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GEOMORPHOLOGICAL REMARKS ON THE TROTUȘ CHANNEL DOWNSTREAM ITS CONFLUENCE WITH THE TAZLĂU

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Observations sur la morphologie du lit mineur de la rivière Trotuș en aval de la confluence du Tazlău. Dans la zone subcarpatique la morphologie du lit mineur du Trotuș est dominée par un secteur sinueux sur les premiers 16 km en aval de la confluence du Tazlău et un secteur à plusieurs bras jusqu'à la confluence avec le Siret. Les éléments qui définissent ce changement mettent en évidence l'existence d'une zone de seuil intrinsèque (fig. 1), associé à un accroissement du transfert des quantités d'alluvions. La dynamique en plan longitudinal (fig. 2B) et vertical (fig. 4) du lit mineur de Trotuș est contrôlée par deux facteurs importants : les conditions climatiques transférées au niveau de la tendance d'accroissement du débit liquide et la lithologie des dépôts pliocènes-quaternaires de la zone que la rivière Trotuș traverse jusqu'à la confluence avec le Siret.

Approach to the problem, data processing and analysis. Between the confluence with the Tazlău and its flow into the Siret, the Trotuș river streams along some 50 km through a Subcarpathian region. When entering the studied sector, its channel is controlled by a 3 948 km^2 drainage basin, mean multiannual discharge of 31.1 cum/sec and a suspended sediment load of 38.1 kg/sec. Before the Trotuș runs into the Siret, the drainage basin surface rises to 4 370 km^2, but discharge volume changes are not significant.

As regards the river channel pattern, one distinguishes a *sinuous* reach along the first 16 km downstream its confluence with the Tazlău and a *braided* reach over the next 44 km up to the point where it flows into the Siret river.

In connection with the above we wish to bring into discussion the following : a) the elements defining the transition from sinuous-to-braided reach in the studied sector ; b) geomorphology of the braided reach ; c) vertical channel dynamics. Researches are intended to afford some preliminary conclusions on sediment sources and the sedimentation regime of the Adjud reservoir (planned on the Siret river downstream its confluence with the Trotuș) which will have a volume of 340 million cum ; at the same time, they could be indicative of the future evaluation of the channel.

The data processed by us were provided by :

— river channel patterns obtained from geomorphological mapping and measurements on maps scale 1/5000, the braiding width of channel (L_d, in meters), braiding index (I_d), length of channel bar long axis (L_o, in meters), maximum width of channel bars (l_o, in meters), braiding angle (θ, in degrees), wavelength of braided channel (λ, in meters), active surface of the channel (S_a, in sq meters), of the slope (I, in $^0/_{00}$) ;

— horizontal channel movement, yielded by measurements of geomorphological maps from the years 1896 and 1974 ;

— channel deposit grain size, from samplings and laboratory analysis of sediments from 24 channel sections, assessing the median diameter (d_{50}), sorting (S_0), skewness (S_k), and kurtosis (k) of the graphic distributions ;

— regime of channel runoff and sediment transport as well as channel bed dynamics, revealed by the measurements made in Vrînceni section.

Elements characterising a sinuous-to-braided channel change. A major defining element is the plane geometry of channels. We have found, however, that a differentiation in the variation of such elements as : river slope, channel width, active channel surface, sediment facies, rate of lateral channel movement occurs in the framework of this geometry. The greatest impact is exerted by slope variation, fact that confirms one of the conclusions reached by S. Schumm, H. Khan (1972), namely, that both slope increase and decrease may become the *intrinsic threshold* in changing the river channel pattern.

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Notable, for the whole channel reach downstream the confluence with the Tazlău,there is a distinct discontinuity of the slope at the contact between the two types of channel (Fig. 1): a generally positive increase of the braiding index, active channel surface and channel lateral movement rate; a decrease of the median diameter of gravel-bed channels (Fig. 1). A detailed

