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PROBLEMS OF MEANDER GEOMORPHOLOGY WITH PARTICULAR EMPHASIS ON THE CHANNEL OF THE BÎRLAD RIVER

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L'étude géomorphologique des méandres et des tendances de méandrer du lit mineur de la rivière de Bîrlad. L'étude géomorphologique des méandres et des tendances de méandrer du lit mineur de la rivière de Bîrlad (L = 247 km, S = 7395 km^2, Q.moy = 6,38 m^3/s) dans des conditions naturelles et aménagées nous a conduit aux conclusions suivantes :
— on a identifié au moins deux générations de méandres dont ceux de premier ordre ou élémentaire reflètent les conditions actuelles d'évolution dans un lit sous-adapté, et ceux de second ordre expriment une phase plus ancienne d'évolution (fig. 1*A*) ;
— les rapports entre le microrelief de « pool » et de « riffle », d'une part et la largeur du lit, d'autre part, sont similaires pour tous les cas de lits analysés, qui évoluent soit dans des conditions naturelles (fig. 2,3) soit aménagées (fig. 1F) ;
— le microrelief de « pool » et de « riffle » d'érosion et d'accumulation est mis en évidence aussi bien dans les lits aménagés que dans ceux naturels ;
— le bilan de l'érosion des rives aux canaux aménagés et de l'accumulation aux lits sous-adaptés souligne également la tendance de méandrer (fig. 1).

1. GENERAL CONSIDERATIONS

The river flows with a sinuosity index exceeding the 1.5 value are considered to be meandered (L.B. Leopold Z.M., G. Wolman, 1957). The phenomenon has significant implications in the fluvial relief evolution; it is highly important to know it for the organization and use of the land close to rivers, for the river flows arrangement, for locating buildings along the streams, etc.

Therefore, quite a lot of studies and researches on the meanders have been undertaken so that a large speciality literature is presently available. However, many aspects of the problem are still open to discussion, opinions differ widely and are often contradictory.

Moreover, the meander phenomenon was found to be not only a river characteristic, but also one of the marine currents : of the Golf-stream (W. L. Langbein and L. B. Leopold ; 1966) Kuro-shivo (V. V. Pokudov, K. O. Veliats 1978), etc., or of the valleys of submarine plains (B. J. Stanley and R. Unrug 1972). It is obvious that in such a situation, the most debatable problem is the cause of meander formation according to the theory of minimum variance (W. B. Langbein and L. B. Leopold's 1966) which affirms that menaders express a state of dynamic balance of the channels ; this view has lately been gaining ground and has been taken over by many specialists. Some of the interdependencies between the geomorphological elements of the meandered channels are also pointing to the above dynamic balance.

Aspects which seemed to be clarified once and for good had to be reconsidered. Among them, the high rate of channel arrangement and

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rectifying brought to the forefront the problem of the bed microrelief and its relations with the channel geometry. Practical necessities imposed the study on laboratory models, although there were few cases when detailed maps of the channel topography could be drawn. If an explanation is to be sought in this respect, we should mention S. A. Schumm's observation (1977) on the significance attached by geologists and geomorphologists to the fluvial system viewed from a historical perspective (long-term evolution) and by engineers in the land use practice. We would like to introduce in this particular context some aspects connected with the meander evolution viewed from a geomorphologist's standpoint some being mentioned here for the first time, others having hardly been discussed in the literature) : a meander hierarchy, the microrelief of beds and the meander formation tendencies and meander-formation under conditions of the anthropic influence.

In order to substantiate our points of view, we focused in the main, on the Bîrlad river channel ; we made a detailed analysis of 5 zones 50° to 1100 m long situated along the river between Vaslui and the confluence with the Siret river. When choosing them we took into account the ratio between the channel width and the analyzed channel reach length, mentioned by T. Dunne and L. B. Leopold (1978, p. 653) for similar researches. Therefore, our observations cannot be considered as based on a single, isolated case ; each zone has specific morphological, hydraulic, dynamic properties. With the same end in view, we applied the calculation of morphological ratios, which are known, checked and found to be logical, e.g. those established by L. B. Leopold and G. M. Wolman (1957), W. B. Langbein and L. B. Leopold (1966).

— the ratio between the meander wavelength (L) and the mean radius of curvature (r_m) expressed by the relationship $L = 4.7\ r_m\ 0.98$;

— the variation of the river deviation angle (φ) from the central axis with downstream direction ;

— the ratio of twice the distance between the riffles to bankful width of channel, which could be used for prognosis assesements of meander-formation ;

— the ratio between the meander wavelength (L) and the meander amplitude (A).

