on which we have focused is related to **the dominant channel bed process** in our study area. The obtained series of time allowed us to extract a global tendency regarding the general state of the bed elevations in the terms of the three dominant fluvial processes: **stability** (in case the vertical oscillations of the bed elevations are under 50 cm); **aggradation** (in case for the observation period taken into consideration, the oscillation of the bed elevation tends to increase, no matter the carried out altitudinal distance). **degradation** (in case for the observation period taken into consideration, the oscillation of the bed elevation tends to descrease, no matter the carried out altitudinal distance). The result of the frequency calculations over the three types of fluvial processes is presented in figure 6, of which we retain the fact that the **degradation tendency**, of deepening the river channels is the most well known fluvial process in the study area.

It is not surprising this observation, it is included in the reports of the majority of researchers, worldwide and not only. For example, for the rivers from the Tuscany region the generalized degradation of the beds in the last decades was over 4 m (Rinaldi, 2003); for the small rivers in southern France, an analysis on the basis of the cores extracted from the trees grown on the surface

adjacent to the river channels, led to a narrowing and deepening tendency of the river channels for the last one hundred years (Liebault, Piegay, 2002). The same situation in Spain, on the Gualdalkivir, Tagus and Jarama rivers, the beds deepening reached up to 9 m in the last 500 years (Uribelarrea et al. 2003). For the rivers from the Polish Carpathians it was set an average deepening between 1.3 m and 3.8 m in the last century (Wyzga, 2008). Even in Romania, on large rivers like Siret or Prut, it was observed a degradation tendency in the last 30-40 years. (Radoane et al., 2008 a,b,c) as also for the Danube (Bondar, 2001; Canciu, 2008), a cause invoked as being of anthropic nature.
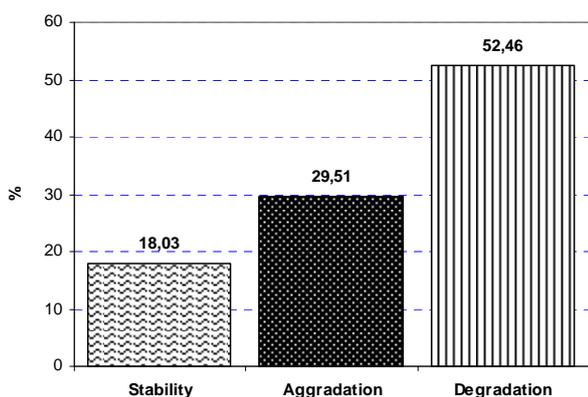
Figure 6. The importance of the fluvial processes in the river beds from the Eastern Carpathians

Further on, we were interested in the evaluation of **the thickness of the mobile layer of the bed elevation**, that material that in a certain period of time is accumulated or removed by the fluvial processes. The thickness of the layer was measured according to the model presented in fig. 4.

It was determined a thickness of the mobile layer of the bed elevation for the whole period of observation and, distinctly, a thickness of the mobile layer for the aggradation phase and another one for the degradation phase of the bed. The analysis of the results is better highlighted in the graphic representation from figure 7.

In this way, for the whole period of observation, the mobile layer under 50 cm has the highest frequency, the frequency being higher during the degradation (of almost 60%). The mobile gravel layer between 50 and 100 cm thickness is carried out with a comparable frequency during the bed degradation and also during the aggradation (around 34%). The largest mobile gravel thicknesses in the bed elevation of over 1 m up to a maximum of 3.5 m are rarely seen and only during the beds' degradation. This last phenomenon was registered at Viseu (Moisei), Iza (Sacel), Moldova (Gura Humorului), Pluton (the Ozana basin), Trotus (Tg. Ocna), Putna (Tulnici) and others.

In conclusion, the average thickness of the mobile layer of the beds of river in the studied area is comprised between 50-100 cm at aggradation and between 100-150 cm at degradation. Thus, the greatest weight of the degradation process of the beds is manifested not only through frequency (Fig. 6), but also through the thickness of the alluviums layer removed through the erosion in depth.

