SELF-REGULATION BY THE TARGET AND CURRENT CONDITIONS OF GEOMORPHOSYSTEMS

A.V. Pozdnyakov[1], A.N.Mahinov[2], A.V.Ushakov[3]

[1]Institute of monitoring of climatic and ecological systems SB RAS; [2]Institute of water and environmental problems, Khabarovsk; [3]Tomsk architectural and building university, Russia (synergeia@imces.ru)

Abstract. The attractive target, or attractor can be considered as a spontaneously formed *target (predefined) condition* - a notion introduced in the theories of cybernetics and regulation of automatic systems. As different from live organisms having homeostatic properties, and from cybernetic systems which have a special managing organ and an organ performing the functions of master control, i.e. determining the amount of input and output matter, energy and information, in inanimate self-organizing integral structures, for example, in geomorphosystems, all these functions are performed by *F-* and *D- streams*. Naturally formed systems have no special regulating organs to determine the size of mismatch between the target and current conditions of the system. Regulating functions in them are performed by their own sizes *H,* connected in a negative and positive feedback cycle with the processes of receiving matter and energy in such a manner that with the increase of *H,* the amount of energy brought into the system decreases.

Keywords: geomorphosystems, F-streams and D-streams, floodplain, self-regulation, dynamic equilibrium, desired values.

1. Introduction. Modern methods of the theory of complex systems allow to build mathematical models of complex systems where self-organizing processes are largely determined by nonlinear effects and feedback. However, there exist some factors that exert significant influence on the dynamics of geomorphosystems, but hardly can be adequately expressed in the language of mathematical models. Conceptual modeling allows us to overcome this difficulty. It is based on the methods of synergetic, which, together with the theory of dynamic systems and classical geomorphology, enable to display the dynamics of geomorphological systems.

The most adequate for mathematical modeling of complex systems is the concept of model dynamics based on equilibrium. This concept is based on dynamic equilibrium, the tendency to which is observed in the evolution of all geomorphosystems (Pozdnyakov, 1976; 1988). As an objective law, it is revealed in the evolution of fluvial relief in general, and in river channel processes in particular, demonstrating the ability of these systems to self-organization.

2. General laws of self-organization in geosystems. The study of the dynamics of natural objects of different origin, generalization and interpretation of the gathered material (Pozdnyakov, 1988; 2002), has revealed that the formation and functioning of self-organizing systems occurs in the process of dialectic interaction of streams transferring two types of energy: *F-streams* and *D-streams*.

Energy in F-streams ("energy for itself") is accumulated in different kinds of matter (of which it is formed) and is used for the own system functioning - preservation of itself. A part of energy *(E)* is released as metabolites into the environment.

Energy in *D-streams* is the energy forcedly given *to the outer system Y* (this energy will be called "energy for satellite").

Action *of F-streams* forming the system is irreversibly directed to the growth of its output parameters: size, volume, efficiency, etc. The ability to consume the discharge of matter and energy in *F-stream,* with the system parameters approaching some limiting value, fades. It is due to the fact, that all integral self-regulated formations, for the objective reasons connected with their internal structure and functioning characteristics, have a growth limit. It is set by the action of negative feedback force: the bigger is the system in its volume, total weight, efficiency and other output parameters, the less matter, energy and information, necessary for its existence and development, it accumulates. If the system had reached its limiting size or characteristics, its functions would be reduced to the processing of matter and energy coming from the environment into other forms, and to releasing them back into the space (environment) in the same amount. It would provide for the existence of the integral system, but its growth would stop, and the system would repeat itself in contents, form and size. This mechanism of self-regulation is proper to integral natural and artificial formations of any types: biotic, abiotic (inert), bioinert, etc. Naturally, it is not the system size or efficiency, that play the role of the negative feedback, but the changing consumption of matter (*M), energy (E), information (I)- MEI*, due to the growth of the system parameters. The same amount *of MEI* is shared with time between a constantly growing number of "consumers", making up the system elements.

D-streams, leading to the system disorganization, form a part of matter, energy and information, which is taken away from the new forms of *MEI*, appearing and accumulating in the system, and used by another system being formed. Thus, the system loses an opportunity to reach its highest level of development, but acquires a new, lower limit of *MEI* and characteristic time of development. In other words, some part of *MEI* acts as *F-stream* forming another system.