In order to calculate these ratios we used data obtained by measurements on topographic maps (scale 1/5000) and airphotograms as well as topometric plans *) (scale 1/500) of the zones to be studied (Pain, Rediu-Vaslui, Banca, Ghidigeni, Tecuci). In the Rediu-Crasna area, extremely accurate measurements of the bankfull width of channel were taken every 100—150 m along 18 km downstream. The deposits thickness in the point bars were assessed by soundings for each section ; in the arranged channels, the volume of deposits dislocated from the banks was also measured. As the point bar microrelief and especially the deposits structure and grain size are highly significant for finding out the flood plain and meander evolution, we carried out complex analyses on several point bars and convex banks. The analysis was made according to the H. E. Reineck and I. B.

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* An important contribution to the topometric surveys was made by technicians V. Frunzete and I. Chiorcea ; we are particularly grateful for their help.

Singh method (1975, p. 229—260) and there are two diagrams exemplifying the cases of the Muntenii de Jos and Banca point bars (Fig. 3). Thus we obtained a pool of data enabling us to correlate some aspects of meander geomorphometry and morphology with those of sedimentology and morphogenetic balance.

2. PRESENT EVOLUTION CONDITIONS OF THE BÎRLAD RIVER CHANNEL

The Bîrlad river is 247 km long and has a 7395 km² large hydrographic basin. Between Rediu (Vaslui) and the junction with the Siret river (the studied area) along 214 km, the channel has a mean sinuosity coefficient of 1.6 and for some channel segments the coefficient is over 3. This reflects a hypertrophy of the sinuosity phenomenon reflected by the presence of many "gooseneck" meanders; according to S. A. Schumm's classification, (1963), the Bîrlad river can thus be included in the category of meandering and sinuous rivers.

The river has a torrential character (I. Ujvári, 1972) and over 70% of its annual discharge occurs in spring and summer. The high torrential character as well as discharges of maximum influence on the dynamics of the channels morphology may also be found when analyzing the maximum, mean and monimum discharges at different assurements calculated on the basis of several data, over a 25-year period (1952—1977) (Table 1).

Table 1

Annual mean discharges with different assurements (Bîrlad river)

Hydrometric station	Annual mean Q (m³/s)	Annual mean Q with different assurements			
		50%	60%	70%	80%
Vaslui	2.37	2.00	1.60	1.20	0.85
Bîrlad	3.37	4.60	3.80	2.80	1.60
Tecuci	9.01	8.00	6.50	5.00	3.50

Table 2

Maximum and minimum discharges with different assurements (Bîrlad river)

Hydrometric station	Max Q at .... of:				Minimum mean monthly Q with 95% assurement (m³/s)	Min. mean daily Q with 95% assurement (m³/s)
	0.1%	1%	5%	10%		
Vaslui	755	480	240	205	in the range of several litres	0.000
Bîrlad	860	545	340	250	0.045	0.010
Tecuci	705	480	320	250	0.200	0.110

Once every 3 to 5 years, the river dries up downstream of the town of Bîrlad. On the other hand, the rate of high floods and floods (I. Ichim, 1968), points to the fact that at least twice a year, bankfull or near bankfull discharges may occur; they are the most important sequences in the channels dynamics. The possible alternation between dry-up or minimum flow phases and bankfull discharge sequences at a river, the basin of which is covering more than 4000 km ^{2} (which is the surface reaching downstream the Bîrlad town), is highly significant for the morphoclimatic and morphogenetic conditions — namely the alternation between scour and fill sequences occurring, in this case, at one season interval. The phenomenon is enhanced by the high rate of the slopes erosion as compared to the transport capacity of the main stream which results in a longer "fill" sequence as against the "scour" one.

An important element in the meander evolution of this river is also the anthropic influence, materialized in : a) a considerable decrease of discharges on some meandering channels and b) the formation of new channels. In the first case, underfit channels result ; this is a most often quoted phenomenon in the literature, starting with W. M. Davis (1913) and bears a special significance on the study of the channels paleomorphology. In the second case, we cannot talk about a phase of minimum decrease of the factors involved in the meander formation, as this is known from the "theory of minimum variance". Therefore, the newly created channel undergoes a strong evolutionary process ; it is far from striking a dynamic balance, marked by a wide variety of the hydraulic geometry. The area we considered, between Rediu and Crasna, presents both types of anthropic influence (Fig. 1).

3. THE PROBLEM OF MEANDER GENERATIONS

In relation to their evolution, the meanders of the Bîrlad river are divagating while in relation to the form of representations in a plane they are : regular, irregular and sinuous.

