DIFFERENTIATIONS IN THE SEDIMENTATION OF THE RESERVOIRS BASINS FROM THE SOMEŞUL CALD CASCADE SYSTEM

Gheorghe ŞERBAN*, Mircea ALEXE
„Babeş-Bolyai" University, Cluj-Napoca, Faculty of Geography,
Chair of Phisical and Technical Geography

*** Correspondence:** Gheorghe ŞERBAN, Universitatea „Babeş-Bolyai", Facultatea de Geografie, Catedra de Geografie Fizică şi Tehnică, Str. Clinicilor, Nr. 5-7, 400006, Cluj-Napoca, România, Tel. +40-(264)-596116, Fax +40-(264)-597988, email: serban@geografie.ubbcluj.ro
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ABSTRACT. After a general presentation of the afferent basin of the reservoirs from the Someşul Cald Valley, the authors proced to a short analysis of the suspension flows, which determine the reservoir sedimentations. There are put into evidence several aspects concerning the drainage basin framing on the ground erosion map of Romania, distinguishing low values of this phenomenon, but also the existence of several spaces with anomaly character, respectively values among most erect, due to the presence of the friable sedimentary rocks. This aspect is confirmed by the values measured at the hydrometric stations, included in text under tables and correlation and variation charts form of the specific parameters. In the second part of the study there are emphasized several aspects concerning the zones of maximum intensity of the silting phenomenon, thanks to the graphic elements implemented with GIS technics. In the case of the four reservoirs the principal affluents outlets are characterized by important alluvial deposits, frequently organized under dejection cones form, or reefs and alluvial strings, depending on the volume and the dynamics of waters from retentions. Particular evolutions are registered in the two small lakes situated in the downstream of the system, where the lateral contribution of consistent suspension flows leads to spectacular evolutions in some basin compartments, establishing even some small deltas. Also, the existence of some hard rocks layers, which traverse the lacustrine basins, establishes a differentiated sedimentation of these compartments (example the Gilău retention). In the dam zones the delicate sediments slide quickly (for example inferior miocen clays), with negative influence in the utilization of water resources for different purposes.

Keywords: reservoirs, suspension flow, sedimentation, accumulation shapes, digital plan model of the basins

INTRODUCTION

The hydrographic basin of the reservoirs from the Someşul Cald valley is situated to the north of the Apuseni Mountains, overrighting the Gilău, Muntele Mare and a bit of Bihorului massives. The point of meeting betwen Someşul Cald with Someşul Rece, formed Someşul Mic, but because the length and the superior flow of this spring it is considered the river of Someşul Cald (fig. 1).

In the studied space are included the basins of the rivers Somesul Rece and Somesul Cald, but the anthropic factor added the superior basin of Iara Valley (up to the Bondureasa dam) and her left affluents Valea Calu, Şoimul and Lindrul, after the underground deviation of these waters towards the Someşul Cald power system, although geographically this belongs to the Mureş basin *(Serban, 1999)*.

The boundary between the two Somes rivers it's given by the hills which starts from the main summit of the Gilău-Muntele Mare massifs, from Petreasa peak, flowing through Chicera Negrului, Fântânele clearing, Mărişel village, Ijar peak, Dealul Arsurii, Blidaru peak, Dealul Cetăţii, and ending on the Gilau's lake shore.

The boundary between the Somes Rece basin and the superior basin of Ierii Valley it's given by the (interfluviu) which starts from the main summit of the Gilău-Muntele Mare massifs, from Piatra Groşilor peak, flowing thorough Tina Bogdanului, Dumitreasa peak, Dobrin, Buturii peak, Testieşu peak, , Plopi, Dealul Custurii, and still ending on the Gilau's lake shore.

The extremly favorable conditions made posible a hydrotechnics construction of big amplitude, which valorized a part of the natural existing potential of the zone. The 860 km^2 in the section of the Gilău dam (inferior limit of the studied basin) were submissive to the construction from the years '60, existing four big rettentions on the Somesul Cald Valley (Fântânele, Tarniţa, Someşu Cald and Gilău) as well as some catchments in the Somesul Rece basin destinated for the supplementation of the affluent flow in the four lakes (*Şerban et al., 2003*).

The area of the present study has several particullary characters, among which:

- the frame of the scenery is very picturesque, varied and attractive;
- the presence of ethnographic objects and natural(protegees areas, rezervations and monuments of the nature) valuably, among them some are actually on the course of the water(quays, gorges)

- the alternance of the living zones(villages, houses of vacantion) And wild zones or with minimum anthropic impact;
- a big variability in time and space of hydrologic of the hidrologic characters of the watercourses, the alternance of accumulations by zones with big slopes of leakages;
- the absences near total of the industrial pollution;
- the intense utilization of above-ground waters in diverse aims, inclusively as drinking-water, without the previous treatment;
- the maximal grown, in the last years, of the sources of pollution, mainly by the dejection waters;
- the initial quality of the water is very good, it can constitute a excelency source;
- the reduced supervision of the water quality;
- the Someşul Rece and Someşul Cald rivers debouched into the Gilău retention - the drinkable watery source for across 400000 persons from Someşul Mic corridor and the contiguous areas (Cluj-Napoca, Gherla etc.).

