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ON THE ANTHROPIC INFLUENCE TIME IN MORPHOGENESIS WITH A SPECIAL REGARD TO THE PROBLEM OF CHANNEL DYNAMICS

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Le temps d'influence anthropique en morphogenèse en ce qui regarde la dynamique des lits mineurs. L'influence anthropique dans l'évolution d'un système morphologique détermine une discontinuité dynamique. La durée d'existence de la discontinuité représente le temps d'influence anthropique en morphogenèse. Dans l'appréciation du temps on doit avoir en vue : le *temps de réaction* du système et le *temps de relâchement*; à son tour, le temps de relâchement peut être divisé en *temps d'impact* (correspondant à la phase des changements plus forts en système) et *temps d'atténuation* de l'influence anthropique (correspondant à la phase de diminution du rythme des changements en système, par suite de l'influence anthropique).

Theoretical approach. In the development of the geomorphological thinking, *the concept of time* has been reduced, for several times, to the notion of landscape age on the scale of geological evolution. Discussions took place especially in the context of accepting or not the Davisian cycle theory. Alongside the ampleness of the anthropic intervention on morphogenesis, in the direction of performing some works (canals, embankments, dams, melioration systems etc.) by means of which to control, at least for a short period, the processes of deposition and erosion, the problem has been raised of forecasting their working time. The discussion on time in morphogenesis has again become a necessity, discussion which may be considered to have taken place at the same time as the system approach gained ground in the geomorphological research.

Unfortunately, interpreting landscape evolution in the conception of dynamic equilibrium theory came up to minimize the role of time. In this respect, Hack's opinion (1960, p. 94) is well known "the evolution of landform does not depend on time, but is an effect of energy change applied to the system". This interpretation called attention upon it especially as an alternative to the " cyclic time" conception defined by Davis, Schumm and Lichty (1965) stated that between the two conceptions ("cyclic time" and "dynamic equilibrium") there existed no "irreconciliation", as Chorley considered (1962, p. B5), if the limits of space and time in which we analyse the geomorphological phenomena are defined.

For our purpose we shall not take into account the manyfold discussion offered by these two conceptions. But we do know that *the time of anthropic influence in morphogenesis* must be approached in the light of systemic conception, in general, and of the "dynamic equilibrium theory", in particular. Thus, there exists the possibility to establish what Mackin (1948, p. 465) plastically called, "a link" between the engineering interpretation and the geological interpretation of time in the changes of river morphology.

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Alongside the projecting of any arrangement system which implies action on landform, a forecast on its working is undertaken. But this cannot be considered a defining of the time of anthropic influence in morphogenesis. The best proof, in this respect, is the existence of some functional dams even somewhere at the beginning of our era (e.g. the Proserpina and Cornalbo dams, both in Spain, which had been built in the time of Emperor Trajan-cf. Chiriac et al., 1976), while recent dams became unfunctional shortly after they started to work.

Defining the time of anthropic influence in morphogenesis has not only a practical importance, but bears also on the thorough theoretical study of landform dynamics as we have to face an anthropic influence of a degree never met before. As an example, over 50 % of the flow of the world's rivers is controlled by dams, while in our country, the general outlines of the arrangement of drainage basins will be completed up to 1990. Taking into consideration the systemic conception, we must accept that the dynamics of the present processes occurs largely through *control systems* (arranged drainage basins, respectively) which, because of economical reasons, will be maintained by man — as far as possible — at the level of some optimal systems, at the level of meeting to the best the purpose of arrangements. On the other hand, we cannot expect radical changes of the morphoclimatic conditions. Consequently, controlling the dynamics of some of the processes may have some implications which can hardly be predicted in the actual stage. This, once more, justifies the necessity for such discussions.

For the theoretical approach to the notion we refer to, the following have been taken into account:

— Time may be recognized in the morphological changes, but in the rate of processes, too;

— A river is a *process-response system*, that is to say a continuous state of mutual relations between a *cascading system* and a *morphological system*;

— The state of enthropy of a morphological system is expressed, in the first place, at the level of the value of landform energy, of the slope, in general;

— For the evolution of a morphological system, the anthropic influence represents an *extrinsec threshold* (cf. Schumm, 1977). This causes radical answers in the system. So much the more we must consider the *reaction time* and the *relaxation time* of the system (in the conception of Chorley and Kennedy, 1971, p. 240). We have also in mind the possibility to divide the relaxation time in an interval of rapid changes which take place in the first part of the system reaction, what we call *time of anthropical impact in morphogenesis* and the interval of influence reduction, which we call *smoothing time*.

— At the scale of the geomorphological evolution time of a fluvial system, we may consider (according to the dynamic equilibrium theory) that the moment of the anthropical intervention in morphogenesis, the variables that condition the evolution of the forms are in a relative equilibrium. By means of building dams [1] and other regularization, sudden

[1] Dams cause changes that can be compared to the effect of climatic changes (Leopold et al., 1964, p. 453).

changes in the cascading system occur. In the water and sediment transport there appears a dynamic discontinuity, which moves along the channel and, in fact, materializes erosion and deposition as a reaction of the morphological system and the cascading system.