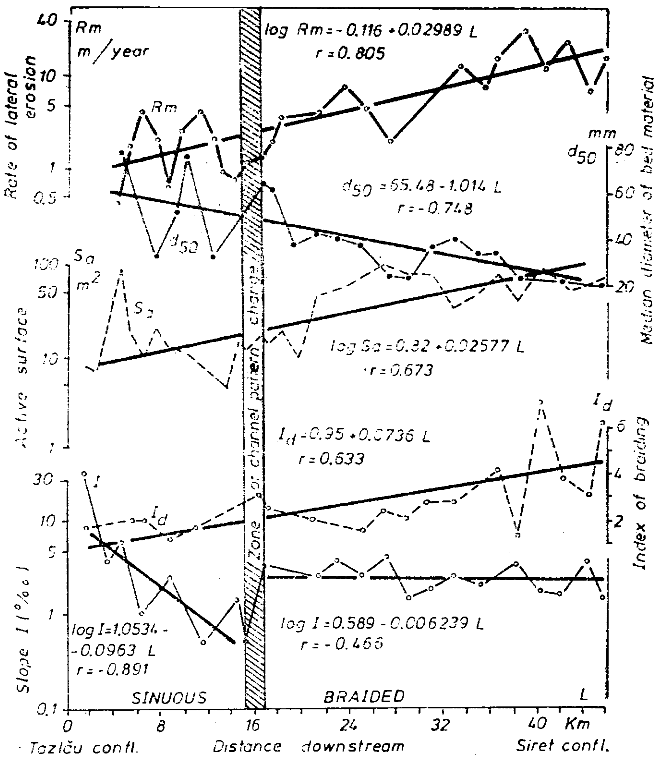

Fig. 1. — Variation of some elements along the Trotuș river characteristic of a sinuous-to-braided channel change.

analysis of channel deposit grain-size indices indicates that at the level of the sediment facies, the transition between the two channel types takes place over a longer distance (about 6—8 km). This transition is reflected in a sudden fall in the median diameter of gravel and skewness of distribution, the sorting index, a relative stabilization of the mesokurtic type of sharp distribution variation (Table 1). Sinuosity itself is connected with a more even distribution of gravel while channel braiding features by a heterogeneous distribution and a lower correlation of grain-size indices with the water factor. This situation might indicate a greater sediment inflow from the lateral streams flowing into the channel, and strongly 'contaminating' grain-size distribution.

From the above we may conclude that a *sinuous-to-braided river channel pattern change reflects a morphodynamic discontinuity and is associated with a change in the sediment flow regime.* Thus, in the Vrinceni section (situated at 8 km donwstream the confluence with the Tazlău, that is in full sinuous reach), a quantity of 1,239,135 cum flows annually. After the valley begins crossing the Subcarpathian area, cut by numerous ephemeral streams that run directly into the Trotuș channel, the quantity of suspended sediment load in the river bed increases by about 7% (estimated from the measurement of some gullies in the Copăcești zone — right slope of the Trotuș river); this quantity proves too much for the transport capacity of this river to be flown through a sinuous channel without a corresponding rise of the discharge. The channel's reaction to the change occurred in the sediment transport is to deposit part of it in

Table 1

Channel deposit grain size in the Trotuș river

Measured section Trotuș river	Median diameter d_{50} (mm)	Trask coefficients (in mm)			Folk coefficients (in phi Ø)			
		Sorting	Skewness	Kurtosis	Mean diameter (Ø)	Sorting	Skewness	Kurtosis
1	52	1.44	1.0	0.30	−5.56	0.981	−0.473	1.483
2	75	1.47	0.65	0.27	−5.90	1.398	−0.728	2.425
3	19	3.83	0.32	0.32	−2.95	2.195	−0.585	0.348
4	40	2.84	0.31	0.35	−4.35	1.258	−0.680	0.625
5	52	2.03	0.81	0.35	−5.33	2.021	−0.554	1.046
6	79	0.65	0.63	0.31	−5.83	3.753	−0.702	2.113
7	30	3.65	0.54	0.34	−4.11	2.791	−0.469	0.434
8	24	4.93	0.33	0.36	−3.61	2.89	−0.488	0.432
9	69	1.88	0.76	0.36	−5.68	1.162	−0.758	1.383
10	61	1.51	0.75	0.32	−5.60	1.06	−0.674	3.127
11	39	2.08	0.73	0.29	−4.80	2.19	−0.542	0.938
12	42	1.89	0.70	0.30	−4.75	2.03	−0.638	1.234
13	40	1.89	0.65	0.25	−4.77	2.07	−0.547	1.24
14	35	2.28	0.42	0.34	−4.47	1.86	−0.67	0.996
15	23	2.78	0.56	0.34	−3.88	2.34	−0.465	0.574
16	23	2.77	0.39	0.35	−3.53	2.41	−1.046	0.508
17	34	2.61	0.43	0.33	−4.25	2.31	−0.615	0.745
18	41	1.72	0.70	0.25	−4.87	2.04	−0.615	1.132
19	24	2.22	0.62	0.32	−4.20	1.98	−0.512	0.739
20	34	1.87	0.78	0.30	−4.60	2.04	−0.776	1.09
21	22	2.95	0.55	0.34	−3.78	3.80	−0.277	1.01
22	22	2.35	0.86	0.32	−4.30	1.66	−0.256	0.918
23	20	2.97	0.57	0.34	−3.65	2.45	−0.717	1.03
24	22	2,89	0. 62	0,31	−3,92	2,35	−0.449	1.09

channel bars and have the channel braided. There is a twofold aspect of this phenomenon : on the one hand, there is an overlapping of intrinsic thresholds, and on the other hand, an eloquent case of "complex response of the system" (in the sense of S. Schumm, 1977), in this case of the channel system to the change of a morphogenesis control factor.