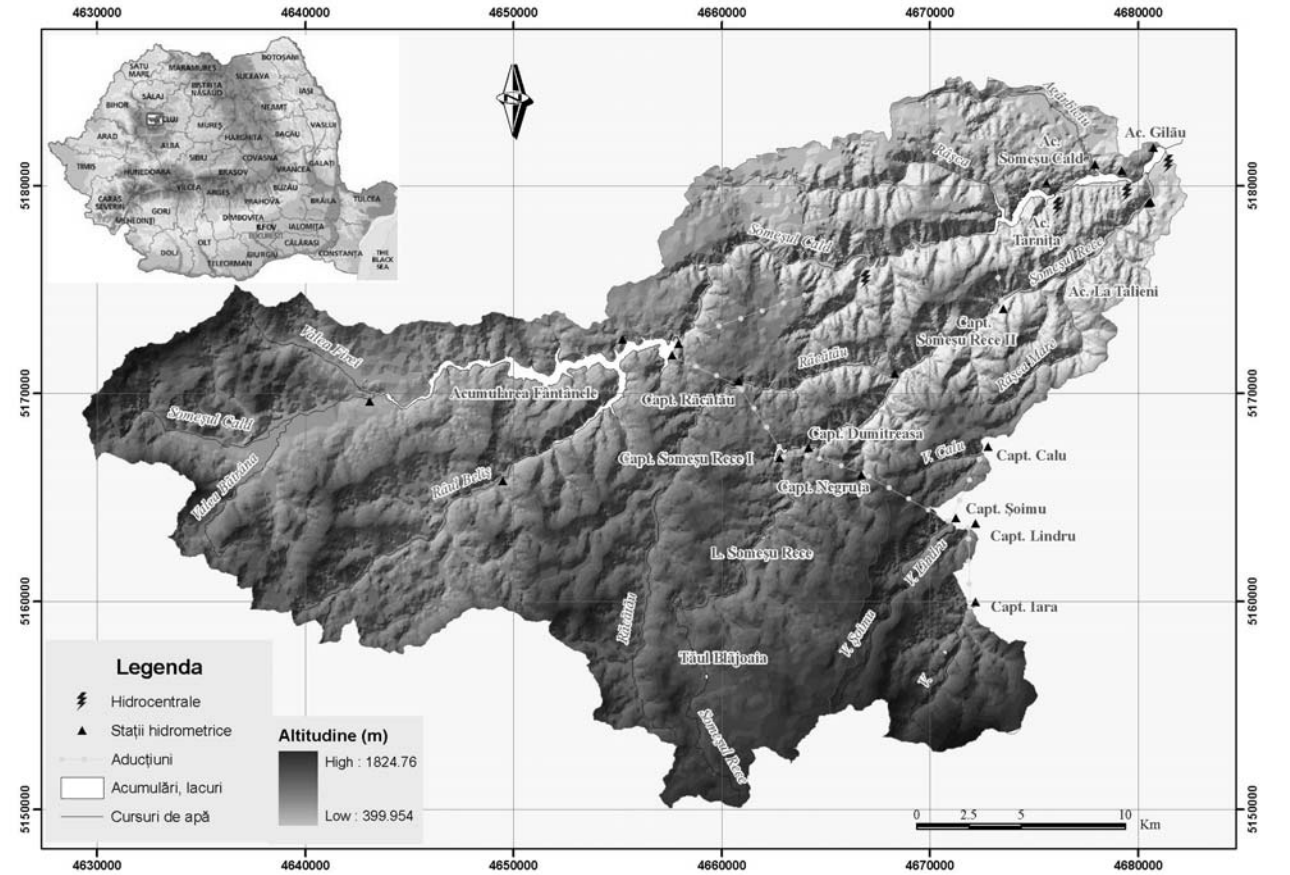

Fig. 1 General map of the drainage basin of the reservoirs of the Someşul Cald Valley.

THE SUSPENSION FLOWS WHICH CONDITIONNING THE LAKES SEDIMENTATION

The afferent basin of accumulations from Somesul Cald takes part in the category of territories with a reduced rate of erosion of the grounds (fig. 2), the values are contained, on average, between 0 and 0.5 t/ha.year in west part and central and a bit more higher 0.5 – 1.0 t/ha.year in north-east of studied space (*Rădoane et al., 2003)*.

Although the slopes are large, the reduced intensity of the silting phenomenon of some retentions is explicated through the distinguished resistance of the rocks, through the dense extension of the forest carpet in the deforested spaces , by anthropic interfere with a reduced amplitude in the biggest part of the basin (*Şerban et al., 2003*).

There are, spaces in the basin, wich induct anomalies in this repartition, by natural causes, anthropic or through conjugated cause of the two elements. This kind of areals appear in the inferior basin of Someşul Rece river, pursuant to the accelerate alteration of the granits from Muntele Mare Mountains *(Mac, 1998)*, in the Râşca affluent basin, but most in the one of Agârbiciu river, where the presence of sedimentary rocks with a reduced density of the forest background, permit the massive movements of sediments in the periods with average and maxims flows.

For a better illustration the afirmedated ones, were remaked dates from 4 hydrometric stations, and were monitorized the amounts of suspension debit entered into the system of the reservoirs (table 1). The period of observation toked in the calculus corresponds the interval betwen 1981-1997 at three from these ones. Although the age of operation of the fourth station (Someşul Cald, on the Agârbiciu river) was very short (1979 - 1982), obtained data from prolusion were eloquent in the explication of the silting process of the Someşul Cald reservoir basin, situated below influence of the most important transport of suspension flow from the basin.

The obtained results the bigest amounts of suspensions camed from the zone with sedimentarry rocks from north-east of the basin, transported by the left affluent of Someşul Cald river, the Agarbiciu river (1.034 kg/s).

The values had been determinated last years in the zone with the the occasion of a campaign of measurements and prolusion made in the July month of the years 2001 and 2003 on another neighbouring watercourse, Râşca Valley. In the results from the week that the campaign lasted (4 - 10 the July), in 2001, they were surpriseing flows as much in conditions of the freshet, and of lower leakages, very good correlated with ones from the Căpuş river, at the Căpuşu Mare hidrometric station, situated slightly to north. The average suspension flow established in the campaign duration was of 0.784 kg/s, very approached of the one from Agârbiciu river. This, reported to the basin surface of 59 km^2, give an significant average specific suspension flow, estimated to 4.190 t/ha.year.