If *F-stream* is the supply of *MEI* from the environment, *D-stream* is the "compelled" discharge of *MEI* by the system. *F-stream* is formed on the environment, *D-stream* - on the concrete system or sub-environment; *F-stream* characterizes the system as a consumer of resources, *D-stream* characterizes the same system as a resource provider for the needs of other systems. The growth of the system size as approaching the limit characteristics, asymptotically fades, because the discharge of *MEI* in *D-stream* tends to that in *F-stream*. However, the discharge of *MEI* in *D-stream*, with increase in the system size, grows up to some limit value. Hence, *F*-and *D-streams* have their individual limits. Theoretically, in the final variant of the system evolution, the balance of *MEI* discharge in both streams must be established, characterizing the system's state of dynamic equilibrium. In practice, this state is never reached, though the tendency to it is objective, and, can be said, is immanently inherent to all integral self-regulated structures.

An integral system, at a constant discharge of matter and energy coming from the environment, and in the absence of another system creating *D-stream*, is evolving in a deterministic manner and reaches saturation when it achieves some limit, depending on the environment capacity, on the accumulation *of MEI* inside the system, when the discharge of matter and energy on the system's input and output are equal. But, because dynamics of both systems is interconnected, and the evolution *of "consumer"* is always delayed in comparison with *"resource",* their interaction has a clearly expressed oscillatory nature.

3. Quantitative regularities in floodplain formation. Channel process is expressed in the formation of river reaches, rifts, meanders and floodplain. As floodplain is a periodically flooded surface during high

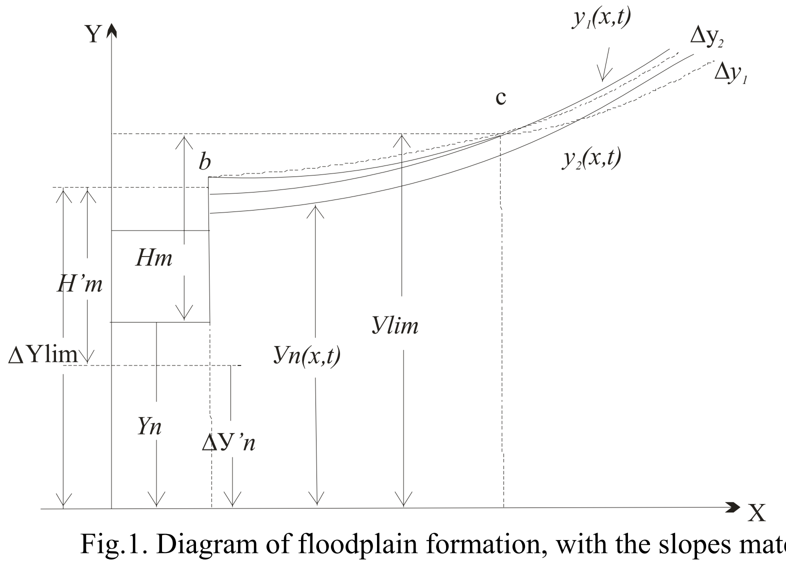

Fig.1. Diagram of floodplain formation, with the slopes material accumulating on its surface

Y_n – river bottom height, changing with time (t); $\Delta Y'_n$ – river bottom height after the river incision during Δ_t; H_m – maximum water level during flooding; H'_m – the same, after the river incision and bottom height lowering till $\Delta Y'_n$; ΔY_{lim} – limit height of floodplain after incision of river till the height $\Delta Y'_n$; Y_{lim} – limit height of floodplain until the incision starts; b – c – surface flooded during high waters, a – distance from the coordinate y to the river channel slope; X_{lim} – limit width of the floodplain, flooded during high waters; $y_1(x, t)$ – slope surface height; Δy_1 – the same, after its lowering; $y_2(x, t)$ – slope foundation surface height; Δy_2 – the same after its lowering due to weathering.

waters, it naturally connects river channel with slopes, being one of boundary expressions of the water stream activity. Floodplain dynamics is inseparable from the channel dynamics. It is formed at simultaneous horizontal and vertical displacement of the river channel, that is at $Y=Y(x, y)$, where x, y - horizontal and vertical coordinates, Y – floodplain height. When $dy/dt=0$ (for not lowering river channel), the river, being displaced in a horizontal plane, leaves behind a low surface, which flooding during high waters (total duration of flooding) changes from the maximum during the initial moment of time t_0 to zero in the moment t_n. In a similar manner changed is the total amount of accumulated material on the floodplain surface.