On the morphology of the braided channel reach. The fact that the Trotuș river channel is braided downstream the confluence with the Tazlău over some two thirds of its course requires some specifications concerning this morphological type, the more so as the channel will suffer the direct impact of the reservoir over much of this reach. Besides, as known, gravel-bed channels are anastomosed channels, which makes them have characters in common with deltaic channels. Our analysis therefore has also an applied character, because in this case, anastomosing — a phenomenon developing in channels upstream reservoirs — is already a morphogenetic phase achieved under natural conditions.

In studying the braided reach we followed the analysis suggested by M. Church, D. Jones (1982, Fig. 3A). We wish to discuss the following : a) an outline of the elements defining the braided channel of the Trotuș river, and b) the channel bars pattern.

a) The main elements characterizing the braided Trotuș channel are : braiding index 1.1—7.2 with a tendency to increase downstream ; slope 1—5‰ tending to decrease downstream ; increase of the active channel surface accompanied by an augmented rate of channel lateral movement of up to some 40 m/year (Fig. 2A) ; downstream decrease of gravel size from 40 mm to 20 mm in diameter (Fig. 1).

b) In the case of gravel-bed channels, braiding is a morphodynamic sign of areas of temporary deposition of the sediment transported by rivers and of great channel instability. One-arm rectilinear channel 'Knots' or segments (R) (Fig. 2B) separating the segments of several-arm channels (D) (Fig. 2B) occur in areas where a stronger sediment transport takes place.

As for the braided channel pattern in the studied reach, investigations led us to the following conclusions :

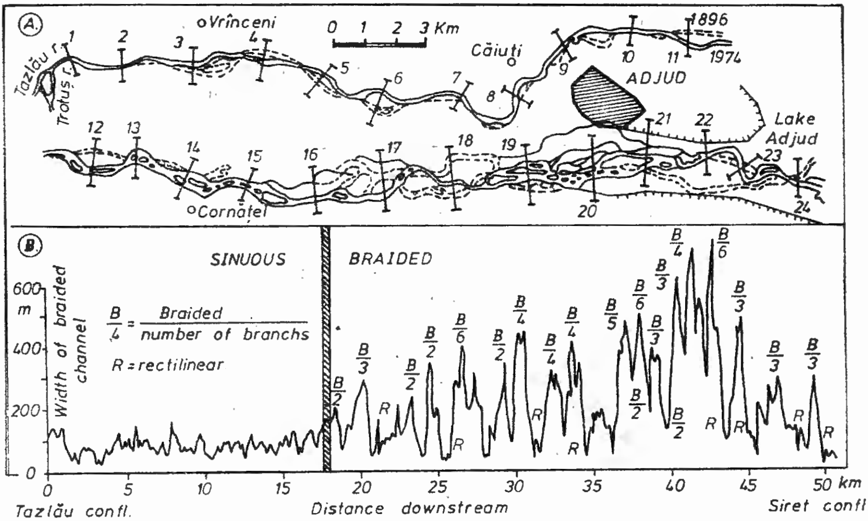

Fig. 2. A. — The course of the Trotuş river channel downstream the confluence with the Tazlău, in the years 1896 and 1974.

B. — Variation of the braiding width of the Trotuş channel downstream its confluence with the Tazlău.

— braiding wavelength (λ) rises to over 2.5 km, decreasing downstream ; between the braiding angle (θ) and the former there is a relation of the type :

$$\theta = 70.302 - 0.0144 ; \quad n = 14 ; \quad r = -0.481$$

n = number of analysed cases and r = correlation coefficient) ;