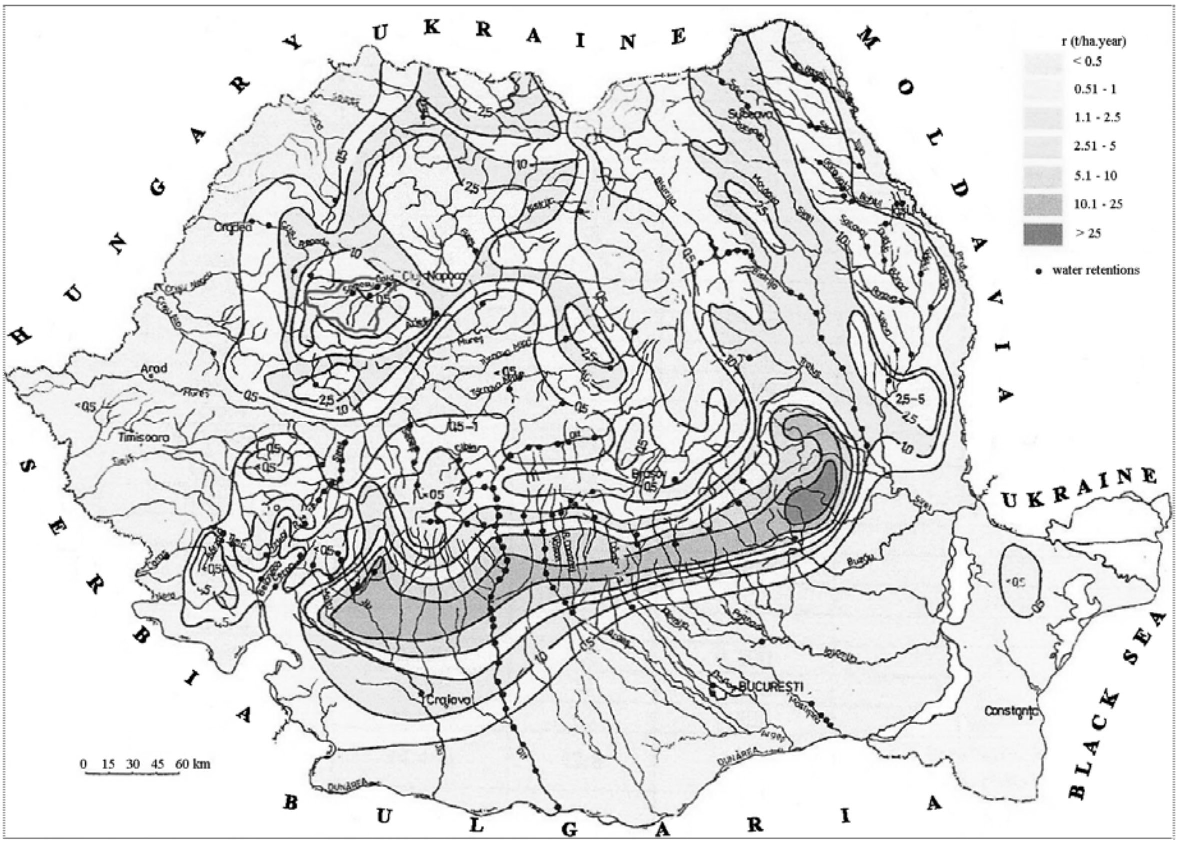

Fig. 2. The position of the reservoirs from the Romanian territory in report with the rate of erosion of the grounds (after Rădoane et al., 2003)

Also, the high values are comming back at the river Beliş, at the Poiana Horea hidrometric station (0.548 kg/s), because of the sedimentary rocks presents in the superior half of the basin, and massifs deforesting produced in last the period.

Someşul Rece river, at the entrance in Gilău reservoir, it is found in the shade of suspension transport, below the effect of the two catchments from the upper side of the drainage basin. Only that, at the phases of maximum leakages, the suspension flow is remaked in great measures, reaching very high values (54.5 kg/s, at the flash-flood from December 1995), the evidence is the contiguous evolution of the delta developed at the confluence of the river with the reservoir.

The situation can be blamed on the alteration of the granits of Muntele Mare, how it was sayd previously, as well as antropic interference from the last period (inclusively important deforesting).

The relation betwen the specific average suspension flow (r - t/ha.year) and average altitude of the basin (H - m) show the effect of the catchments on the Someşul Rece river flow, through the abbot on the left of vallue curve. A relative relation gathered could be established between the suspension flow and the surface of hydrographic drainage basin (fig. 3).

About the temporal evolution of the suspension flows at hydrometric stations, it can be made important prolusion *(Pandi, 1997)*. So, regarding *the average* ***monthly multianually*** *suspension flows*, the most meaned pulses are produced in the winter and in the season of spring, as well as, sporadically, in the season of winter, more accentuated on the Beliş river (fig. 4a)

This comes to confirm the characterization, regarding the type of regime of flow. The river Agarbiciu does the exception from the rule, because the solid flow significant grows at the most little flash-floods that are produced on the contents of his basin.

At the *mounthly multianual maxims of suspension flows* (fig. 4b) the evolution is a little different, from a station to another. So, in the west of the basin, at station Smida the maxim is produced at the end of the estival season (113 kg/s), existing two secoundary pulses in the beginning of the spring and end of the autumn.