Thus, the floodplain dynamics is determined by the amount of material $Q(t)$, left as sediment (amount of warp on a unit of area) during the period of flooding, and the amount of material $q(t)$, removed during the time between floods. With the floodplain height approaching some limit height Y_{lim}, which equals the maximal height of floods, $\Delta Q(t) \to 0$, a $q(t) \to max$. From here, we can build a functional diagram of the floodplain height change depending on time (Pozdnyakov, 1988; Pozdnyakov et al., 1983, 1986):

$$dQ/dt = Q\,(Y,t) - q(Y,t) \qquad (1)$$

This equation allows us to describe non-monotonous behavior of different floodplain massifs. As floodplain systems, like all geomorphosystems, are dissipative structures, they should eventually come to a stable condition: $dY/dt=0$. This mode is possible in cases: $Q=q=0$ and $Q=q=const.$

In the first case, the floodplain level would reach the maximum height of flooding and would not be flooded any more. It would cause significant decrease in the amount of material left on its surface as sediments and the system would start to degrade. This variant is purely theoretical, as such conditions, where the streams of matter are absent, can appear only in a homogeneous environment.

The second case characterizes the final stage in the formation of floodplain system as an integral unity in concrete external conditions and determines its dynamic equilibrium. In terms of the theory of dynamic systems, this condition corresponds to the limit cycle. Real floodplain systems never achieve it, but approach to it indefinitely closely, repeating themselves and not changing essentially in their basic morphological and morphometric parameters. Thus, a high floodplain, approaching its limit height, shows morphological completeness. If for any reasons the floodplain surface becomes higher than the limit height Y_{lim}, it will not be flooded any more and will become a terrace, which means that the limit cycle of the floodplain system will be destroyed, as well as the system itself.

The equation (1) allows to take into account the river incision, accumulation of material onto the floodplain from slopes and denudation from the floodplain surface, also the dynamics of mobile inundated islands and vegetative communities on them (Pozdnyakov, 1988).

It is known, that

$$Y_n(t) = Y_n^0 + N_0 m, \qquad (2)$$

and thus, with the increase in height, the amount of flooding is changed proportionally to the difference of the floodplain limit height (Y_{lim}) and its height at the present time $Y_n(t)$ (Pozdnyakov et al., 1983; 1986):

$$\partial N/\partial t = \alpha\,[Y_{lim} - Y_n(t)], \qquad (3)$$

Where α - constant of proportionality.

If the floodplain surface is inclined towards the channel, for example due to the accumulation of material coming from the river valley slopes, the duration of flooding will be not only the function of time, but also of the coordinate x. In this case

$$N(x,t) = \frac{Y_{\lim} - Y_n^0(x)}{m} + N(x) - \frac{Y_{\lim} - Y_n^0(x)}{m}\exp(-\alpha m t). \qquad (4)$$

Using this formula, it is possible to calculate the duration of flooding at a set moment of time at any point of the floodplain surface. Actually, if the surface incline were not disturbed by other factors, in some time it would become horizontal. Thus, this formula allows us to determine the increase of the floodplain height, which surface is complicated with former river-bed depressions or banks.

Usually, the detrital material from slopes comes to the river channel through the floodplain surface. Taking this into account, the floodplain height will vary in time as follows:

$$Y_n\,(x, t) = Y_1\,(x, t) + mN\,(x, t). \qquad (5)$$

By differentiating, we receive the following equation of floodplain height change:

$$\partial Y_n\,(x, t)/\partial t = \partial Y_1\,(x, t)/\partial t + \alpha\, m[Y_{lim} - Y_n\,(x, t)]. \qquad (6)$$

It reflects the interaction of floodplain and slope evolution.

4. Mobile islands. One more form of river channel relief reflecting complex and plural connections in the system "stream – channel" are mobile islands. Formation and development of islands is caused by the combination of self-organizing processes and time-space changes in the external environment. The islands functioning mechanism is expressed in bringing their form into conformity with the river stream's high-speed structure. Evolution of mobile islands is represented as an endless chain of interaction of basic driving forces: high-speed stream, change of external conditions, the island's form (external reflection of its morphogenesis) and the process of its formation. The organizing incentive for the island formation process – the structure of its functional relations. The high-speed field of the stream instantly changes at the change of external conditions. In turn, the changes in the high-speed stream structure change the material transfer process. It leads to the transformation of the island's form within the stream action limits.