Concluding we may say that: *the anthropical influence time in morphogenesis represents the manifestation duration of the dynamic discontinuity introduced by the anthropical intervention into the morphological system.* The extent to which this discontinuity manifests itself depends on the order of magnitude of the fluvial system and on the ampleness of the influence. As it is a dynamic system which is also the control element of time and its space of manifestation, is represented by the river slope. The moment when the river slope regains its initial value, characterizes the reestablishing of the dynamic equilibrium in the system and it marks the end of the time of anthropical influence in morphogenesis, a fact that means: *reaction time* + *relaxation time,* together with the two sequences proposed by us, relaxation time = *impact time* + *smoothing time.*

Examplifications. We propose some approaches to appreciate the anthropical influence time in morphogenesis regarding the effect of dams and regularization in channel dynamics.

1. As to the *influence of dams on channel dynamics* we chiefly notice two dynamic discontinuities: a) in the upstream dam, characterized by channel aggradation; b) in the downstream dam, characterized by degradation and in some cases by aggradation.

a) On the basis of own researches and interpretation of data from the literature, we calculated the time of anthropical influence of the channels from several above dams. As appreciating element, we used the relation between the original slope of the channel and the deposition slope above the dam. This element is frequently used in the practice of forecasting the arrangements of this type (Ionescu and Răzvan, 1974). Analysing the resulted curves (Fig. 1), we noticed that in the first 5–7 years an accelerated aggradation of the channels took place accompanied by a shifting of the deposition areas upstream and by an evident slope reduction. The equation of curve $y_1 = 0.22x$ may by considered, in this case, the limit of the time of anthropical impact in morphogenesis. Latei on there could be noticed a tendency to approaching the situation when the final slope (y) comes to be equal to the initial slope (x) and the condition of the equilibrium present before the arrangement is attained. Thus, curve $y_2 = 0.59x$ renders the situation 30 years later, when the reservoirs were in an advanced stage of silting.

b) In the downstream dams, with water evacuation through the dams, the channel attained through degradation, a dynamic equilibrium, either by meeting hard rocks or because of armoring phenomenon. For the case of channel the below dams, with no direct water evacuation, aggradation processes are characteristic, caused by the inflow of load from tributaries which exceeds the transporting capacity of the main channel. As an example let us take the case of the Bistriţa channel downstream the Izvoru Muntelui Dam (formed in 1960, with a storage of 1210×10^6 m^3), which on a distance of about 15 km recorded an aggradation rate of 12 cm/year (1974–1977), while between 1977–1979 the same rate was of 4.5 cm/year.

The most important sediments appeared in the junction areas ; below them, as the river slope became steeper, degradation was characteristic. We can, thus, presume that the impact time prolongs to 1977. Consequently, it is possible for the Bistrița channel in the downstream dam to attain a state of equilibrium in time when the dam is still functional. After the total silting of the reservoir, another change in the dynamic equilibrium shall appear, another relaxation period [2].

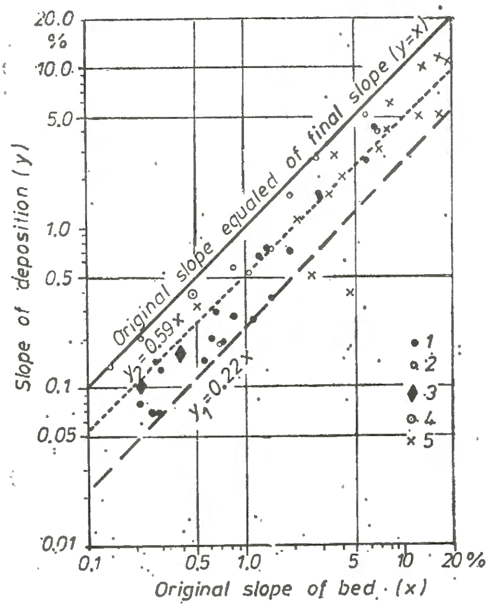

Fig. 1. — Relation between the initial slope of channel (x) and the deposition slope (y) upstream the dams, as a modality of appreciating the time of anthropical influence. *1*, Slopes that appeared after 5—7 years upstream of some small reservoirs in the U.S.A. (cf. the data of L.B. Leopold et al., 1964, pp. 262—265) ; *2*, the same examples after 30 years ; *3*, slopes occurring after 17 years, on the Bistrița channel upstream the Izvoru Muntelui Reservoir; *4*, slopes occurring after 4 years, on the Racova channel upstream the Pușcași river (Bîrlad basin) ; *5*, slopes occurring after 10—14 years through the silting of some small dams on the Potoci torrential basin (left shore of Izvoru Muntelui Reservoir).