Table 1

THE MAIN ELEMENTS OF AVERAGE SUSPENSION FLOW AT THE HYDROMETRIC STATIONS FROM THE BASIN (AFTER THE ROMANIAN WATER AUTHORITY, SOMEŞ-TISA, CLUJ SUBSIDIARY)

Nr. crt.	River	Station	F (kmp)	H med (m)	R (kg/s)	W (t)	r (t/ha.year)
1	Someşul Cald	Smida	110	1293	0,211	6664	0,606
2	Beliş	Poiana Horea	85	1259	0,548	17277	2,033
3	Agârbiciu	Someşul Cald	28	705	1,034	32609	11,857
4	Someşul Rece	Someşul Rece-sat	334	1218	0,050	1581	0,047

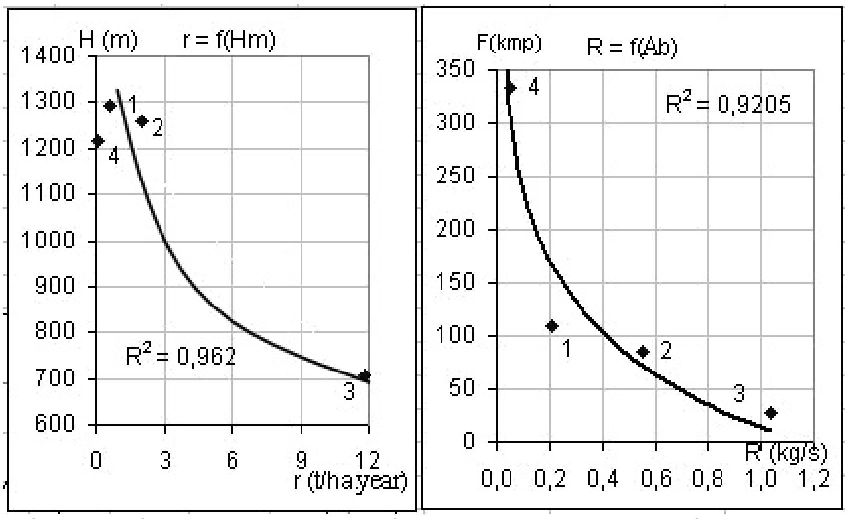

Fig. 3. Relations of the specific average suspension flows with average altitude of the drainage basin and of the suspension flows with the basin surface

On river Agarbiciu, at the Someşul Cald station it keeps the configuration with the two peaks from the average flows, the one from the Mai (147 kg/s - exceeding the one of Someşul Cald, at Smida), and in the rest of the year appear peaks less meaned of this parameter. Stations Poiana Horea and Somesul Rece-village ar characterized by a long evolution with a single peak, at the beginning of the winter and less throbs during the year.

In ***multianual profile*** (fig. 5a.b) *the average annual suspension flows* presents oscilations from one year to another, especially on the Beliş river, where appear with a high frequencie relative big values (0.5 - 1 kg/s); also, it can be noticed a spectacular grown on Agârbiciu river, along of the flash-flood from 1981, when the value were 3.5 times bigger than the other stations.

At the *annual maxims flows* the situations more clearly. The extremes appear differed from a river to another, depending on the manifestation of the physic and geographic factors. So, on Agârbiciu river the maximum flow corresponds to the 1980 year, while on Someşul Cald river this is produced in the 1983 year.

The same similitude, wich threats same conditions of flow between the two neighbouring basins, manifests on the Beliş river and Someşul Rece river as on the average monthly multianual suspension flows. The maximum appears at the flash-flood from the year 1995, and the rest of the analysed period it is not branded by values to atract the attention.

In such conditions, its will be affected by the suspension flow the two smaller reservoir basins (Someşul Cald and Gilău) where it drains the sediments of the lateral affluents of Agârbiciu and respectively, Someşul Rece, exaples frequently meet in the profile literature (*Giurma, 1997*).

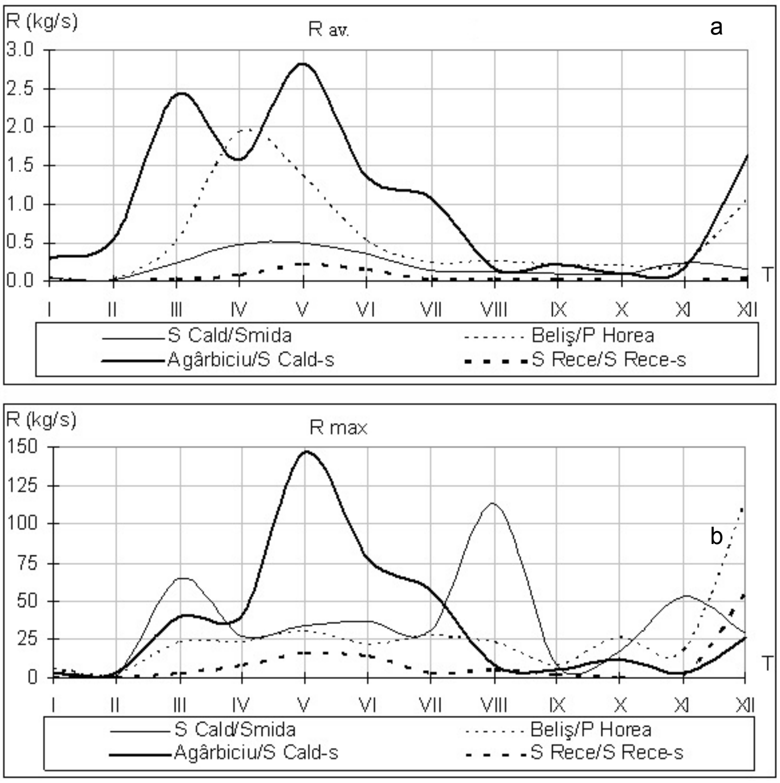

Fig 4. Variation in yearly profile of the average monthly multianual suspension flows (a) and the monthly maxims (b) in the studied basin