4. Relation between the bed-elevation changes and discharge

It is very well known that the discharge represents the main active force for the river bed modelling.
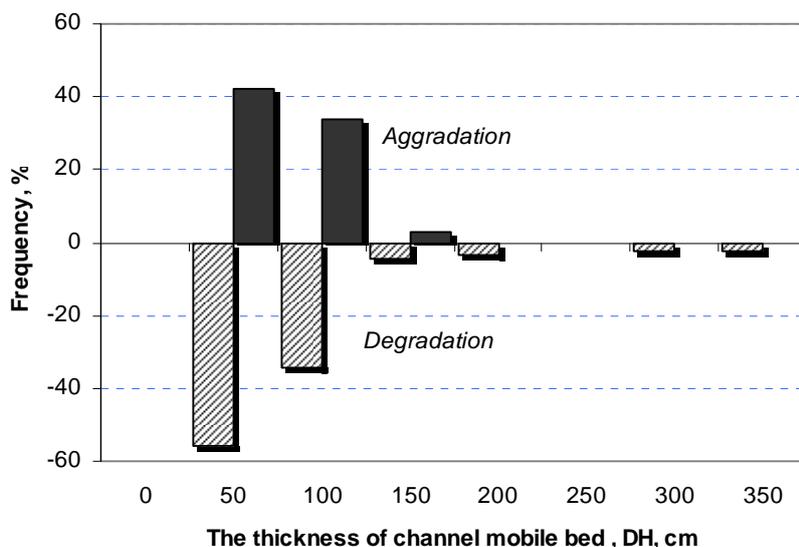

Figure 7. The frequency of the bed processes on different classes of the mobile bed thickness.

On this basis, we can issue the observation that the vertical changes of the bed elevations are controlled by the variations of the discharge that crosses the river section. In the easiest way the relation would be like that: a large discharge, a flood, determine a strong erosion, a deepening of the bed elevation, and a low discharge should favour the materials accumulation in the bed elevation, so the aggradation. Or, in reality the situation is not that simple. Each river bed section was studied in detail and under this aspect in order to identify the relation between the two variables. It was chosen for exemplification the Brodina hydrometric station of the Suceava River, representative for the mountainous river beds, with a rocky bed, so a great rugosity of the bed elevation (Fig. 8). A second section selected for the presentation was Goioasa, on the Trotus River and is characterized by a bed with bedrock bed (Fig. 9).

The series of time of the bed elevation height was superposed on the series of time of the discharges. The careful observation of the variations of the two processes of which one we suppose is the cause (*Q*), and the second one is the effect (*BE*) confirm this state for the short phases of scour type or hydraulic fill. There graphically marked the moments when great floods took place, such as in 1969, 1970, 1975 or 2005, 2006. Each time the bed elevation reacted through the sudden deepening and sometimes it came back to the previous position after a few months. Other times the bed elevation managed to remodel the removed layer of alluviums material, only after a few years or even at all during the period of our observations.

The behaviours of the Suceava River bed at Brodina is suggestive in this meaning: after the historical floods from 1969-1970 the bed elevation deepens with almost 1 m, in the next 6-7 years it manages to remodel the mobile layer of alluvium material through aggradation, after which it takes place a new negative leap to smaller size floods than the previous ones. The regeneration of the alluvium
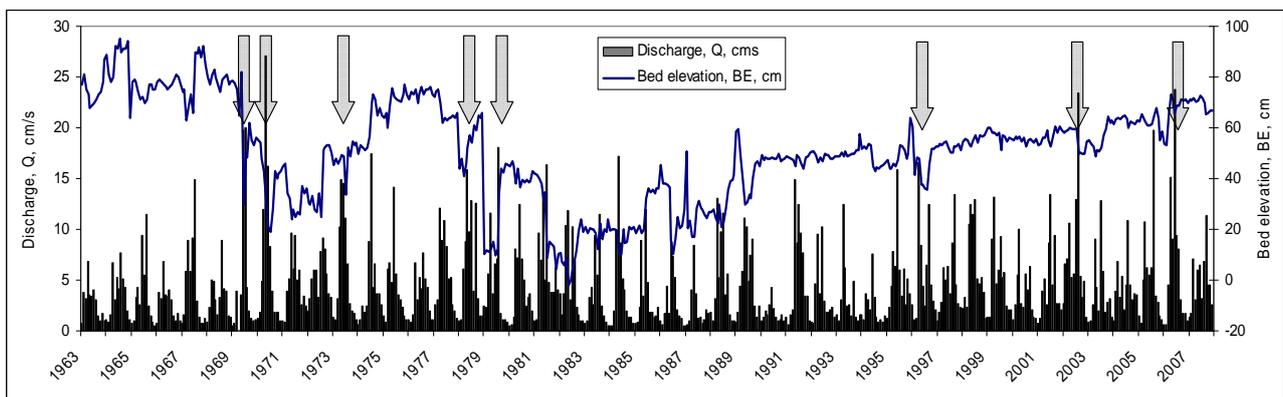

