THE RESERVOIRS SILTING IN ROMANIA

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Key words: sediment sources, reservoirs, silting process, Romania

Reservoirs silting from Romania. Romania ranks among countries with the greatest achievements in the field of dams in the world. Among the 80 membership countries of the ICOLD, Romania ranks the 19^{th} as regards of „large dams" (246) and the 9^{th} in Europe. The reservoirs arranged behind dams are characterised by small capacities, generally, under 200 mil. mc. In this paper we try a knowledge about the silting rate of the Romania's reservoirs related to the morphodynamic conditions of the drainage basins. The total erosion rate from Romania's territory is, on the average, 125 mil. t/year out of which 45-50 mil. t/year are transferred by rivers. About 1,550 kg/s of sediments are removed from Romania's territory meaning a specific sediment yield ratio of 206 t/km^2/year. There are areas where the sediment yield is about 2500 t/km^2/year only the suspended sediments (i.e. Sub Carpathians of the Bend and Getic Piedmont) and areas where the sediment yield is of under 10 t/km^2/year (i.e. Carpathian area covered of the crystalline rocks). We analyzed 138 reservoirs with initial volumes between 1 x 10^6 m^3 and 1,230 x 10^6 m^3 for which there is a determination of the silting time. The reservoir's silting from the Romania is characterized so: *very serious* for a number of 15 reservoirs with an average volume of 8 mil. mc, situated in the area of high sediment yield (over 500 t/km^2/year) with a silting time ranks between 2 to 10 years; *serious* for a number of 30 reservoirs, with the volumes under 35 mil. mc, and the silting time between 10 to 50 years. These reservoirs are situated in area of over 250 t/km^2/year, many of them being arranged as a cascade of small reservoirs on the main rivers; difficult for 13 reservoirs for which the silting time is of under 100 years and, as rule, are situated in the area of 200 t/km^2/year.

INTRODUCTION

The dams and reservoirs created behind them have represented a domain of interest for geomorphology, especially for its dynamic branch, because it has been stated that such anthropic structures cause irreversible changes in the dynamics of the fluvial systems. The issue has been debated upon in a series of works and PhD thesis, especially by the research team from "Stejarul" Research Station from Piatra Neamț, but also by researchers from other domains of activity. The arguments brought forward deal especially with the fact that nowadays the large dams of the world with their hydrographic systems have been in most of their part and some of them totally controlled by dams with their reservoirs, with a water volume of 5-6 times the average discharge of all the rivers in the world, estimated at almost 1250 km^3/s (Ichim, Rădoane, 1986).The arrangement of transversal dam work introduced great discontinuities in the transportation of sediments, in the evolution of riverbeds and the adjoining slopes, which in geological time are controlled with a very reduced rate of manifestation by the tectonic movements and the variations of the general base level. As for the development in space and the duration of manifestation of the influence of such anthropic structures, William and Wolman (1984) have estimated on the basis of the analysis of an important number of cases, that on the big rivers course the distance may be of hundred km, and the duration of thousand years degree. Or, as we shall see, such structures are to be found also in Romania having a total volume of almost 13 thousand millions m^3 (1/3 of the entire volume of water carried in one year by the interior rivers (Jelev, 1992). Moreover, they are accompanied by the dislocation important amounts of rocks, by terrigenous materials, which, only between 1950-1990, in the context of hydropower arrangement have totalized 500 mil. m^3 embankment, 771 km of dams, 33 mil. m^3 of surface concrete, 12 mil. m^3 of underground excavations on 669 km drifts.

This work refers only to one of the processes that reservoirs undergo once they are placed in a river system – the silting. More precisely, we try to make a synthesis of the knowledge stage of the dam lakes silting in Romania that we want to approach on the basis of the relations with our territory morphodynamics and considering the substantial accumulations of new data. The factual material that we have is structured as follows: a)the construction of dams and the arrangement of reservoirs in Romania; b)the problem of sediments sources; c)the silting of reservoirs

THE CONSTRUCTION OF DAMS AND THE ARRANGEMENT OF RESERVOIRS IN ROMANIA

Romania is known as a country where the tradition of dam construction and of the arrangement of lakes is very old. There are mentioned Saard and Cristurul Pool near Turda, attested even from the XIIth century, and the oldest reservoir dating as early as 1780, whose dam, of 23 meters high, after several repairs is still functionable. It is about Tăutu Mare reservoir from Metaliferi Mountains built for the gold mines (Popovici, 2000). Since the XVth century in Romania a big interest has been shown for the arrangement of the rivers with small accretion and water falls. There are documents that certify pools as early as 1448, and in Braşov area, according to some historical documents, between 1503-1550 there were 28 pools. In another old document, Moldova was described as ” rich in pools”, some of them probably existing at least from the period of Ştefan cel Mare (the reservoirs Hârlău, Belceşti, Şipote, Dinischean), and other ones arranged later, especially during Alexandru Lăpuşneanu and Vasile Lupu’s reigns. Moreover, in Vasile Lupu’s period Dracşani Pool was enlarged, and it is still considered to be one of the largest pools in Romania (S = 486 ha, Tv = 5,5 mil. m^3).

The modern and contemporary period marked in Romania an increasing interest in the arrangement of water falls for hydropower purposes. So that, at the end of the XIXth century the first hydroelectric power stations were built on Dâmbovița, in Bucharest (1890) and on Sadu, near Sibiu (1896), without having too much water accumulation. The ample study about the hydropower reserves, of the brilliant scientist D. Pavel (1933) may be considered the first synthesis on arrangement conditions of dams and on dam reservoirs in Romania. Until 1940, 128 hydropower plants were built but the water accumulations were not so important. Starting from the ’60, the rhythm of arranging reservoirs became faster, culminating between 1980-1990, when a number of 78 reservoirs were put into operation.