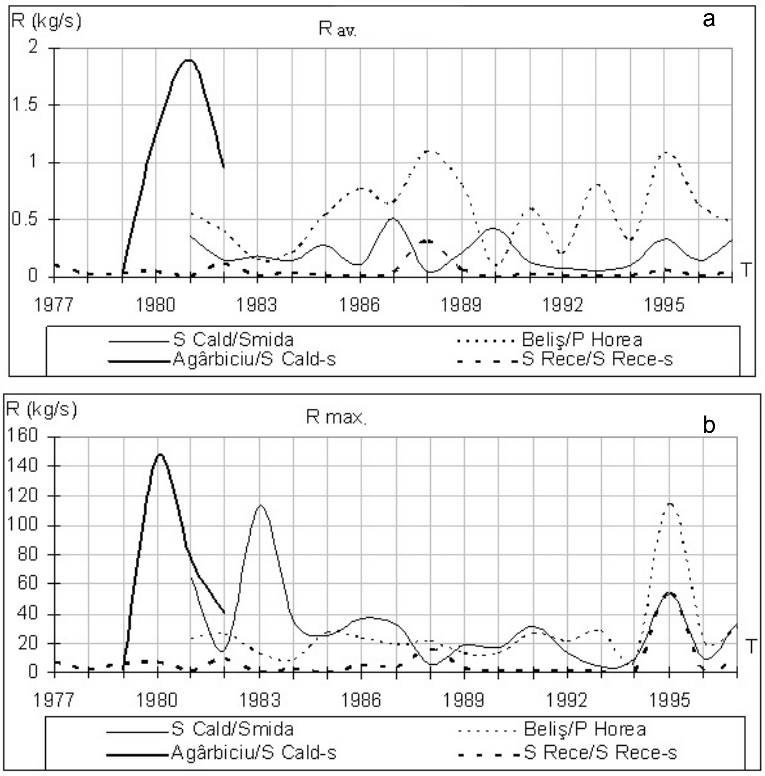

Fig. 5. Variation in multianual profile of the suspension average annual flows (a) and the suspension maxims annual flows (b) in the studied basin

AREAS OF MAXIMUM INTENSITY OF SEDIMENTATION IN THE RESERVOIR BASINS

The GIS technics using in the basin modellings has made possible the realisation of plan and tridimensional digital models of the reservoir basins, elements of big utility in the analysis of the areal dispersion of the sediments (*Kondratyev et al., 1999, Şerban et al., 2005, Alexe et al., 2006)*.

Generally, in the Someşul Cald cascade reservoir systems these corresponding of the areas of the main affluence of rivers, the specify situations also to other lacustrine units (*Bojoi et al., 1972, Ichim et al., 1976)*.

For the *Fântânele reservoir* these are represented by the outlets of several rivers (Someşul Cald, Beliş, Pârâul Porculuircului – near of the dam) and a few more vigorous brooks directly affluent into the lake in the median zone, under the shape of developed alluvial cones (fig. 6).

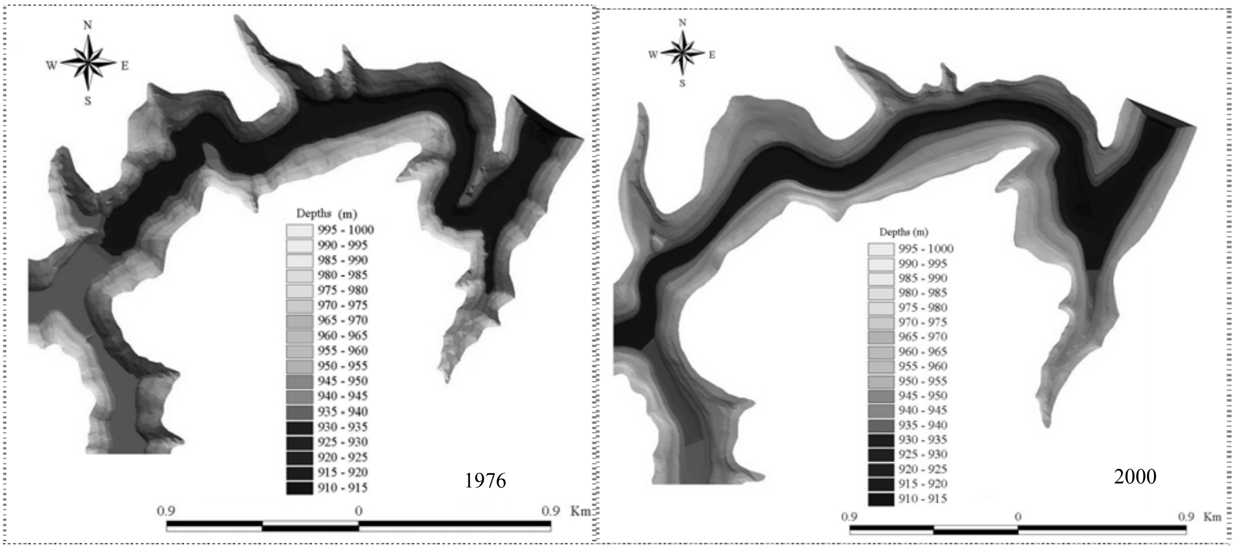

Fig. 6. The relief plan model of the basin (TIN) in the Fântânele dam area

The deposits has appreciable thickness (up to 3.25 meters value measured on the Someşul Cald river thalweg in the opening made by the erosion till the natural rock) and they are being constituite from gravel thickly at the base (Ø = 5 ÷ 63 mm), across which takes place a consistence counterpane of sand and mud (about 2.70 meters thickness). The observations were possible in the period of emptying of the lake, to repair and verify on the forced pipeline betwen the dam and the Mărişelu powerstation (fig. 7).