Regular meanders or in a dynamic balance impose uniform conditions (J. F. Friedkin 1945, S. A. Schumm 1977). In the Bîrlad river valley such meanders are rare. We took two examples : two successive meanders in the area of the Muntenii de Jos locality and a meander near the Roşieşti locality (Fig. 1, A—b and B). The radius of curvature of the meander loops varies within very narrow limits (50—70 m), the distance along a meander between 400—700 m, the sinuosity coefficient between 1.8—3.1 and the deviation angle reaches the maximum value of 125°, when it is equal with ω, a characteristic of the gooseneck type of meanders. The tendency of the exemplified meanders to come close to a dynamic balance is also confirmed by the graphic representation of the deviation angle φ alongside the s distance, along the meander, following a sine-generated curve (Fig. 2). This expresses the most stable form of meanders (W. B. Langbein and L. B. Leopold 1966).

As regards the channel sinuosity type the irregular meanders are prevalent all along the Bîrlad river and the size of elements varies within very large limits (Fig. 1, A—C). This aspect points to the lack of a dynamic balance in the channel evolution and to real possibilities for natural changes of the present flow. The possibility is generated by the process of agreement between the mutual relationships established among the evolution factors in view of achieving the so-called "minimum variance".

The sinuous meanders also constitute a characteristic of this river (Fig. 1A). However, we should point out a recently found aspect (by I. Ichim and Maria Rădoane, 1979), namely the meander generations.

It is conspicuous that in a channel area such as that shown in Fig. 1A, smaller meanders are to be found on a larger bend, some of which are already in a dynamic balance phase. Apparently, the phenomenon seems to contradict some of the already discussed relations. In fact, there are two meander generations (Ist rank or elementary meanders and IInd rank meanders, which may include a series of elementary meanders along the bends).

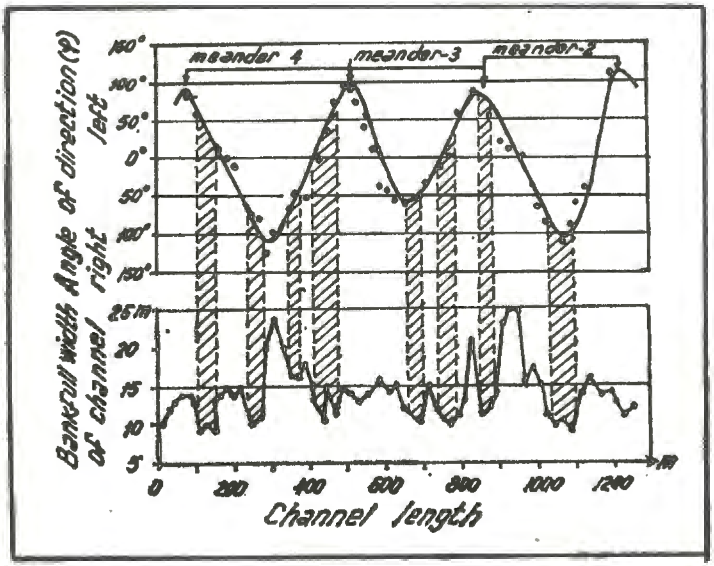

Fig. 2. — The variation of the deviation angle and of the channel width along the meanders in the Muntenii de Jos area (the "b" area shown in Fig. 1).

Ist rank meanders are a direct consequence of the present evolution conditions of channels whereas IInd rank meanders represent the effect of conditions characterized by a significantly more important flow than the present one. Thus, present meanders are formed under conditions of channel underfitness, as against the phase of creation of the IInd rank meanders.

Taking into account the differenciations imposed by the emergence of the underfitness phenomenon in the meanders evolution G. H. Dury (1970) brought forward evolution phases of the Pleistocene. We may also mention, in support of the meander generations idea that present talwegs have a permanent tendency to meander formation within the area of Ist rank meanders. Therefore, a channel "pre-meandering" stage can be underlined. The talweg course in the meander loop of the Bîrlad channel in the Banca area is clearly pointing to this phenomenon (Fig. 3). The diagram of some morphological relations on meander generations (Fig. 1) confirms the already known laws within the framework of the minimum variance theory, allowing us to draw the following conclusion: meanders vary morphodynamically never morphogenetically.

4. THE CHANNEL MICRORELIEF AND THE MEANDER-FORMATION PROBLEM

Researches undertaken thus far inferred that there are many reciprocity relationships between the meander formation processes and the channels microrelief, in the main, point bars, riffles, pools, etc.

In the meander-formation process there is a constant trend toward striking a balance between erosion and accumulation. G. M. Wolman and L. B. Leopold (1957) showed that the volume of deposits eroded from the concave bank is approximately equal to the volume of deposits accumalated in point bars. On the other hand, the character of the point bar deposits (grain size, sorting, structure, bedding, etc.) reflects specific dynamic phases in the meander evolution and in the first place, the phase of bankfull discharges.