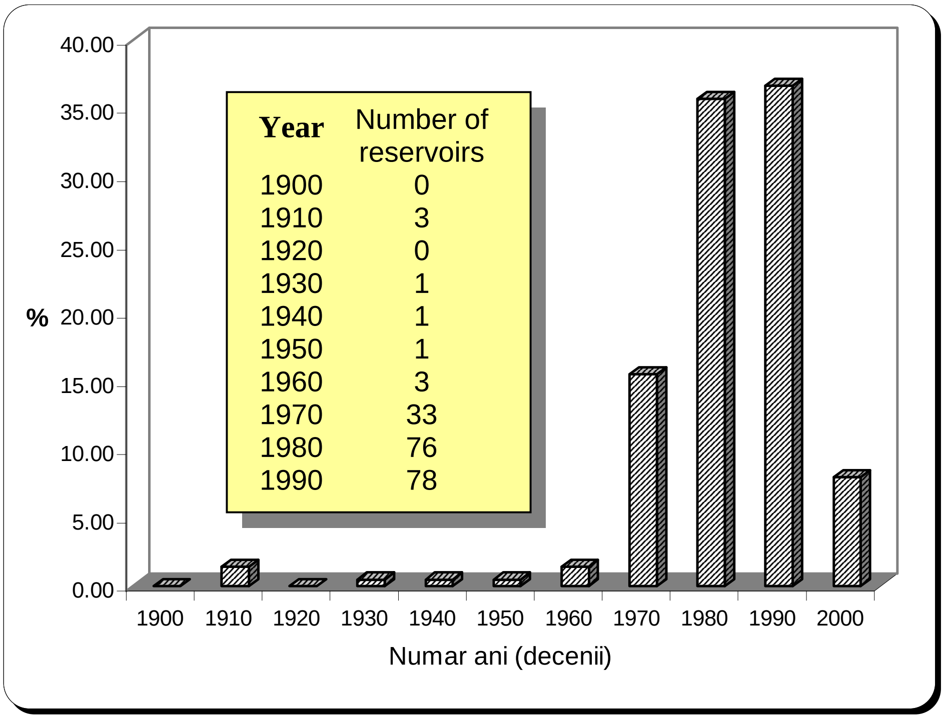

Fig. 1 The rhythm of dams construction in Romania in the XXth century (data offered by the Romanian Committee of the Big Dams, 2000).

After this period a severe decline of dam constructions was registered, between 1991-2000, when only 17 dams from those which had already been started were finished. Otherwise, this dynamics is also graphically illustrated (fig.1), which indicate the rhythm of dam construction in Romania in the XXth century, after the official data published by the Romanian Committee for the Big Dams (2000. At present, the data indicate that Romania is among the countries with the greatest achievements in the world regarding dams, which allowed also technology export (Algiers, Iran, Turkey). Among the 80 countries members of the International Committee of the Big Dams, Romania occupies the 19th place concerning the number of ”big dams” (considered over 15 m height) and the 9th place in Europe. The total number of the big dams is therefore 246, among which almost half are dams under 40 m height. The highest dam is Gura Apelor, on Râul Mare, in Retezat Mountains and it is 168 m. We can add to these another 1500 dams, under 15 m height, the reservoirs having capacities under 1 million m^3.

As a conclusion, we can estimate that the anthropic intervention through the arranging of dams and reservoirs, in the river systems of Romania’s territory, is significant and justifies the concern of the geomorphologists to know the relations between the dynamics of the landscape and the behaviour of these anthropic structures.

THE SEDIMENT SOURCES

The position in a temperate-continental climate and the presence of the Carpathians is defining for the distribution and the system of the geomorphologic process, generating sediments and which expresses, finally, the morphodynamic specific of a territory. This is also the reason why a great importance was given to the problem of sediments flowing on Romania’s rivers, as an indirect expression of the dynamic state of the landscape. Beginning with the main work of Diaconu (1971), we had, for the first time, a global image of the susceptibility to erosion of our country’s territory, of an overwhelming importance for time predictions about dam reservoir silting. Two thesis concerning a general perspective over the dynamic of the Romanian relief have been subsequently elaborated. The first one, written by Moțoc (1984), proposes a general image over the whole territory of Romania, reffering to sediments effluence in comparison with the major types of morphogenetic processes and the main unities of our country landscape It is a pioneer work as far as Romania is concerned. The other synthesis was published by Mociornița and Brateş (1987), who have updated the outflow map after 1970-1980, when most of our rivers reached the maximum liquid flow with 1% or even 0.1% protection rate. It is a work that relies on the entire data base resulted from the national measurement network, over a more than 35 years period. Other updated syntheses have not been known after this date, but for reeditions and interpretations of the above mentioned works, such as, for example, the one from Unesco volume, edited by Zăvoianu, Walling, Şerban (1999), and entitled *Vegetation, land use and erosion processes.*

As far as we are concerned, on the general context concerning the sediments sources problems a new synthesis has been given (unfortunately it hasn't been realised for the entire territory of Romania, but a large part has been treated), on the account of an updated data base. Our approach focuses on the definition of the sediments sources such as: a) *source area* related to the slope basin or riverbeds and with the land use (agricultural, forest, buildings, mining etc) and b) *in comparison to the generating processes*, namely, those that make transition to and into the riverbeds of sediments.

The processing of a large amount of data obtained from various sources (measurements in hydrometric cross-section from the national network ensured by the *Romanian Waters* Administration, indirect estimations on the account of sediment stock from some reservoirs, personal measurements on small basins) has led us to the selection of two control factors as criteria of sediments sources analysis for a large territory, such as Romania. They are: **the lithological composition** of the rocks generator sublayer and **the size of the drainage basins** which provide a selection of the amount of the sediments conveyed from the origin area to the discharging area. The choice of these two factors is also motivated by arguments acquired on the account of the speciality literature analysis (that is authors who have suggested prognosis models of the sediments production such as: Gregory and Walling, 1976; Burns, 1978; Janson, 1982; Zachar, 1982; De Villiers, 1985; Yiu Guo Kang, 1985 etc), but also on the account of personal experiences (the model of multiple regression for the estimation of the sediments production in hydrographic basins with a 400 sq.km (Ichim and Rădoane, 1987).