Fig. 7. Deposits at the end from the upper side of the Fântânele reservoir, in the zone of affluence of Someşul Cald river. The thickness of the sediment layers measures 3.25 meters

It was not posible the effectuation of depth measurements with the echosounder at the Iara-Fântânele aqueduct outlet, to settle the deposits, because the turbillions created in the water mass that could put in danger the gears from endowment and not only. There are a consistence load of sediments in that sector (has in sight the vast space from which the water comes and the important flow of it), because on the next Tarniţa reservoir, were Someşul Rece II aqueduct get into the lake, was noticed a huge alluvial cone, to a half flow of this aqueduct.

In the 6th figure it is noticed the depth diference betwen the two depth observations (1976 and 2000), mainly at the end from the upper side of reservoir. Also, in the other parts of the reservoir basin the sediments were reshaped by the wter currents. Sadly, the very big depth scale (90 m to the maximum level, around the dam) it compels to establish bathymetric contours from 5 to 5 meters, which rezumed in the loss of details in the most sensible zones from the viewpoints of sedimentation.

In the *Tarniţa reservoir* the situation is somehow the same (fig. 8), with the difference that nearly miss the lateral affluents of calibre. These are represented just by the Râşca river and the Someşul Rece II aqueduct. At an end from the upper side of the lake enters the gallery from the Mărişelu powerstation and the Someşul Cald river with a reduced debit, added from the reduced surface betwen the two big accumulations.

The maps put in evidence an important silting at the entrance of the Someşul Rece II aqueduct (marked on the plan model with an arrow), as well as on the Râşca valley channel, marked by the significant deepth differences.

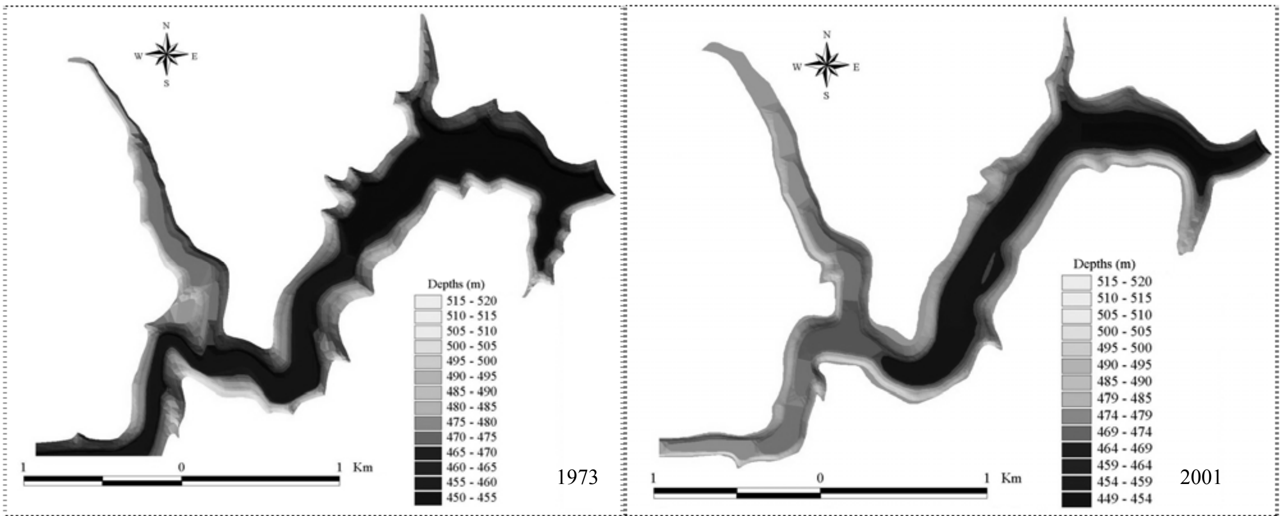

Fig 8. The relief plan model (TIN) of the Tarniţa reservoir basin

At an end of the upper part of resrvoir, on the Someşul Cald branch, the vast colmatage begins hardly from just some hundreds meters, because of the strong currents of clean water from the gallery of evacuation. They dislocate and move the fine sediments towards the interior of the reservoir, toward the outlet zone, creating a veritable hydraulic assortment (pavement material) of the deposits, with a thickley gravel (Ø = 10 ÷ 100 mm) and stones in the damage of the sand and the mud (fig. 9).

The measurements were made and also the topometry, grace to the emptying of two thirds from the retention capacity for repaires and technical verifications to the shuttles of the dam (in the summer of 2001, the month of July). The submersible part of resrvoir was measured with help of the same echosounder PEL 4.

Appreciable thickness of the deposited grounds have been observed on the alluvial cones of some torents and smallers brookss affluente directly in the lake, which were quickly transected on longitudinal profile by the water, soon after the moment of vacuuming the lake. Also, although it is a form of anthropic origin, an semnificative extension was seen the dirt-heap from the gallery of the future underground hydropowerstation, from Lapustesti which was thrown directly into the lake, on the left versant (fig.10).

Fig. 9. The sediments deposits from Tarnita basin on the Someşul Cald branch. The thickness grow from the end of the retention towards the interior (0.30 m to 115 m and 1.21 m to 450 m distance) than they slowly reduce until the Someşul Rece II aqueduct outlet

Also, at the remaking of the topo-bathymetric datas of these retention, because of the big value of depth it was used a difference of level by 5 meters between bathymetric contours.