Besides, on the river parts with rather constant external conditions (geomorphological, hydrological, geological), quasi-periodicity in the location of islands along the river is noted. This fact can be explained, if to recognize the existence of self-oscillations in the stream, caused by the stream internal properties (Pozdnyakov, 1988; Makkaveyev, 1960; Velikanov, 1958). Relations of these properties (physical, hydro-dynamical), forming the stream internal structure, determine the processes responsible for the creation of islands in some parts of the river channel. Expression (1) is also used to analyze the dynamics of mobile islands. Their morphology, height and structure are determined by the interaction of two processes - increase of surface height, according to the equation (2), and island movement, as a result of washing out the island's upstream side and accumulation of material on the island's downstream side. These two processes work continuously, but their activity depends on the stream's hydrodynamics. In some river parts, the washout of mobile islands is slowing down; in other parts, due to the increase of washout speed, the island's length is shortened and its height reduced. In some conditions the island can completely disappear or joint to some river bank.

Behind any body, in this case island (Fig. 3), when water is flowing around it, so-called turbulent trace is formed (Abramovitch, 1960; Ginevsky, 1969). Distribution of speeds in this trace behind the island obeys the same law, as in a free turbulent jet. Right downstream the island, a zone of zero speeds and whirlpools is formed. As the moving liquid grasps particles of water from this zone, the last is gradually washed away and tapered out, gradually disappearing at some distance from the island. Thus, right behind the island, a zone of zero speeds is formed. Further downstream, the current speed increases and speed diagram in the trace is gradually straightened. Speeds distribution in the trace, as well as in a free jet, can be found using the formula (Abramovitch, 1960):

$$U/U_m = [1 - (y/b)^{1,5}]^2, \qquad (7)$$

where U - speed at the distance y from the trace axis; b – half-width of the trace; U_m - speed on the trace axis downstream the zero speed zone.

Growing of the island occurs due to intensive accumulation of material within the trace borders.

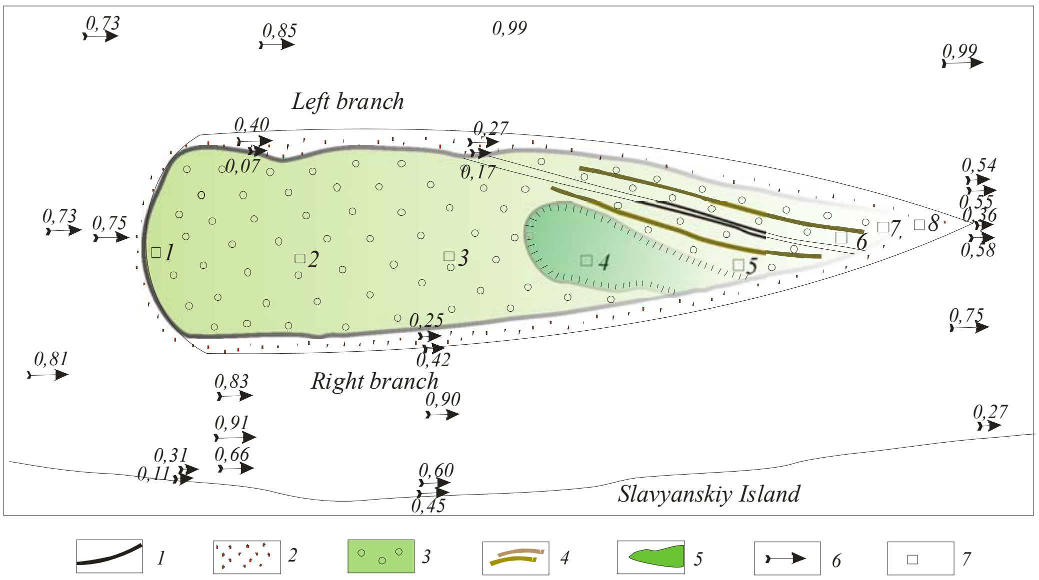

Fig. 2. Geomorphological diagram of island moving in river channel (Voroniy island, Amur river, Far East). *1* – benches with intensive washing out; *2* – sand shoal; *3* – trees vegetation; *4* – banks; *5* – depressions; *6* – water flow speed during flooding (m/s); *7* – position and numbers of profile cuts.

When the water level falls (in a low-water), some dry land appears and the trace is formed further downstream.

The island's length and height depend on the ratio of washout speeds on its top part and accumulation of material within the trace zone. During the time interval Δt, the island's coast is washed away and recedes at a distance - ΔZ. At the same time, its surface height grows, due to the sedimentation of detrital particles in high waters, and simultaneously, the island's length is increased by ΔZ, due to the accumulation of material within the trace borders. The direction of the island's movement coincides with the direction of watercourse.