Our proposal focused on the acquiring some predictive equations of sediments production for Romania in which the two controlling factors (the **lithologic substratum** and the **size of the drainage basins**) should be considered independent variables. The data base which we had at our disposal refers to 212 cross sections, controlled by basins varying from 0,17 km^2 to over 10 000 km^2, for 13 areas from our country, lithologically and geomorphologically different. The data processing consisted of many stages which have ultimately led to the equations listed in the table 1. These relations are rendered in figure 2, from which we can easily infer that for the Romania's territory there is a pretty big variability of sediments generating in different areas of the country. These equations are power functions, and their parameters (mainly *a* and *b* regression coefficients) can be used in subsequent classification analysis.

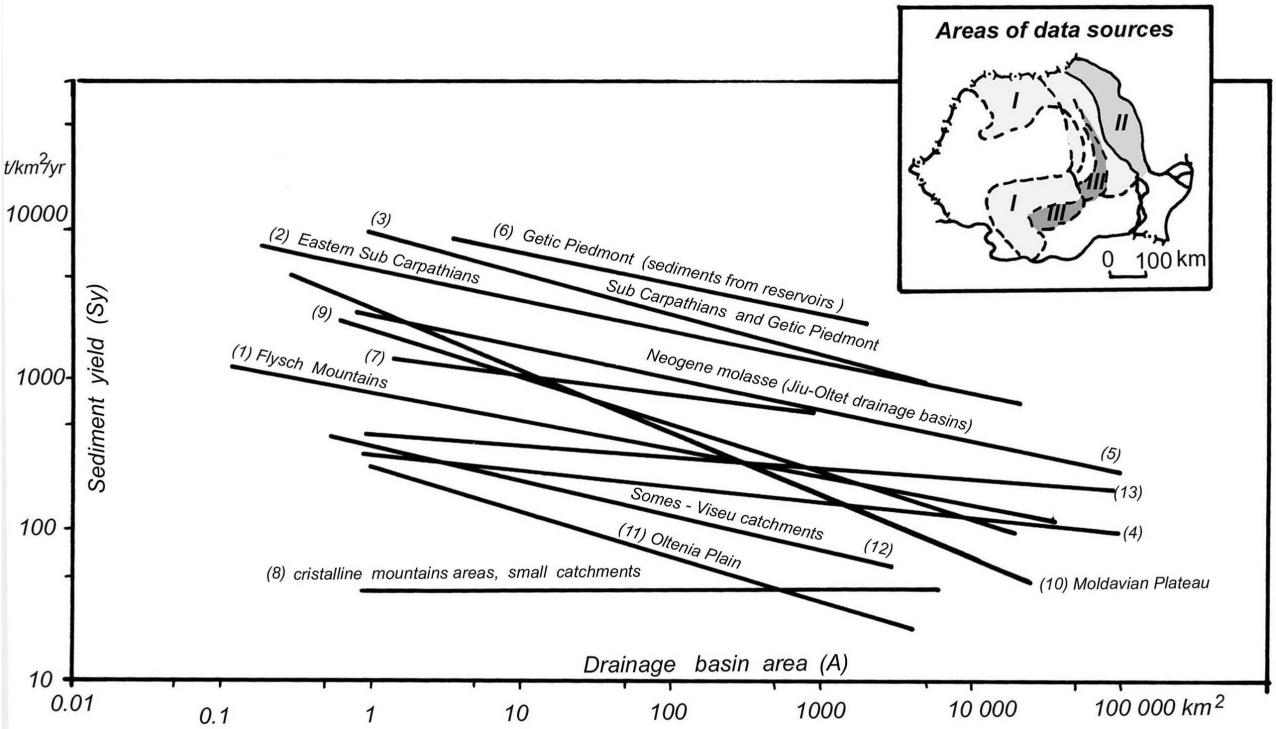

Fig. 2. Relationships between the sediment yields and the drainage basin areas for different morpholithological conditions of the Romania (numbers have a correspondance with the table 1)

a regression coefficient has values from 42.861 to 10 006.4. Its meaning in the relation is that it is closely connected to the actual conditions for which the function was created (mainly morpholithological in our case). From this point of view *a* regression coefficient can be used in cluster classification analysis.

b regression coefficient denotes the inclination degree of the slope regression line. In our case it varies between –0.0072 when the regression line is almost horizontal and –0.4316 when the line is more inclined, therefore there is a higher sensitivity. The other statistical tests have helped us to accept or refuse the predicative significance of the equations, some of theme being less sensitive then the others.

Table 1. The centralization of the relations between the specific sediments production and the reception basins surface for various morphological conditions in Romania (*SY* = sediment yield; *A* = drainage basin area).

Description of the area	Statistic parameters of $SY = a A^b$ relations				No. of obs. (*n*)
	a	*b*	*r*	R^2	
(1) The flysch mountain area (the Eastern Carpathians)	738.48	-0.167	0.799	0.639	49
(2) The Neogene molasse area (the Eastern Sub-Carpathians)	5677.47	0.220	0.904	0.817	35
(3) The Neogene molasse and Quaternary deposits area (Sub-Carpathians and Getic Piedmont)	9367.43	-0.277	0.647	0.419	11
(4) The crystalline mountains area (Jiu)	320.40	-0.103	0.364	0.133	12

-mining influences-					
(5) The Neogene molasse area (Jiu-Olteţ)	2094.93	-0.175	0.879	0.772	18
(6) The Getic Piemont(on the basis of lake sediments)*	10006.40	-0.194	0.336	0.113	6
(7) The crystalline mountains area (on the basis of lake sediments)*	1450.82	-0.124	0.746	0.557	4
(8) Small basins in the crystalline mountains area*	42.86	-0.007	0.451	0.203	8
(9) Moldavian Plateau (Bârlad)	2203.00	-0.318	0.670	0.449	15
(10) Moldavian Plateau, the Plain of Moldova (Jijia)	3217.98	-0.432	0.362	0.131	13
(11) The Plain of Oltenia	268.27	-0.284	0.511	0.261	12
(12) The crystalline and volcanic mountains area (Someş-Vişeu)	361.16	-0.224	0.491	0.241	12
(13) The region of the internal flysch (Someş-Vişeu)	435.25	-0.073	0.212	0.045	17

* the bedload was take in calculation

Cluster Analysis was applied in order to find the best groups among the great number of studied data on the basis of which we should realise a territory regionalization with a similar power of generating sediments. With that end in view. we used the regression coefficient ***a***, whose variation synthesizes the complexity of the morphological and morphodynamic conditions in a certain area. The clusters were fixed by calculating the variance-within-the-groups and the variance-among-groups, according to the methodology described by Johnston (1980). The graphic result is rendered in figure 3 where it is observed that the coefficients tend to group into three clusters.