On the bed accumulation, in the opening created by the advance on the vertical of Someşul Cald river in the alluvial deposits, up to the natural rock ,appears a series of springs camed from the crosroads betwen iron-stone situated betwen the rock levels. This resource was exploited in its neighborhood, outside the drainage basin limit, at Căpuşu Mic, situated on the left versant of the basin.

Fig. 10 Natural and anthropic amassement shapes, on the versants of the Tarniţa reservoir basin. First image represents the cone of a torrent at precinct 500 meters of the lake tail, the second one, the dirt-heap from the gallery base of the future hydropowerstation from Lapuşteşti

In the case of smaller accumulations from the lower side of the basin, where Someşul Cald is also, the repartition of the sediments on the reservoir basin is not the same, because of the deepths smaller comparative with the reservoirs from the upper side, of the inferior capacities and a different transit of the water (fig. 11).

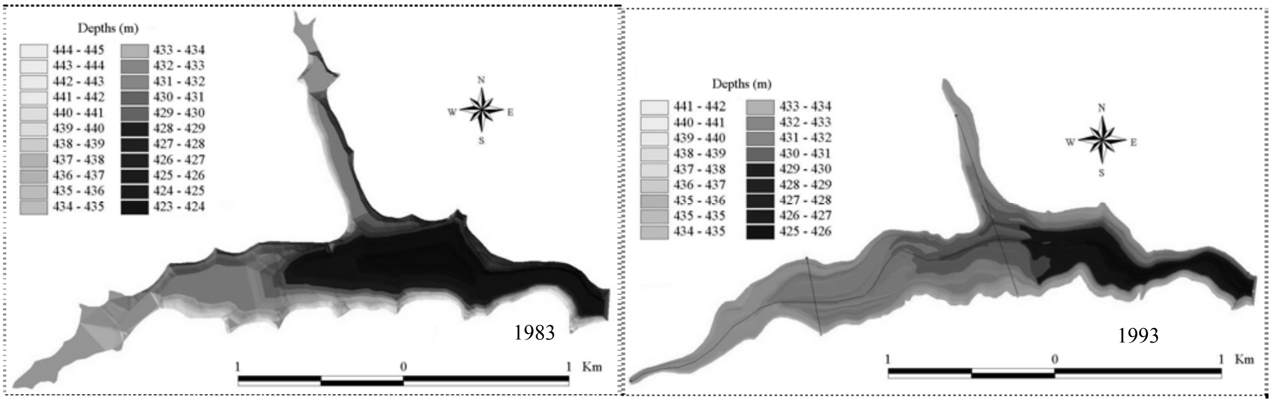

Fig. 11 The relief plan model (TIN) of the Someşul Cald reservoir basin

Although exists a massive transport of sediments (maximum in the basin, after what it has ben seen at the analysis of suspension flow), these were puted in other modes than the normal ones, because the water curents extremely active that come from the Tarniţa hydropowerstation (*Şerban et al., 2006*).

In this sense, comparative with the previous situations, the reservoir basins space, the most silted its not at the outlet of Agârbiciu river, where it had to be regarding the normal conditions of sedimentation to exist an alluvial cone, but on the opposite versant of the reservoir basin (fig. 11 - 1993).

The character of buffer lake between Tarniţa and Gilău lakes and the frecvently water discharges of the powerstation from the upper side, made the sediments to take other way using the currents towards the opposite border with Agârbiciu river, taking the shape of banks and longitudinal sand banks. A part of the deposited amount was spreaded in the superior sector of the reservoir basin, in the relaxed period of the discharges, under the same forms (fig. 12).

The silting process affected most *the entrance of the Agârbiciu valley into the lake*, were there have been builded small dams, in the aim of sediment decantations, quickly clogged up, then *the median compartment of the reservoir basin* on the biggest extension and *the left versant of the reservoir basin* down-stream of the confluence with Agârbiciu river, all because of the deviation of the sediments camed from the river by the longitudinal currents towards the left border of the reservoir.

As composition, in the Someşul Cald retention, prevail flatly the sediments of clay type miocen inferior, which would constitute a problem for the water treatment stations to make the water drinkable. As a matter of fact, the basic reasoning for wich they built this dam was to stop the clay afflux towards the Gilău reservoir, to ashure a turbidity as lower as possible at the entrance of the water in the treatment station from the homonymous locality.

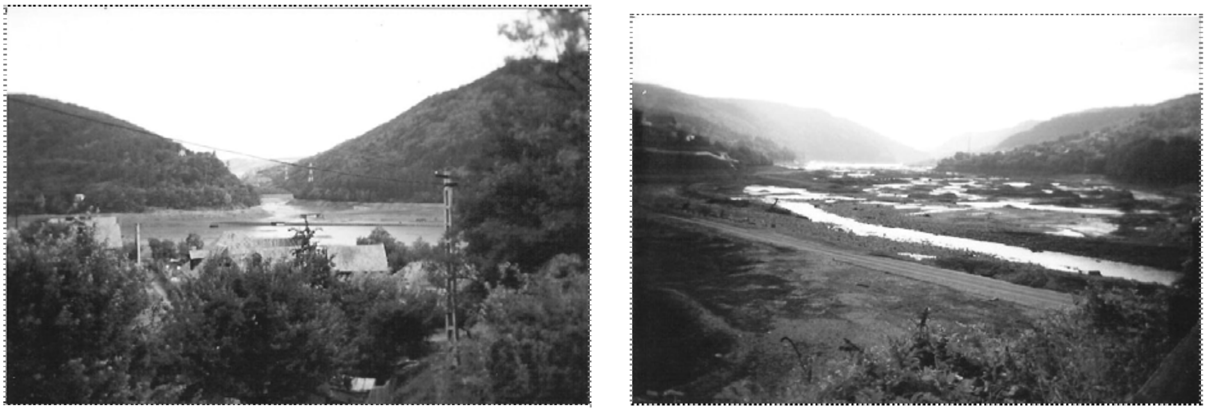

Fig. 12 The superior and the median compartment of the emptyed Someşul Cald reservoir basin. Can see the resulted shapes after the conjugation of anthropic actions in the period of pre-accumulation, with the one of water currents in the submersible phase (a) and the Agârbiciu river outlet in reservoir (b)