In this context, observations on the point bars of the Bîrlad river led us to the following findings:

— generally, active point bars are small, sometimes they are merely "stickings" of deposits to the convex bank;

— morphologically, point bars are characterised either by an alternation of ridges and swales parallel to the river flow (Fig. 3), cross section and the topographic chart, Muntenii de Jos point bar), 1.5—2 m wide and with 0.5 — 1 m denivelations or by 0.8 to 5 m wide successive steps (Fig. 3 and Photo 1, the Banca point bar). Both ridges and steps are phases of the channel migration to the concave bank, when the ridge or the superior step is comprised in the river meadow;

— the channel migration rate to the concave bank estimated on the basis of the analysis of certain point bars is 1.4 cm/annually;

— from the grain size point of view, deposits are characterised by the prevalence of sand fractions, generally smaller than 0.2 mm in diameter. A cross section displays a gradual distribution: at the bottom, medium sands, in the upper part — silts and clays (Fig. 3 the Muntenii de Jos point bar). This grain size distribution, typical of a single accumulation phase was identified several times in a single section due to the point bar deposits, proving that the formation of point bars along the Bîrlad river was a several stage phenomenon. Thus, in case of the Banca point bar, a grain size analysis of a cross section in the point bar step included in the meadow pointed to at least three accumulation phases that we marked as Ist, IInd and IIIrd (Fig. 3). The phases were clearly expressed in the cross section, due to the uneven distribution of the medium diameter (*Md*), of the 75% diameter on the grain size curve (Q_3) and of the 25% diameter (Q_1). At the beginning of each phase sediments have a better sorting index than those at the end of the phase; this aspect is clearly emphasised by the grain size curves type.

The situation is much more complex in the accumulation of the Muntenii point bar (Fig. 3, the Muntenii de Jos point bar), where the section in deposits is also displayed in a longitudinal section (along approx.

260 m). There is a general gradual location of the medium diameter *(Md)* of sediment particles, from rough (maximum 0.2 mm) to fine (to 0.005 mm) both in a cross and longitudinal section. In the cross section, the accumulation phases are distinguished by the variation of the medium diameter (Q_2) and of the Q_3 and Q_1 diameters; the sorting index is hardly approaching the 1 value, which points to the fact that deposits are fine and relatively homogenous, a good sorting being prevented. This may be one of the conditions which, according to laboratory experiments carried out by J. F. Friedkin (1945) and S. A. Schumm, H. Khan (1972) enabled the development of regular, symmetrical meanders in the Muntenii de Jos area (Fig. 1 B).

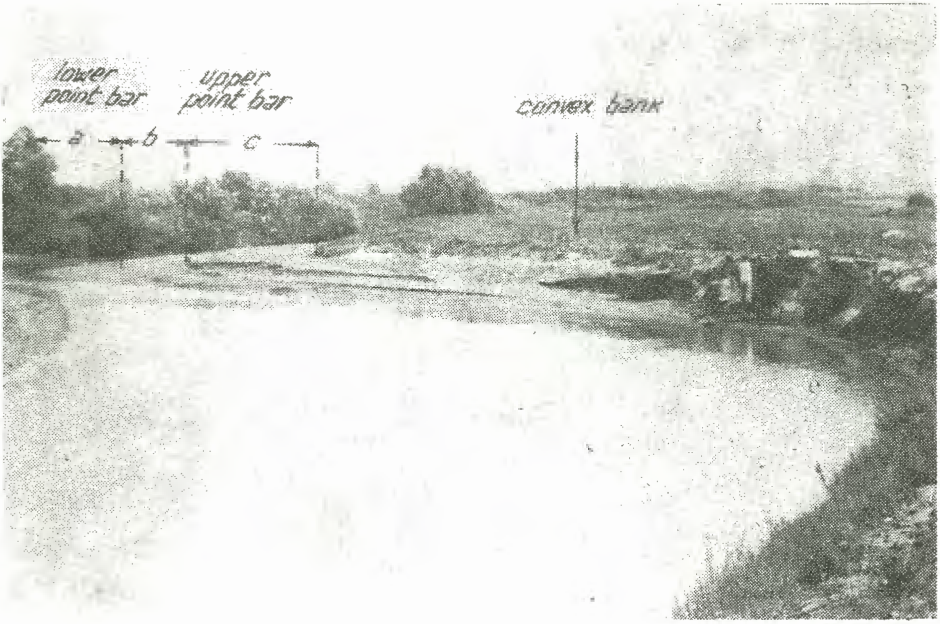

Photo 1. — Active point bar terraced in the Banca channel zone.