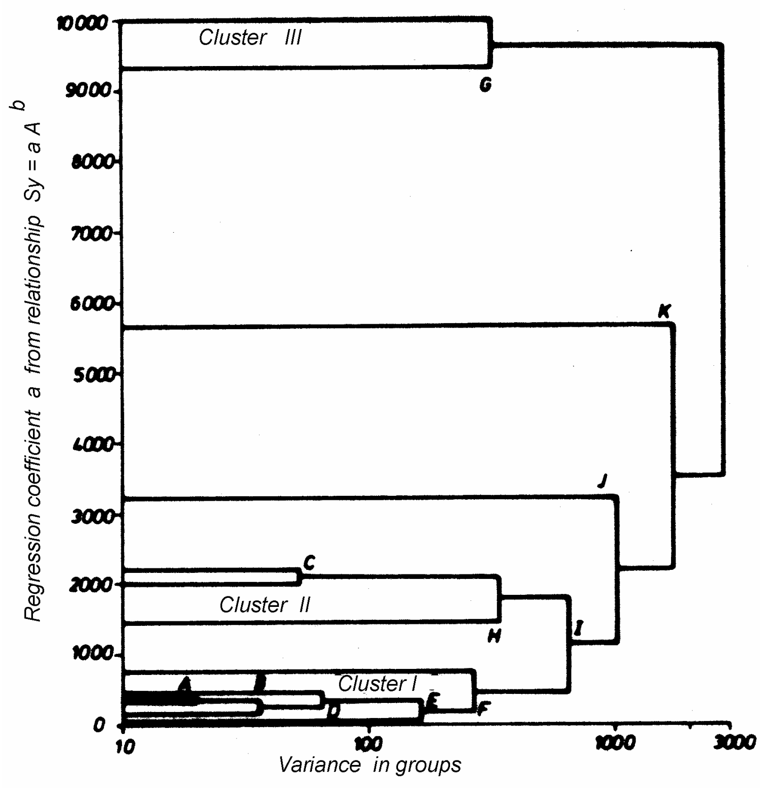

Fig. 3. Cluster analysis on the *a* regression coefficients from the relationships *Sy* = f (*A*) for the morpholithological conditions of Romania.

Cluster I brings together most of the coefficients (in which 4 groups have been concentrated) and characterizes the zones with sediments production of under 700 t/km^2/year. These zones include most of the regions in our country: Moldova Plain, Oltenia Plain, the area of the internal and external flysch, the crystalline zone and volcanic mountains.

Cluster II is made up of 2 subgroups and characterizes the zones with sediments productions of about 2000 t/km^2/year, mainly, Moldavian Plateau and Getic Plateau.

Cluster III characterizes the exceptional sediments productions registered by some small basins in the Bend Subcarpathians and the Getic Piedmont.