2. As to *the effect of some regularizations in the channel dynamics*, two examples are taken into account : a) the evolution of the meanders of the Bîrlad river in the conditions of flow reduction because of retentions and irrigations and b) the evolution of the Sulina channel (the smallest out of the three existing in the Danube Delta) in conditions of rectification.

a) The meanders of the Bîrlad river between Vaslui and the junction point with the Siret river (cca 350 km) has been studied, starting with the analysis of self-correlations between the elements of the meander geometry (Fig. 2), and knowing that these are in direct correlation with the flowing, we identified two dynamic discontinuities in the meander evolution : a stage of palaeomeanders, corresponding to a much greater flow occurring

[1] Detailed aspects in : Maria Rădoane, I. Ichim. E. Florea, N. Rădoane (1979), *Influence of the Izvorul Muntelui Dam on the morphology of the Bistrița channel, below dam* (in press), Proceedings of the "Stejaru" Research Station.

probably at the beginning of the Subatlantic, and another, of present meanders, which is a stage of underfitness of the channel. Reducing the actual flow by more than a half (up to 1985, 9 storages of 261×10^6 m^3 shall be arranged), there will appear a new discontinuity in the meander evolution, a new stage of underfitness of their geometry, respectively. The discontinuities mark the beginning of some relaxation times of the order of hundreds of years. The last discontinuity will represent the beginning of the anthropical influence time.

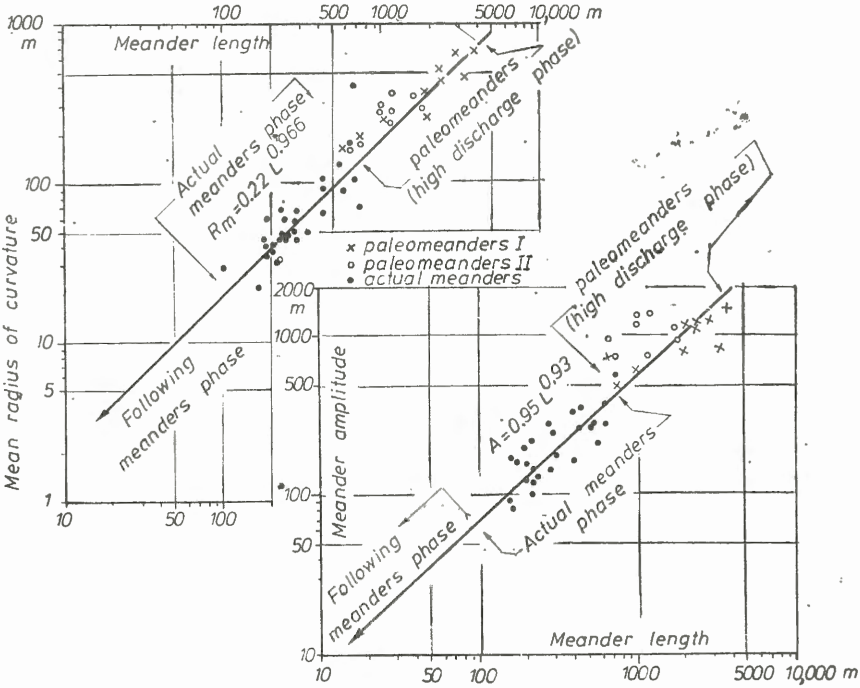

Fig. 2. — Relaxation times marked by dynamic discontinuities in the evolution of the Bîrlad river meanders through flow reduction.

b) Up to 1857, the Sulina channel had a natural evolution : sinuous course, length 83 km, width 250 m, depth 2.5—5 m. Between 1857—1902, the channel was dredged, its banks were rectified and its length reduced to 62.6 km. Thus its discharge grew from 7 % to 17 % of the Danube waters (Bondar and Papadopol, 1973). In the adjustment process of geometry channel variables, the depth increased by 8.5 cm/year. The curves of the depth variations of the Sulina channel (Fig. 3) in three cross-sections, according to data by the same authors, permit the delimitation of the reaction time (1860—1902) and of the period of starting rectifying works of the channel, respectively ; the impact time (1902—1960), a period when the most intense adjustment processes of the channel geometry with new slope and flow conditions took place, culminated with the inversion of the "riffle" and "pool" sectors (e.g. the Big "M" cross-section); after 1970 the evolution of the channel entered the smoothing time, the time of attaining the condition of equilibrium, respectively.

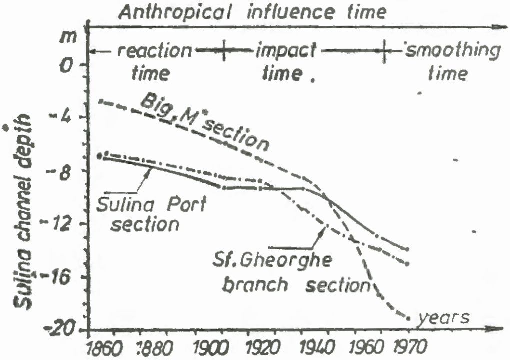

Fig. 3. — Depth variation of the Sulina channel in the conditions of path rectifications (after the data published by C. Bondar and A. Papadopol, 1973).

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