It is more difficult to distinguish continuous accumulation phases in the longitudinal section on account of both the fine character of deposits and especially the discontinuous and lense-like character of accumulations. This is emphasised by the ripple (Photo 2) and megaripple cross bedding, the latter being 40—70 m long (Fig. 3, sedimentary structures in the Muntenii de Jos point bar). This type of structure was also found in the meadow deposits, intercalated with deposits disposed in thin layers.

All the aspects mentioned so far are clearly evincing the fact that meadow deposits are firstly the effect of lateral accumulation of rivers and are barely due to flood processes. In connection with this phenomenon G. M. Wolman and L. B. Leopold (1957) claim that, in general, 80% of meadow deposits are accounted for on the lateral accumulation and about 20% on flood phenomena. Hence, the flood plain is a river creation in the process of steady recession of a bank and accumulation on the other, with deposits from the same meadow which is continually destroyed and rebuilt.

2. The approach to the survey of the riffle and pool microrelief was made on the basis of detailed topometric measurements * on five channel areas of different origin, configuration and evolution conditions: the typical rectilinear Vaslui (Rediu) area; the Banca meander loop section; the channel area covering an afforested zone — Ghidigeni; the arranged area — Tecuci (Fig. 3); the Pain canal sector (Fig. 1 F).

Photo 2. — Ripple cross bedding in the point bars deposits included in the meadow, Banca zone.

Thus we were able to make a precise location of the channel microrelief and of the thalweg course. The conclusions we reached may be summarized as following:

Both topographic plans and the longitudinal sections of the exemplified areas (Fig. 1 F, Fig. 3) show clearly that natural arranged rectilinear or meandered channel beds present a conspicuous alternation of deeper incised and higher raised areas, in a regular succession. By relating this succession of channel denivelations to the bankfull width of channel, we obtained the ratio established by L. B. Leopold and M. G. Wolman (1957) according to which the distance between two successive riffles is 5 to 7 times the channel width. This finding determined us to associate this denivelation microrelief with the riffle and pool ones, acknowledged terms for such microforms in the channels with mobile deposits. Our observations

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* As the scale of maps was reduced by photography, the curves of 0.25 m equidistance were not represented.

pointed out the same regular succession of denivelations in channels without an accumulation bed; therefore we think that the elements for defining the riffles and pools should be reviewed taking into account the context of erosion forms as well.

Thus, the channel in the Vaslui (Rediu) area, typically rectilinear, with a mean width of 12.4 m, with banks with deposits of clay-sand meadow, with mobile deposits on the channel bed (especially silt layers thinner than 50 cm) has, in certain zones, a tendency to get wider, in alternation with other areas where it gets narrower. The larger areas (up to 14—16 m) coincide with zones where the ridge area of riffles is located while the narrower (10—11 m) correspond to sectors of pools (microdepressions). The riffles have a 60 m mean length, are slightly asymmetrical (Fig. 3, longitudinal section), the upstream zone is less long and has a higher declivity (2.2.%) as compared to the downstream one (1.6%). The denivelations on the thalweg line reach 100 cm downstream the riffle and 60 cm upstream. The riffles positions induced a sinuous thalweg course on either side of the channel bed.

The Banca area represents a meander loop of natural channel downstream of which the channel course was modified. The channel is typically sandy, with a 26 m mean width. A characteristic of this area is the location of two microdepressions (pools) in the maximum curvatures of the bend; they differ from the other pools emphasized by the longitudinal section by a higher depth (80—90 cm as compared to 20—40 cm, respectively).

In the rectilinear channel areas there are two upper zones as against the curvature microdepressions. On the surface of this riffle a succession of another generation of riffles and pools may be noted, which si located on both sides of the thalweg sinuosities. Riffles have a mean length of 108 m, the upstream part shorter (45 m) and steeper (0.9%) than the downstream area, with a 62 m mean length and a 0.7% declivity. The distance between two successive riffles varies between 250—290 m.

The Ghidigeni area is a natural channel with a 17 m mean width; it covers a meadow forest, which bears an important influence on the banks morphodynamics (the channel width is undersized as compared to the discharge of that particular section), which has determined a marked deepening of the channel and also a shifting to the horizontal plane; this fact induced the inclusion of trees in the channel bed (Photo 3). The riffle and pool succession followed the same adaptation in relation to the channel width; the distance between two successive riffles is of 110—150 m shorter than that in the upstream Banca area. The mean length of a riffle is of about 120 m, with a high declivity of slope upstream (3.4%) as well as downstream (3.2%); the maximum depth of pools in relation to the ridge of a riffle is of 3.50 m downstream and 3.30 m upstream and can be found in the meander loops of the channel.