The most interesting evolution of the silting phenomenon was observed in the Gilău retention, were the geological factor influenced in a big measure distribution of the sediments on the surface of the reservoir basin *(Pandi et al., 2005)* (fig. 13).

In this sense, the superior sandstones horizon which crosses the basin through the median zone, takes the role of a threshold and determined the narrownes and the it spliting in two sectors; every sector had a self evolution regarding to the sedimentation of the transported suspensions by the lake affluents.

The discrepancy concerning the silting intensity of the two compartments was visible as far back as first years of exploitation, after the given in use of retention. In the superior compartment, in the first phase, it produced a narrownes of the old meadow of Someşul Mic river under the effect of the bilaterally suspension flows (Someşul Cald and Someşul Rece rivers). After a while this disappears as a morphologycal unit (1977) replaced by a twinship of alluvial cones of the two rivers (*Aniţan et al., 1977)*.

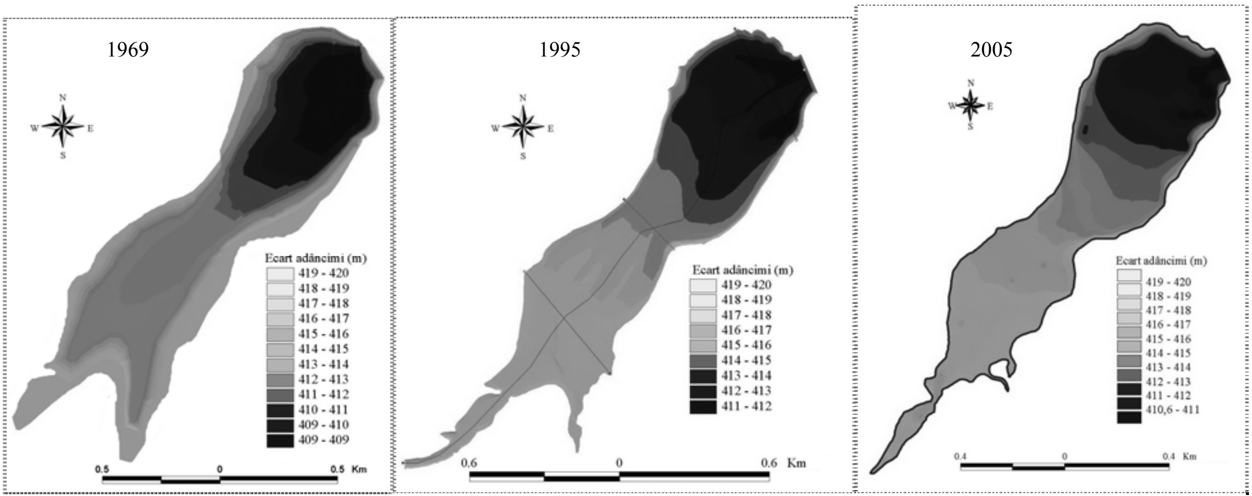

Fig. 13 The relief plan model (TIN) of the Gilău reservoir basin

After the year 1983, when the dam Someşul Cald was finalised, the sediment transport from the main affluent becomes near null and the evolution of the alluvial cone stops. But, the one of Someşul Rece river starts to set up all more and more like a delta and the thalweg slowly pushed towards the left versant, kind of evolution remarked, also, in other studies *(Romanescu, 2002)*. Actually, half the surface of the microdelta is in emersion and fixed by the evoluated vegetation (fig. 14).

All this time the inferior compartment of the reservoir basin was slowly affected by the silting process. The role of the threshold was major in the limiting of aluvionar contribution, the majority of amounts are thrown in the upper side of basin, after the extinction of energy transport of the water currents.

Fig. 14 The Someşul Rece micro-delta and the superior compartment of the Gilău reservoir basin

The small particles, clay types, that arrived in this sector, staying a lot of time in suspension, they were transited through overflow from the dam, eighter they decanted in this space without modifying significantly it morphology.

CONCLUSIONS

The petrographic mosaic from the drainage basin of the reservoirs from Someşul Cald valley enforced a particularry spatial distribution of these units; the most important capacities be gived in use in the superior sector of the basin, in the zone of hard rocks characterised by a reduced suspesion flow. In the inferior compartment of the basin, the reservoirs of small capacity are under negative influence of the petrographic support, constituted from sedimentary rocks, as well as of a consistent afflux of sediments.

These elements causes a differenced sedimentation of the lake basins; these sedimentation are, also, influenced by their morphometric elements, by the types and the disposition of the confluences on the reservoir contours, by the tectonic factor intervention and by the local rocks.

For all the four reservoirs the outlets of the main tributarrys are characterised by important alluvial deposits, which frequently are represented by alluvial cones, alluvial reefs and strings. The remarkable water transit, but, also, the consistent laterally suspension contribution for Someşul Cald and Gilău retentions, influences the sediments repartition on the basin spaces; there are distinguished a fast and an ample evolution of the sedimentarry grown-up forms: lacustrine delta, deviations of thalwegs, submersible channels etc.

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