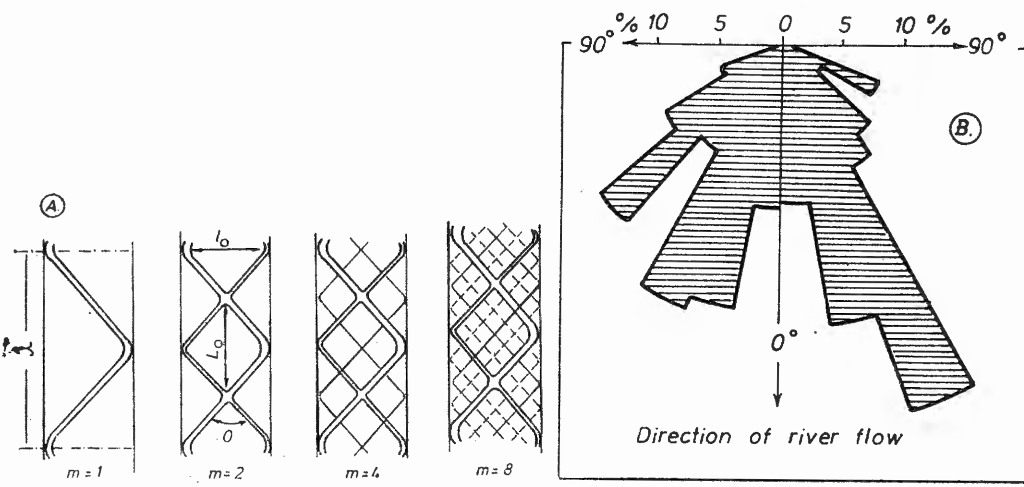

Fig. 3 A. — Hierarchical subdivisions of a braided channel (after Church and Jones, 1982) : m = number of component channels along a wavelength ; θ = braiding angle ; L_0 = length of channel bar ; l_0 = width of channel bar.

B. — Frequency of braiding angles along the Trotuş river.

— the length of channel bars (L_0) tends to decrease downstream from ca 700 m to ca 200 m, according to the relation :

$$\log L_0 = 2.856 - 1.38\ 10^{-5}\ x : \quad n = 54 ; \quad r = 0.543$$

(x = the distance along the river, in meters);

— the length (L_0) and width (l_0) of channel bars changes proportionally to each other along the rivers :

$$l_0 = 82.98 + 0.183\ L_0 ; \ n = 54 ; \ r = 0.581$$

— frequency of braiding angles along the river expresses the downstream dominance of angles between 20—30°. (Fig. 3B).

All the remarks indicate that in the braided reach, the Trotuş channel shows great horizontal instability, with mean lateral movement rates of 6.5 m/year ; this represents up to 250.000 cum/year sediments resulted from river-bank erosion. Our findings are comparable with those reported by G. Wolman, L. Leopold (1957), for various types of global rivers and verify the relation established by J. Hooke (1980) between the channel lateral movement and the surface of the drainage basin.

Vertical dynamics of the Trotuş river. Processing and analysing runoff and sediment transport as well as channel section measurements made over an interval of 33 years (1950—1983) and 20 years, respectively in the Vrînceni sector we have found : a) the channel bed records a metastable variation, with a positive tendency of some 80 cm over the past 20 years :

$$H_p = 192.677 + 0.0524\ t ; \quad n = 821$$

(H_p = channel bed height against "0" marker, in centimeters, t = time in arbitrary units from 1 to 821 over the measured period 1963—1983); b) aggradation takes place against a general tendency of run- off and sediment transport over the past 33 years :

$$\log Q = 1.294 + 0.01078\ t : n = 33$$

$$\log R = 1.054 + 0.02130\ t ; \ n = 33$$

where Q and R are the annual means of discharge and suspended sediment load, and t = time in years. We assume, therefore, that over the past three decades the runoff on the Trotuş river has increased on average, from 19.67 cum/s to 44.63 cum/s (more than twice), while the transport of suspended sediment load rose from 11.34 kg/s to 57.2 kg/s (five times). In the meanwhile, the major tendency of river bed dynamics increased as well (Fig. 4).

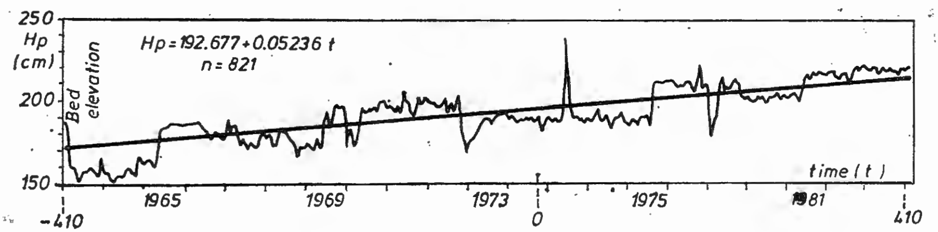

Fig. 4. — Dynamics of the Trotuş channel bed in the Vrînceni sector during 1963—1983.

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