The Tecuci area is a sinuous channel, with banks sloped with concrete slabs; it also displays a riffle and pool relief; we shall not make a detailed appraisal as we do not know the impact of the authropic factor on the modelling of the channel bed.

The Paiu canal (Fig. 1F), built in 1974, with a constant width of 16 m, has evolved according to the same above-mentioned pattern, namely

Photo 3. — Bankfull channel, the Bîrlad river in the Ghidigeni area.

Photo 4. — Riffle and pool succession in the canal of the Bîrlad river.

the succession of riffles and pools, very even spaced (Photo 4). The riffle length is 30—60 m, the pools depth is 80—100 cm, the distance between two succesive riffles is 100 m. We took examples for the 5 natural and artificial areas in order to demonstrate that the riffle and pool relief is not *exclusively an accumulation relief*, as it has so far been defined : the riffle is a "form of lobate accumulation with slopes inclined towards the banks and the deposits grain size is rougher than that of the pool deposits" (L. B. Leopold et al. 1964, p. 203). In fact the authors pointed only to the channels with mobile deposits, thicker than 0.5 mm in diameter. In conclusion, we consider that under very different evolution conditions, the channels have a similar microrelief, determined by the riffle and pool distribution which may consist of both accumulation and erosion forms while thalwegs follow a winding course. The erosion *riffle-pool* association and the thalweg sinuosity are fully evincive of a permanently impending state of meander formation. Some assessments of the meander formation process could be made if applying, on the one hand, the ratio between two successive riffles and the bankfull width of the channel and, on the other hand, if knowing the significant part played in the meander formation by the two microforms (riffle in the inflexion area of bends and pool in the maximum curvature zone). The diagram presenting these ratios for the 5 analyzed channel areas is highly significant from this point of view; a special discussion here would be superfluous (Fig. 3).

5. ANTHROPIC INFLUENCES ON MEANDER FORMATION

Under the conditions of the river channels arrangement, at least two typical situations of anthropic influence on meander formation emerge; first, by reducing discharges on the natural channels, as a result of the deviation of a huge amount of water along artificial canals or by intensive use for irrigations; secondly, by determining the formation of new meander areas, by creation of new canals and channels.

All along the Bîrlad river valley new channel areas have been arranged, old channels were rectified, so that both types of influence are fairly well felt. We have further developed researches on these influences in the area between Vaslui and Crasna where, along 20 km the Bîrlad flow was deviated on a new canal digged in the meadow deposits (with no concrete slabs or bricklaying sloping). Thus, the old channel flows only the waters from the Vasluieț river, a tributary of the Bîrlad river downstream of Vaslui.

In this case the old channel is underfitted in W. M. Davis (1913) acception of this process. The Vasluieț contribution cannot ensure, as in the case of the old Bîrlad channel, the alternation of "cleaning" and "colmatage" processes. Consequently, a decalibration of the channel occurs, reflected not only by the increase of the deposit volume in the channel, but also by the accumulation process in the meanders concavity. The comparison between the representation of the sinuosity index variation and the volume of accumulations in the channel (Fig. 1D—D', diagrams) points to the fact that the meander formation phenomenon is still characteristic of this channel. At the same time, we may notice the high accumu-

lation rate, indicating the emergence of a morphodynamic imbalance – materialized in the "disappearence" of the meander formation processes in the Bîrlad channel; however small meanders may emerge on the bends of the old channel.

As regards the arranged canal, the course of which is shown in Fig. 1E–E', we assessed the volume of deposits eroded and accumulated in the bank areas and established the balance; we found that while a banck was more eroded, the opposite one underwent less stronger erosion. This enabled us to locate the areas where there is a tendency of formation of meander loops. The erosion balance left bank-right bank along the canal points to the fact that a less eroded bank corresponds, in the same area, to a more eroded one. This expresses the incipient state of meander formation in the canal. A detailed map of the microrelief was drawn for a 200 m long segment, which emphasises an almost perfect succession of riffles and pools (Fig. 1F). We must note that in the area following immediately downstream the riffle ridge, the bankfull width of the channel is larger. The situation shown in photo 4, where a succession of four rapids (ridge areas of the riffles) may be seen, is highly significant, the more so as the area is exempt from a selective erosion of channels. In other words, the channel microrelief, the variation of bank erosion and thalweg sinuosities point clearly toward an acceleration of the evolution of the meander formation in the canal.