Therefore islands can move nearer to one of the banks and join them, forming floodplain massifs, or be washed away.

One of the main characteristics of mobile islands is their movement period *(T)* – the time during which the island moves at the distance equal to its length. It can be found as $T = L / V$, where L - length of island, V-average washout speed of the ledge in the upstream part of the island. The movement period depends on the river's hydro-dynamic mode. Thus, the island's evolution is directed towards establishment of dynamic equilibrium corresponding to hydro-dynamic conditions.

Besides, the movement period *(T)* of the island determines the structure and age of sediments, distribution of soil cover and vegetation along the island, their age limit. The ground and wood vegetation on the island cannot be older than T. For example, at the average speed of island movement of 5m/year and its length of 400m (Fig. 2) T equals 80 years. During this time, dynamic equilibrium of the island's height is established, and the age limit of ground and trees will be the same.

Average total duration of floods for 15-years of observation on the Amur river near the island Voroniy (Fig. 3) makes up 172 days. For this time, the layer of warp of 20 cm is collected at the lowest areas. Hence, m = 0,116 cm.

The river's incision speed at this location is so small, that it can be omitted in calculations. If the island were not washed away, its surface would reach the limit height Y_{lim} = 5m for 200 years. And after 100 years, its height already would make 4.93 m.

As the age of islands is determined by their movement period, the most ancient and, hence, the highest is the island's head part, and its tail is the lowest and youngest. Therefore the floodplain surface on mobile islands is always inclined towards the watercourse. The limit surface height of such islands depends on their movement speed. For example, the floodplain surface on the above considered Voroniy island (Fig. 2) is inclined at 0,5°. Therefore, at annual washout of its head part by 5m, the surface is lowered by tg 0,5 ° · 5м = 0,043 m/year.

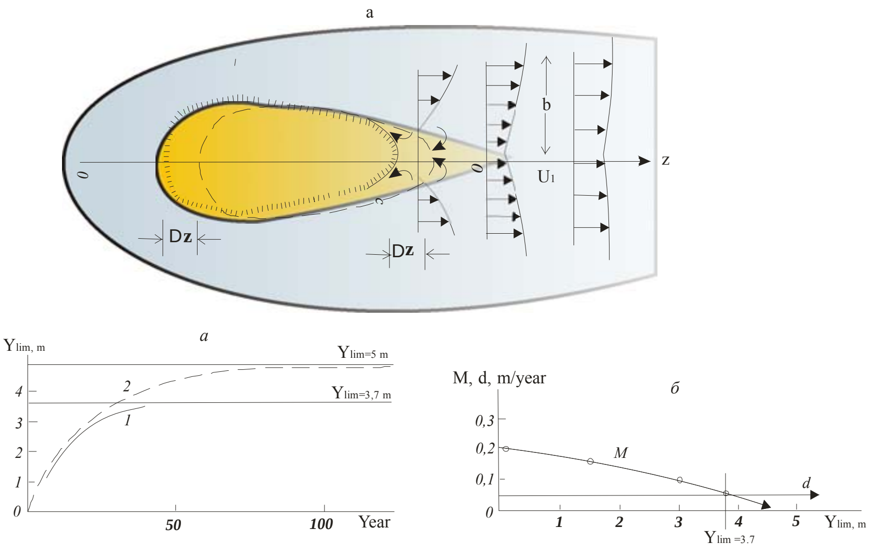

Fig. 3. Changing of limit height changing of the moving island
a) increase of the island's floodplain height, when it is moving (curve 1, Y_{lim} = 3,7 m) and when it is stationary (curve 2, Y_{lim} = 5 м); б) floodplain limit height on the island moving at a speed 5 m/year. M – changing of total amount of warp with the increase of the island's floodplain; d – decrease of floodplain height due to the island's washing out.

Thus, two oppositely directed processes participate in the evolution of mobile islands floodplain: the first - accumulation of warp on the floodplain surface and increase in its height, with simultaneous collection of detrital material within the trace borders downstream the island and increase of the island's length; the second – continuously working washout of the island's head part, causing the surface lowering, its height restriction and simultaneous truncation of the island's length. These two processes work continuously, but their activity is changed depending on the stream hydro-dynamics. In some parts of the river, the washout of mobile islands is slowed down; hence, the movement period and, accordingly, their surface height and length are growing. In other parts, in connection with the increase of washout speed, not only the islands length is shortened, but their height decreases as well. Under corresponding hydro-dynamical conditions, the island can disappear or completely join to some bank.