Figure 8. Temporal changes in mean bed elevation superimposed on peak discharge values for the Suceava River, Brodina gage station.
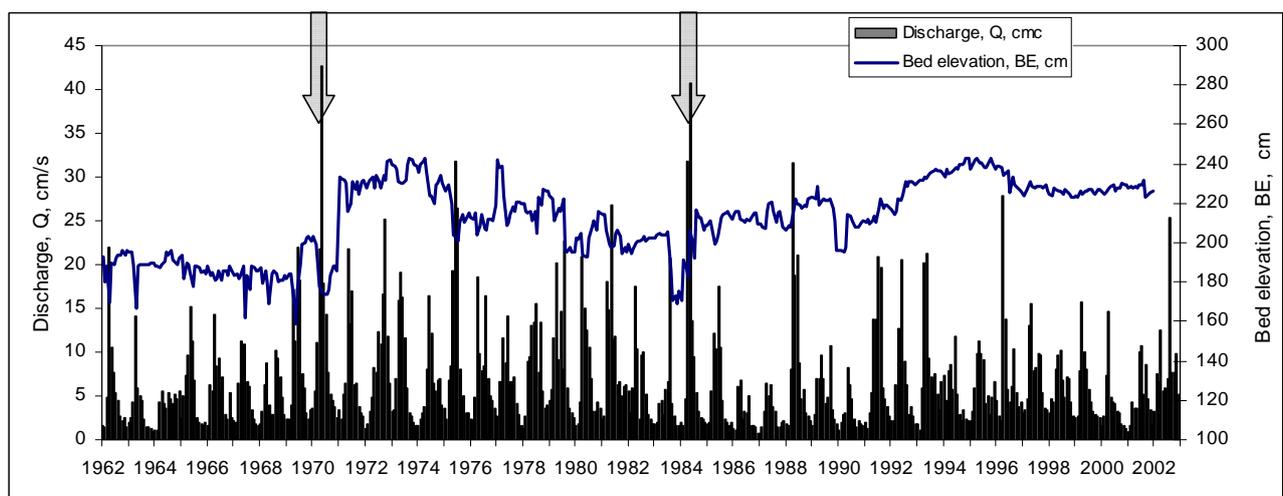

Figure 9. Temporal changes in mean bed elevation superimposed on peak discharge values for the Trotus River, Goioasa gage station.

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layer through aggradation it developed, this time, in a much longer period of time, of over 20 years, a tendency that is also manifested in the present, despite a series of big floods as were those in 2003, 2005 and 2006.The river bed section of Goioasa of the Trotus river (Fig. 9) manifests an aggradation tendency during the whole monitoring period, between 1962 and 2002. The two big floods that took place in 1970 and 1985 din not manage to break this general tendency of aggradation, but only for a short period of time they created some phases of hydraulic scour, after which the bed elevation came back with even a greater force through the regeneration of the bed material.

To both exemplified hydrometric stations (Figs. 8, 9), the observation being valid for all the studied sections of beds in this article, the strong seasonality from the level of the discharge in the bed is not broken and over the vertical change of the bed elevation. Exception make the small oscillations of scour –and- fill type. In rest, the bed elevation responds to other mechanisms.