There is a possibility to foreshadow (Fig. 1E–E') that in an advanced future stage of the evolution of canal sinuosity, 70 m long meanders could occur.

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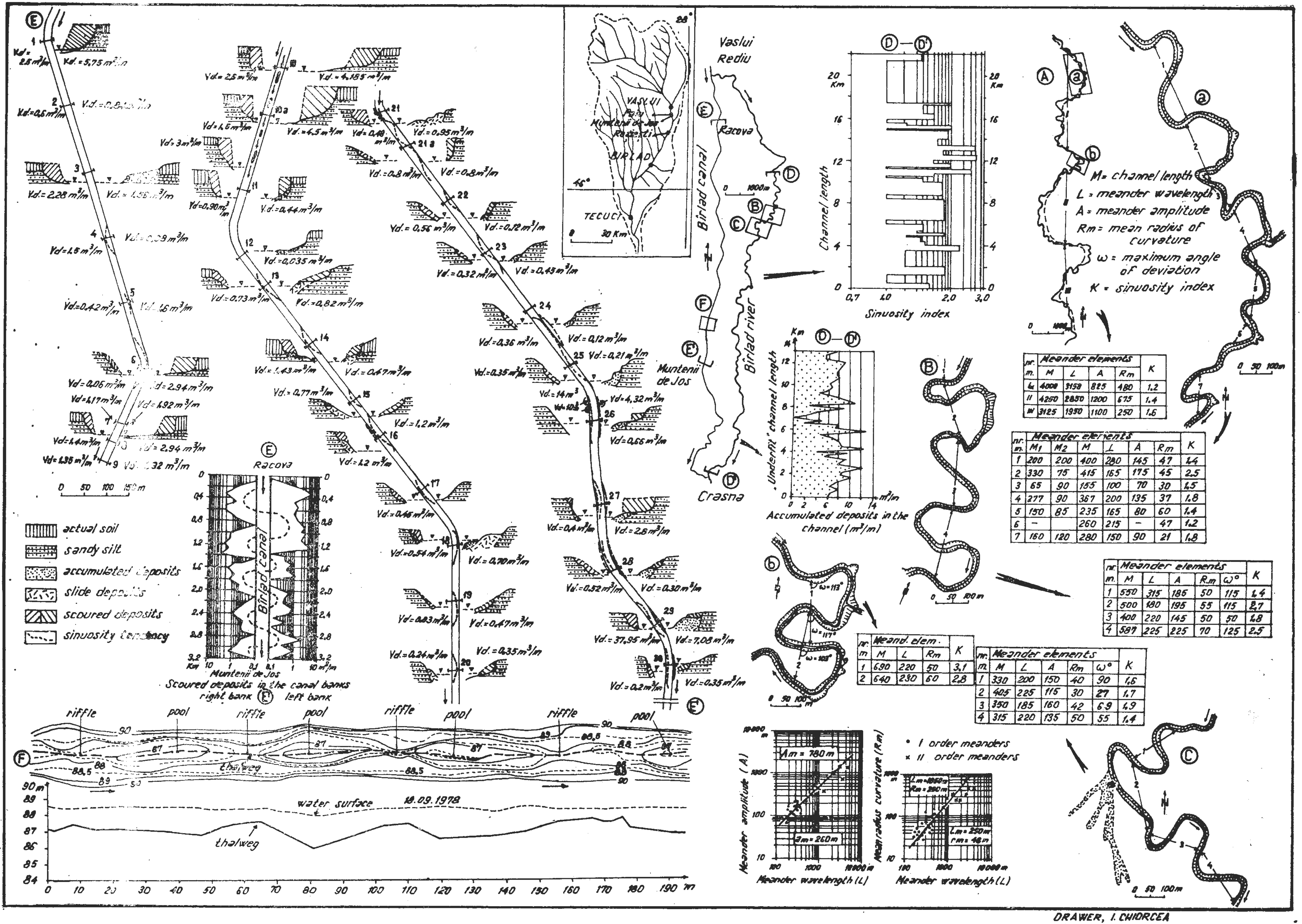

nr. m.	Meander elements M	L	A	Rm	K
I	4000	3158	825	480	1.2
II	4250	2850	1200	675	1.4
III	3125	1950	1100	250	1.6

nr. m.	Meander elements M1	M2	M	L	A	Rm	K
1	200	200	400	280	145	47	1.4
2	330	75	415	165	175	45	2.5
3	65	90	155	100	70	30	1.5
4	277	90	367	200	135	37	1.8
5	150	85	235	165	80	60	1.4
6	–		260	215	–	47	1.2
7	160	120	280	150	90	21	1.8

nr. m.	Meander elements M	L	A	Rm	ω°	K
1	550	315	185	50	115	1.4
2	500	180	195	55	115	2.7
3	400	220	145	50	50	1.8
4	587	225	225	70	125	2.5

nr. m	Meand. elem. M	L	Rm	K
1	690	220	50	3.1
2	640	230	60	2.8

nr. m.	Meander elements M	L	A	Rm	ω°	K
1	330	200	150	40	90	1.6
2	405	225	115	30	27	1.7
3	350	185	160	42	6.9	1.9
4	315	220	135	50	55	1.4

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Fig. 1. — The Bîrlad river. Types of meanders and anthropic influences on meander formation (explanation in the text).