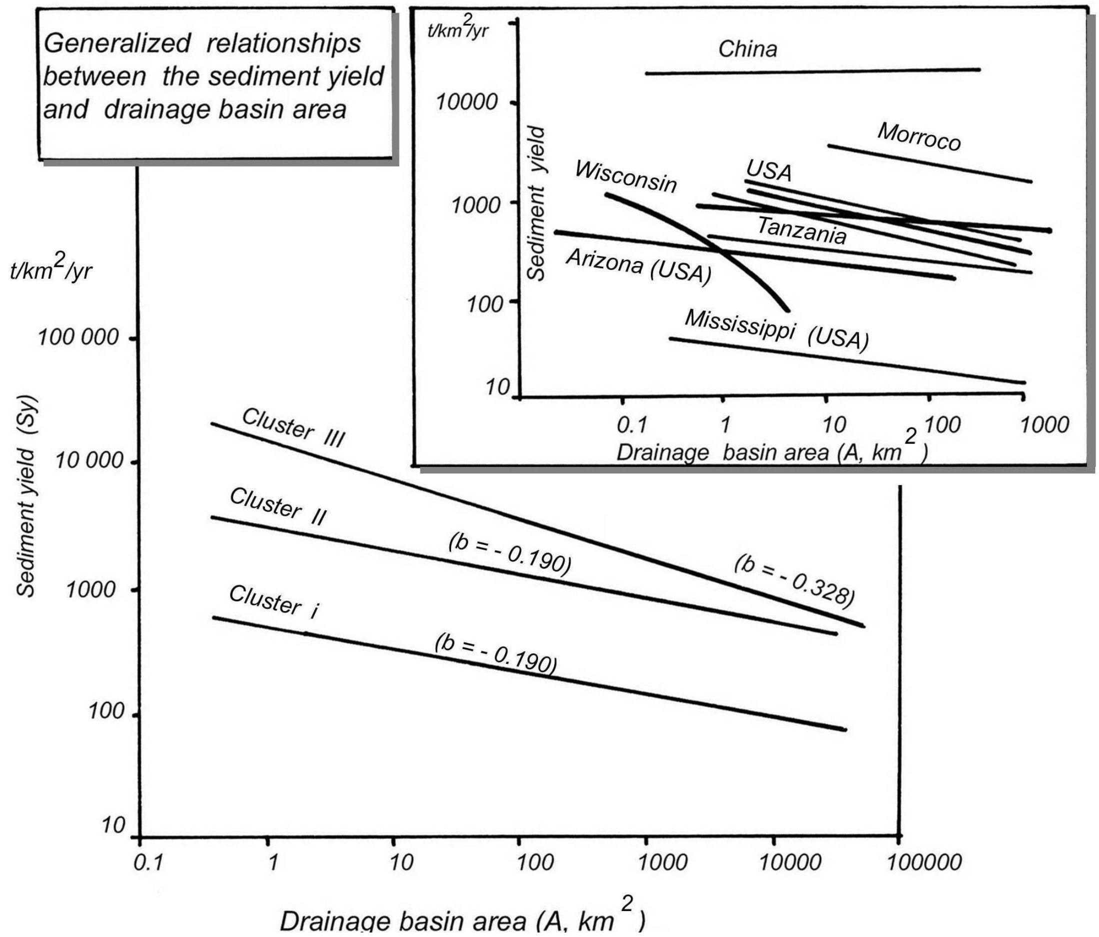

Fig. 4. Generalized relationships between the sediment yield and drainage basin area obtained of Walling (1983) for different conditions of the world (up) and the tendencies centralized for the Romania's territory (down).

On basis of this classification we have obtained generalized relations *S*y = f(*A*) (fig. 4) for the mentioned groups, which may be compared to Walling's generalized tendencies (1983) for different regions of the world. The general observations which are to be keep in mind from this analysis are that:

- In Romania's case there is a ''delay'' in the sedimentsl transit from the source area to the effluence area expressed by the negative relation of the specific sedimentsl production once the size of the hydrographic basins has increased. The phenomenon is due to the selective transportation of the sediments inside a drainage system. This ''loss of sediments'' takes place on the slope of –0.190 for the areas in Groups I and II and on a higher slope of *b* = 0.328 for the areas in Group III;

- Most of Romania's territory's enters the global centralized tendency belonging to Walling (1983), with regression slope of – 0.125. We may estimste that the areas in Group I, which characterizes the most part of morpholihological areas in our country, are placed in the regression line of maximum intensity areas, situation which may be assimilated to a medium condition of specific sedimentsl production for the most part of the Globe. On the contrary, the second and third group, although characterize areas with little extinction (the curvature sub-Carpathians and Getic sub-Carpathians), are registered as some of the most productive alluvial suppliers in the world.

THE SILTING OF DAM RESERVOIRS

The interest for the reservoirs silting study has decreased immediately after the slowing down of the dam construction in Romania, although the present reservoirs need an attentive supervision from this point of view. But we must not neglect the fact that a study on the silting of dam reservoirs needs an expensive price, the main reason for which the researches in this domain have decreased lately.

As far as we are concerned, we have a rich experience in the study of the phenomenon and an important data base which helps us approach the problem of knowing better the dam reservoirs silting in Romania, the way it is now, trying to relate it to the morphodynamic characteristics of our country's territory, to highlight the extreme situations and the possible causes of this process.

The data base on which our observations ground, includes, on the one hand, a situation on the dimensions of the lacustrine basins (capacity, area, position inside the hydrographic basin), on the other hand a situation upon the silted volume of the basin and a evaluation of the silting time of 50% of the initial storage capacity of the lake. All these data have been obtained from extremely different sources, from our own researches on some lakes in Bistrița Valley, Siret Valley, Buzău Valley, to attentive research of scientific production appeared in the last decades, the archives of The Institute of Hydropower Studies and Projections, The Romanian Committee for Great Dams, INMH, Aquaproject and others. Because of the scanty space that our work dispose, we will present a part of this statistic data under the form of a table (table 2).

Table 2. The silting situations of some storage basins from Romania

Nr. Crt	The drainage basin	The reservoir	The initial volume 10^6 m^3	The silting volume		Year of exploitation beginning	The source
				%	10^6 m^3		
1.		Vidraru	420,000	-	-	1967	Fl. Ionescu (1980)
2.		Oiești	1,800	74	1,330	1967	I. Ichim et al.(1994)
3.		Cerbureni	1,620	68	1,100	1966	"
4.		Curtea de Argeş	0,890	88	0,700	1972	"
5.		Zigoneni	13,300	15	2,000	1973	"
6.	Argeş	Vâlcele	40,000	62	2,500	1977	"
7.		Bascov	5,400	93	5,000	1971	"
8.		Piteşti	4,800	85	4,000	1970	"
9.		Ogrezeni	0,500	100	0,500	1967	"
10.		Baciu	0,600	38	0,230	1967	"
11.		Vîlsan	0,200	50	0,100	1967	"
12.		Cumpăna	0,260	38	0,100	1967	"
13.		Budeasa	26,44	10,3		1980	D. Roşca (1987)
14.		Paltinu	56,000	4	2,000	1972	Fl. Ionescu (1980)
15.		Pucioasa	10,600	22	2,300	1974	"
16.	Ialomița	Voila	0,500	70	0,350	1972	"
17.	Olt	Săcele	18,300	1,6	0,300	1976	"
18.		Vidra	340,000			1974	"
19.		R. Vâlcea	19,000	33	6,300	1974	"
20.		Dăeşti	10,800	32	3,500	1976	"
21.		Rîureni	7,300	14	1,000	1977	"