In this way it is applied the extremely low correlation degree between the height of the bed elevation and the size of the discharge, exemplified for the two sections of the Suceava and Trotus Rivers (Figs. 10 and 11). Even though the researcher's common sense says that no change in the bed elevation can take place without taking into consideration the force that carries out this movement, respectively, the water flow that crosses the bed section at a certain moment, the obtained relation, of cause – effect type misses sensitivity and probability.
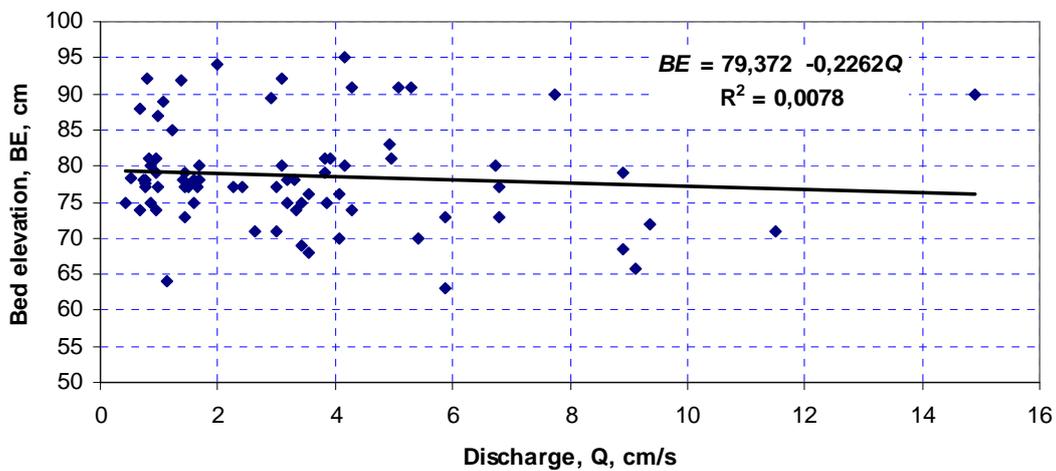

Figure10. Relation between the height of the river bed (BE) and the size of the liquid flow (Q) at the Brodina hydrometric station, the Suceava River.
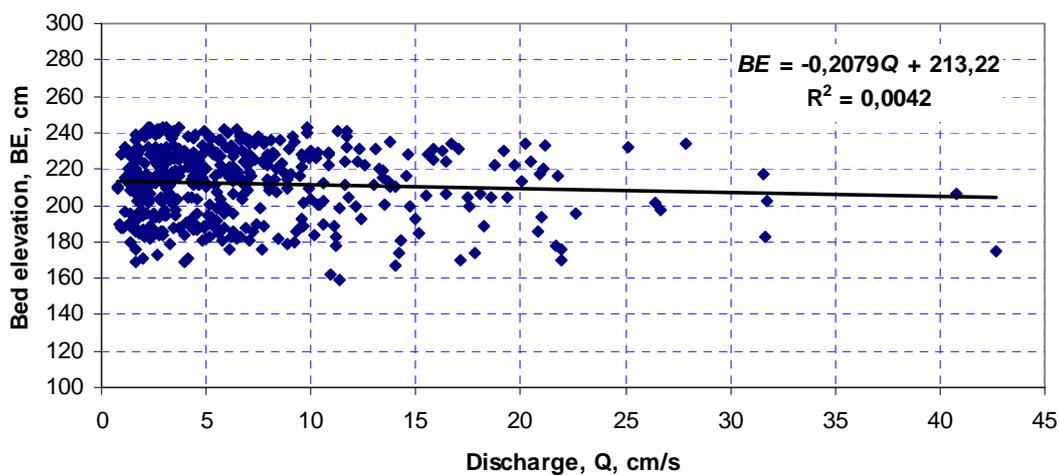

Figure 11. Relation between the height of the river bed (BE) and the size of the liquid flow (Q) at the Goioasa hydrometric station, the Trotus River.

On the whole, the relation is negative, meaning that as the discharges grow, the bed elevation tends to deepen, but the large degree of spreading the points and the very low inclination of the regression line do not give us the right to consider a strong relation between the two variables (Fig. 10 and Fig. 11). The motivation of this situation results from the fact that appear many other variables: floods succession and frequency, the difference between floods and big waters, the suspended sediment flows, the nature of the river bed, the evolution state of the longitudinal profile. It can not be contested the fact that the discharge and the load of the water with sediments determines the river beds regradation, in tight concordance with the river bed pavement.

The explanation, as it results from the variation of the series of time (Fig. 8 and Fig. 9) is related to the behavior of the solid load of the river and ruggedness of the bed elevation that determines a change of the bed elevation behavior, that is hard to predict for a long period of time. It is strongly verified the hypothesis expressed as part of the paper introduction, that the changes of the vertical bed elevation, in a negative or positive meaning in a comparison with a reference level, are a direct answer **of the surplus or deficit of solid material transported** by the river and secondarily thanks to the size of the discharge. The suspended load of the river is very sensitive to any change that takes place in the drainage basin from upstream, especially those of human nature.