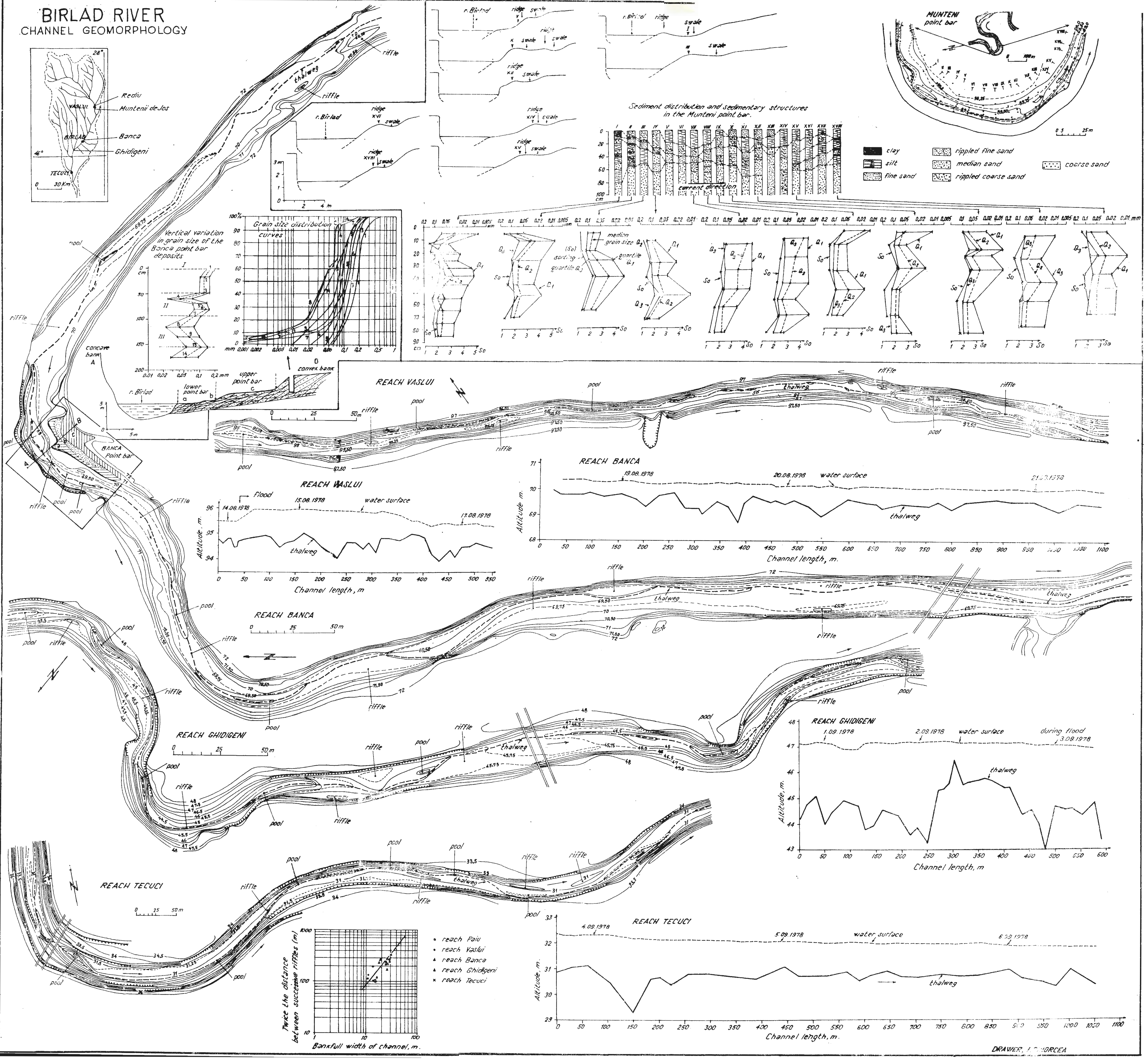

Fig. 3. — The Bîrlad river. The geomorphology of the minor channel.