22.		Govora	18,500	27	5,000	1975	“
23.		Băbeni	59,650	8,3		1977	“
24.		Străjeşti	202,70	3,2		1978	D. Roşca (1987)
25.		Ioneşti		2,5		1980	“
26.	Mureş	Luduş	0,300	100	0,300	1964	Fl. Ionescu (1980)
27.		Mintia	5,000	74	5,700	1965	“
28.		Cinciş	43,000	3,5	1,500	1969	“
29.	Siret	Bucecea	14,400	12,8	1,85	1978 (evaluation 1978-1986)	P. Olaru (1992)
30.		Galbeni	40,000	18,9	7,500	1983 (evaluation 1984-1986)	“
31.		Poiana Uzului	170,000	1,40	2,500	1975 (evaluation 1975-1986)	“
32.		Iz. Muntelui	1230,000	1,3	16,000	1962	Rădoane (1983)
33.		Pîngărați	6,700	40	2,700	1964	Ciaglic et al.(1973) Rădoane (1986;1999)
34.		Vaduri	5,600	34,6		1966	Rădoane (1999)
35.		Bîtca Doamnei	10,000	27,2		1966	“
36.		Piatra N.	12,000	3,4	0,400	1966	“
37.		Racova	8,600	36	3,100	1964	P. Olaru (1992)
38.		Gîrleni	5,100	37,4		1965	“
39.		Lilieci	7,400	12,6		1966	“
40.		Bacău	7,400	15,8	0,300	1966	“
41.		Belci	12,000	50	6,000	1964 (destroyed 1991)	“
42.		Puşcaşi (r.Racova)	17,200	62,3	10,900	1973 (evaluation 1973-1998)	Gh. Purnavel (1999)
43.		Antoheşti (r.Berheşti)	0,220	40,91	0,090	1984 (evaluation 1984-1995)	“
44.		Găiceana (r.Ghilăveşti)	0,410	41,46	0,170	1984 (evaluation 1984-1995)	“
45.		Cuibul Vulturilor (r.Tutova)	9,500	32,63	3,100	1978 (evaluation 1978-1992)	“
46.		Rîpa Albastră (r.Simila)	10,600	21,13	2,240	1979 (evaluation 1979-1993)	“
47.		Fiticheşti (r.Pereschiv)	5,500	52,60	2,890	1977 (evaluation 1977-1993)	“
48.	Bahlui	Tansa	33,000	1	0,300		Pricop et al (1990)
49.		Plopi	24,000	1	0,250		“
50.		Pod Iloaiei	37,000	32,3	11,948	1964 (evaluation 1964-1975)	Zavati, Giurma (1982)
51.		Cucuteni	14,000	5,43	0,761	1964 (evaluation 1965-1975)	“
52.		Ezăreni	3,500	13,6	0,476	1963 (evaluation 1963-1975)	“
53.		Ciubeşti	12,300	5,2	0,637	1963 (evaluation 1963-1975)	“
54.		Chirița	7,500	13	0,100		Fl. Ionescu (1980)
55.		Aroneanu		19,98	0,296	1964 (evaluation 1964-1985)	Pricop et al. (1990)
56.	Jijia	Hălceni	3,500		0,030	1981 (evaluation 1981-1989)	Amăriucăi, Hlihor (1990)
57.	Jiu	Işalnița	5,000	92	4,600	1960	Fl. Ionescu (1980)

The estimation of the stage of the reservoir silting requires some knowledge about the initial capacity of the lakes, of a parameter which is called – accumulations coefficient (α) and which is defined as the relation between the volume of the hydrographical basin's liquid drain and the reservoir's initial capacity; of another parameter which is called silting time, of 50% from the reservoir's volume (T50). The analysis of these parameters has been done on the basis of a permanent correlation with the morphodynamic features of Romania's territory. Moreover, the table was completed with a map, which indicates the repartition of the anthropic reservoirs following the latest data supplied by the Romanian Committee for the Big Dams, superposed over the map of the specific production of sediments on Romania's territory, map brought up to date as well (fig 5).

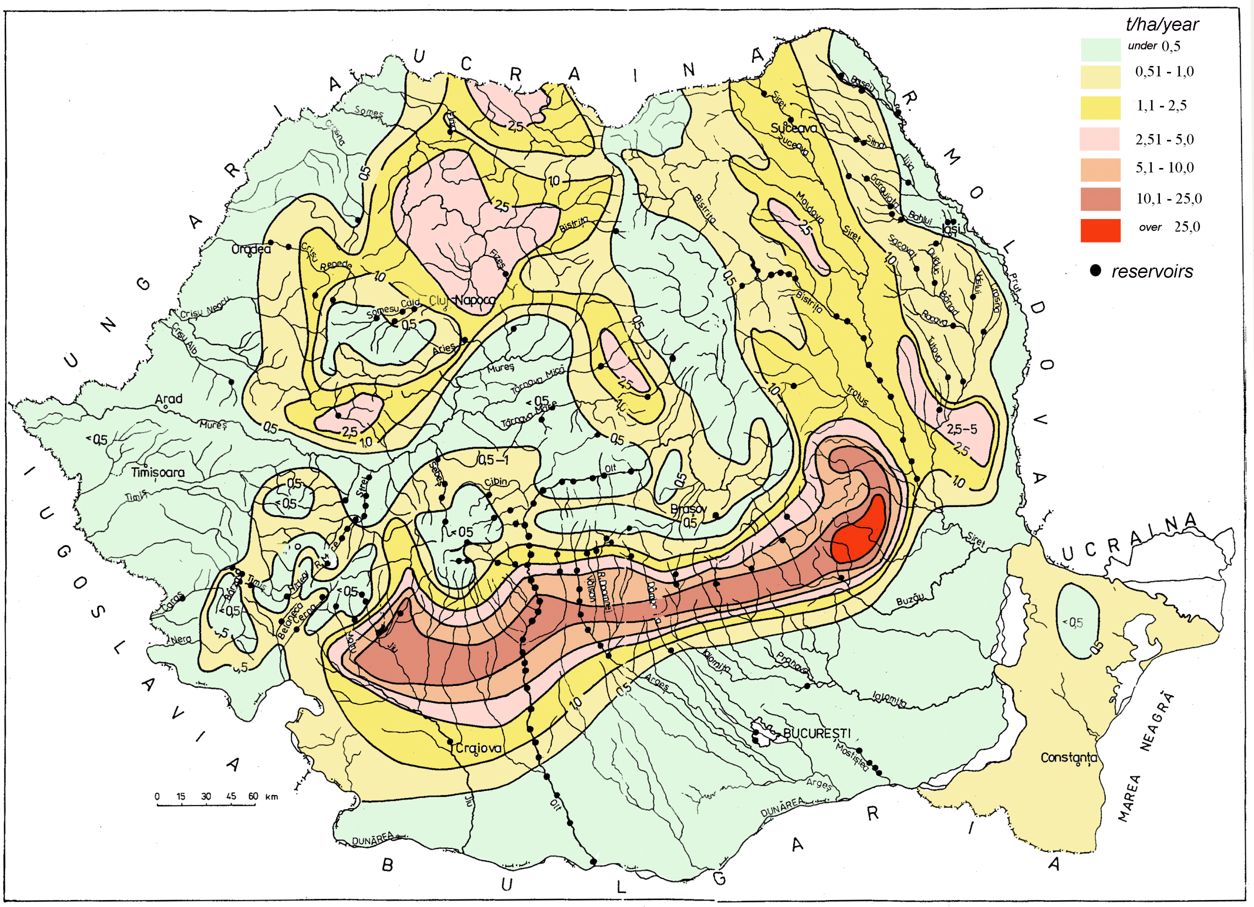

Fig. 5. Position of reservoirs in relation with the specific production of sediments.