For the studied area, in this phase of research, we have no representative data base regarding the solid load and that we can use in order to explain in details the behavior of the bed elevation in each considered section. And not even in which concerns the role of the other above mentioned factors, meaning: the frequency and succession of the floods, the differentiation between floods and big waters, the nature of the bed elevation, the evolution state of the longitudinal profile, etc. It is a vast problem that will remain open for the future research.
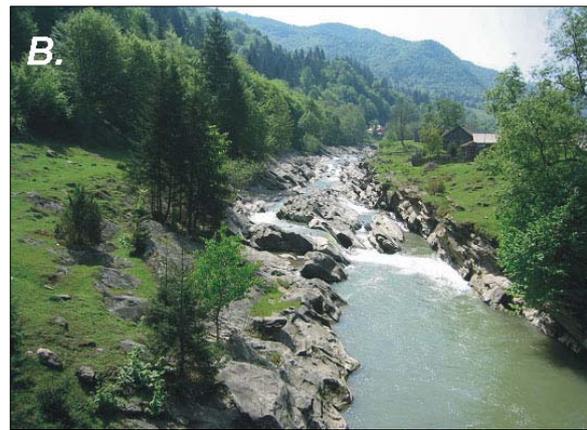

Figure 12. Illustration on the mountain river bed behaviour at the certain fluvial processes: degradation, Somes River at headwaters (piers are digged out about 1 m) (A); Tarcau River bed in bedrock (B); Borsa River at Borsa gage station, bed degradation (C); Bistrita river channel aggradation upstream of Izvoru Muntelui Reservoir (D) (foto N. Rădoane A,B and D; foto G. Pandi C).

5. CONCLUSIONS

The analysis of the bed processes as series of time for the 60 transversal sections of the hydrometric stations from an area representative for the Romanian Carpathians highlighted the fact that there is no standard model of evolution that to be followed by all the minor beds. Even if the investigated river beds have a rugged bed, formed by boulder and gravel, they are located at altitudes between 600 m and 1500 m, and the basins of these rivers drain only the mountainous area, their behavior registering a large variety of evolutions regarding the vertical change of the bed elevation (Fig. 12). That is why, only an approach on the basis of statistic methods made possible the extraction of some common features.

In this way, the fluvial process that characterizes 52% of the cases is the **degradation**, the deepening of the bed elevation in phases that can last 4-8 years, the most frequent, and rarely, the degradation characterized a continuous phase of 24 years (for example, the Trotus river in the Fagetel section). In comparison with other research on the river beds from the Polish Carpathians (Korpak, 2007; Wyzga, 2008), from the south-eastern mountainous area of France (Liebault, Piegay, 2002), from Italy (Rinaldi, 2003) where there is reported a tendency of deepening and narrowing of the common river beds for all the rivers, in the case studied by us, there also appears a tendency of **aggradation** of the river beds, even though with a percentage of 29%. Not even this process was registered continuously in the case of a river bed during the 30-50 years of observations, but it was instituted as aggradation phases with period of 4-8 years, the most frequent. The thickness of the bed material layer that was removed by erosion in depth reached a maximum of 3.5 m in the Ozana basin, 3 m in the Putna vranceana basin, under 3 m in the Trotus basin. In rest, the most frequent value of depth was comprised between 0.5 m-1.5 m. In which concerns the river bed aggradation, the regeneration of the alluvium layer in period of 4-8 years, this one reached thicknesses of 0.5-1m and rarely exceeded 1 m.

In the case of researches on the European rivers, the aggradation process is reported as a common state of the rivers in the time of the Small Glaciation (XVI-XIX centuries), and after that in the XXth century, the incision of the river beds became dominant thanks to the numerous works of damming and embanking of the rivers and extraction of large quantities of minerals from the river beds.

The third state of the bed elevation variability is stability, when the vertical oscillations exceed 50 cm, and the formed series of time does not present any kind of tendency, the amount of oscillations for the observation period being zero. Although, in most of the geomorphologic studies it is considered that the rivers beds in the mountainous area are stable, the measurements showed that only 18% of the cases studied by us were included in this category.

The presence of the three fluvial processes in the case of the same river beds section with alternative manifestations in the observation period it is explained by the characteristic movement of the solid load under the form of waves or pulsations that spread downstream (Radoane, Ichim, Pandi, 1991; Paige, Hickin, 2000). The necessary time for such a solid load wave (deduced form the big oscillations of the bed elevations) to cross a certain point towards upstream is comprised between 4-8 years in the present case But related to this phenomenon our plan is to approach it in another paper on the basis of a new set of data in order to avoid launching ourselves in speculations without coverage.

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