Concerning the capacity of the lacustrian basins. As one can see from the graphic representations belonging to the fig. 6, the reservoirs in Romania are characterised by storage capacities relatively small. Almost 90% of the existent reservoirs have capacities under 200 million m^3, and among these half of them have capacities under 20 million m^3. The relief conditions and the ones concerning the Romania's rivers flow offered smaller changes for the arrangement of big dams and, implicitly, of big lakes. The only a few exceptions are known: the Izvoru Muntelui Reservoir the biggest among the interior rivers of our country, Vidraru on Argeş, Vidra on Lotru, Siriu on Buzău, Gura Apelor on Râu Mare etc. A lot of the existing rivers are arranged in waterfall on great rivers (Bistriţa, Siret, Buzău, Argeş, Olt), with specific exploitation conditions, which reflects directly over a certain silting rate. This is how the great number of lakes on the rivers Olt, Argeş and

Siret illustrated on a graphic in the fig. 6 is to be explained. The reservoir capacity and the exploitation conditions are important elements, which control the sediments restraining degree, sediments from source area.

The capacity of lakes is decisive for the evaluation of the rhythm and of the silting length due to a very simple reasoning: the more a lacustrian basin is bigger, the more it can stock a volume of sediments large enough without affecting its functionality and there are many examples in this direction. On the contrary, a lacustrian basin with a reduced capacity can become silted in a relatively short period, of only a few or a few tens of years, even at relatively modest comings of sediments. The study of Dendy et. al. (1973) for 1100 dam reservoirs in USA indicated that the great majority of small lakes are becoming silted in less than 30 years.

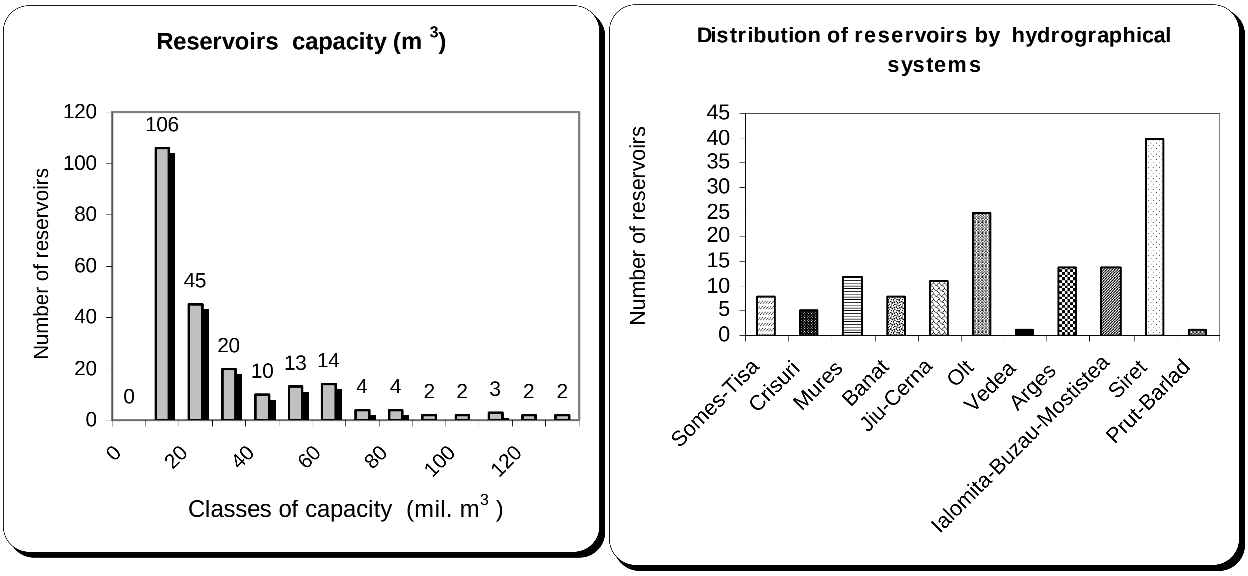

Fig. 6. The repartition of the dam reservoirs in Romania (on the left, the histogram of the dam reservoir's capacity, under 140 millions mc; on the right, the repartition of dam reservoirs on hydrographical systems)

The silting rate. There are, in Romania, dam reservoirs which have been functional for centuries (like those in Banat Mountain or Metaliferi Mountains), but there are also lakes which became silted in a period of a few years. From the data we have at our disposal we keep in our mind a few observations of general character:

- on the whole country, in an average period of 15 years, in the dam reservoirs from the interior rivers have been deposited about 200 millions m^3 of sediments (from which almost a half only the reservoirs on the rivers Argeş and Olt), with an yearly instalment of 13,4 millions m^3, which represents 27% from the total supply of sediments, averaged and multi yearly;

- **the most important yearly rates of silting** have been on the lakes from the sub-Carpathian area with easy erodible rocks, on Argeş river: Piteşti 15,7%, Bascov 11,7%, Oieşti 9,5%, Cerbureni 7,3% and Curtea de Argeş 5,3%; also the lake Galbeni, on Siret, 10,6%;

- **average yearly rates of quick silting** have been recorded also at the first lakes, built on the Olt river: Govora 8,27%, Rm. Vâlcea 5,63% and Dăeşti 4,90%; in the same category are included the lakes Pângăraţi on Bistriţa, 3,45% or Pucioasa, on Ialomiţa, 2,58%;

- low rate of silting have been registered at the big reservoirs, Izvoru Muntelui of 0,03% and Vidraru of 0,04%, which ensure them with a millenary running, unless some incalculable situations occur.

Retaining as a basis of interpretation the necessary time for silting of 50% of the initial volume of every lake, 138 reservoirs from Romania, with initial storage capacity between $1x10^6$ m^3 and $1230x10^6$ m^3 have been analysed. For these reservoirs determinations have been made, regarding the silting rate, using various methods and different experts. Their repartition depending on the major units of relief (fig. 7) indicates that from the total number of analysed reservoirs, only 44 are found in the mountain area of the country, the region with the smallest rhythm of sediments production. The other lakes are placed in the region of plateau and hill, sub-Carpathians, piedmont and plain, all these being characterised through an accelerated rhythm of producing the sediments, excepting the regions of plain.

In this general situation, the silting time of 50% of reservoir's volume reflects the means of reply, through silting, of the hydrographic basins, in comparison with the main morphodynamic regions of the analysed territory: it is reduced to less than 100 years for the lakes which are found in the regions with great production of sediments (Sub-Carpathians, plateau and piedmont) and it' s three figure hundreds of years for the reservoirs situated in mountain and plain areas. In other words, only 57 reservoirs have enough silting time to justify the investment and important perturbation on the environment.

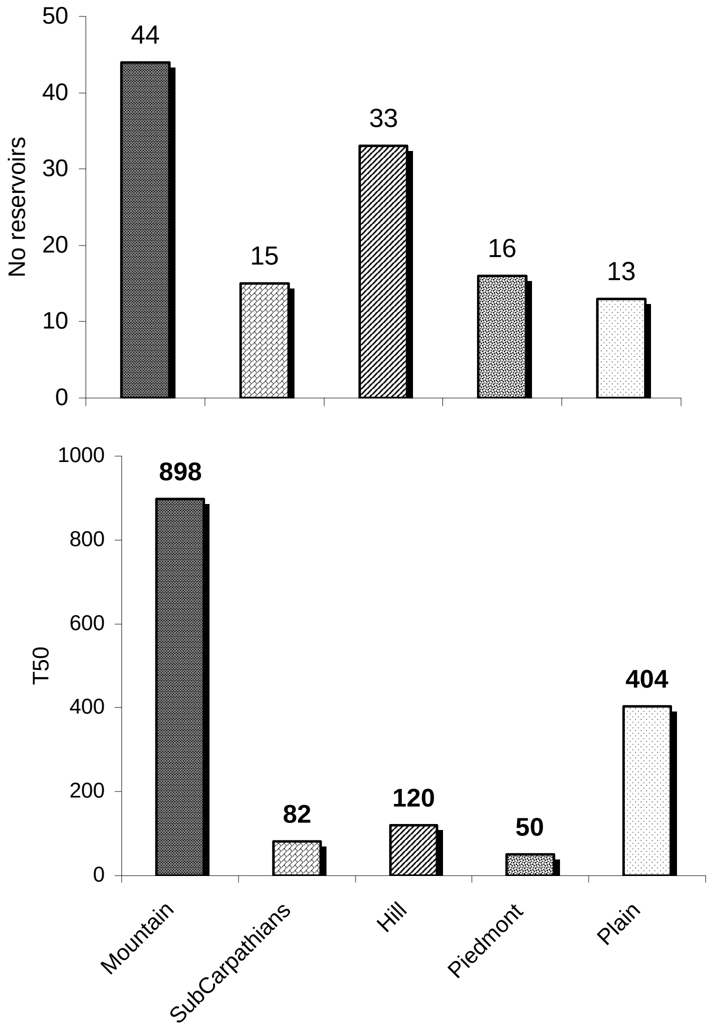

Fig. 7. Distribution of reservoirs in relation with main units of landforms (up). Time of silting 50% of initial storage capacity (down).

As a conclusion, the situation of the dam reservoirs silting from Romania is as follows:

- **very serious** for a number of 15 dam reservoirs with average dimensions o 8 mil. m^3 , all of them situated in the SubCarpathian area, one of important sediments production (over 500t/km²/year); the silting time T50 of these reservoirs having values between 2-10 years;
- **serious** for a number of 30 dam reservoirs, with average capacities of 35 mil.mc, and the silting time T50 varies between 10-50 years. In this case the reservoirs are also situated in the area of important specific sediments production of over 250 t/km²/year, the case of the rivers Olt, Argeş, Buzău and Bistrița but also of the reservoirs in Bârladului basin.
- **difficult**, for 13 dam reservoirs, with a silting time ander 100 years and which are usually situated at about 200t/km²/year (e.g. Rogojeşti on Siret, Izbiceni on Olt, Bacău on Bistrița, Văliug on Bârzava).

Following this general image of the silting phenomenon in the dam reservoirs in Romania we have to take into consideration the fact that in some arrangement projects priority it was given to the strict economic aspect and it was seriously eluded the knowledge the relief potential to reply in such an accelerated rhythm to sediments release and transport through the collector net. It is the situation of the reservoirs arranged in cascade on the rivers Argeş, Olt or Bistrița. Important sums of money are spent efforts are made to desilt some important reservoirs for the hydropower system functioning, such as Oieşti reservoir on Argeş and Pângărați on Bistrița. On the other hand it is admitted the fact that there haven't been done sediments keeping works in the source areas first and only after that the proper execution of the reservoir; in fact so many time the right order has been totally changed. The notorious examples in this situation are Bascov reservoir and Piteşti, entirely silted in two years.

As geomorfologists, it is or duty to admit that we owe to the other domains of activity a map with the morphodynamic potential of Romania, elaborated on quantitative grounds, with all the geomorphologic processes taken into consideration, so that it could represent a bases for the sustainable use of the territory.

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