In the latter case, the factor causing decrease in the island's height becomes equal to zero and floodplain surface height reaches its greatest possible maximum. For example, on the studied island Voroniy, the limit height of floodplain in one of Amur channels equals not 5m, but 3.7 m (Fig. 3). At this floodplain height, the amount of warp deposited on it equals the surface lowering due to the island's washout. If the island joins some bank or stops its movement (for example, the river starts to actively recede to another bank and the island is in the zone of not washing speeds), the floodplain height on the island reaches the greatest possible value, equal to 5 m.

The described pattern is observed also in cases when the river is displaced to one of the banks. Then, at the opposite bank, due to intensive material accumulation in the zone of not washing speeds, the floodplain will be increased in width, and the central parts of the floodplain will rise up to its limit height and be leveled. Along with this, in the direction of the "young" bank, the floodplain height becomes lower, and its relief is more dissected (alternation of near-channel banks, former river-bed depressions). Gradually, these sites also rise up to the limit height.

This is the mechanism of increasing the floodplain height on the inundated lands located between the river bends.

On the rivers with high transporting ability, about 90% of islands do not reach their limit parameters, as the time of their existence is shorter than the time necessary to achieve these values. If the island joins the coast or stops its movement (for example, the river actively starts to recede towards another coast and the island gets into a zone of not washing speeds), the floodplain height on it will reach the greatest possible value.

When the floodplain is formed in the result of displacement of rifts, reaches and bends downstream the river, we notice, on the one hand, washout of the inundated lands located between the channel bends, and on the other hand - increase in its length, due to the formation of shallows near the convex bank and subsequent increase of its height due to the accumulation of material during high waters. Gradually the height of the forming floodplain approaches some stable value in the given conditions, that means that the transition process is over and the equilibrium mode is established.

Due to the displacement of bends, each floodplain massif has its own duration of existence. The floodplain limit height depends on the bends fluctuation frequency and the speed of their displacement. For example, at the washout speed of 0.5 m/year, and length of floodplain massif of 200 m (distance between the bends), the period *(T)* of floodplain development will be equal to 400 years. During this time all inundated land (composing it detrital material, mineralogical structure, soil cover and vegetation) will completely be replaced by new one. This is the explanation for the existence of floodplains of different levels. The floodplain of a larger size also has a larger height, than the same floodplain of a smaller size. We can observe this everywhere in nature: the floodplains formed on small islands or on river parts, located between the closely placed river bends, have the smallest height. All floodplains reach their limit height, but each one reaches its own, in tendency to increase their orderliness.

5. Principles of self-regulation by the target and current conditions of systems. The attractive target, or attractor can be considered as a spontaneously formed *target (predefined) condition* - a notion introduced in the theories of cybernetics and regulation of automatic systems. As different from live organisms having homeostatic properties, and from cybernetic systems which have a special managing organ and an organ performing the functions of master control, i.e. determining the amount of input and output matter, energy and information, in inanimate self-organizing integral structures, for example, in geomorphosystems, all these functions are performed by *F-* and *D- streams*. The functional diagram is shown on Fig. 4.

The desired values in the self-regulated processes of geomorphodynamics are the parameters of relief forms sizes: height *(H)*; surface area of slopes *(S)*; form volumes (V); underwater slope width (*B)*; slope steepness *(α),* which should achieve concrete quantitative values at existing intensities of litho-streams, when achieving the limit cycle mode.

The diagrams of simultaneous and interconnected changes of material discharge *P* and *q* in F-and D-litho-streams accordingly, depending on the growth of the relief forms sizes (*H, S* and *V*), always cross. The diagrams' crossing point indicates the equality of discharges *(P=q)*, whereas its projection onto the abscissa *x* - shows dynamically equilibrium sizes of forms, or, using the terminology of auto-regulation theory, - ***desired values.*** It is clear that *H, S* and *V* are directly determined by the intensity of litho-dynamic streams. Thus, *P* and *q* for the regulated values (*H, S* and *V)* act in the role of ***master control,*** i.e. determine the target condition - attractor, to be reached by the values *H, S* and *V*, when the equality *P* = *q* is established.

Development of geomorphosystems is constantly under the influence of perturbation actions, deflecting the regulated values *H, S* and *V* from their target value, i.e. breaking the system's equilibrium. For geomorphosystems, such perturbation actions can be the changes of weather (for example, rare storm downpours or transient, in comparison with geological duration, climate changes), causing sharp increase of the denudation speed, i.e. increase of the discharge *q* in *D*-stream. When the former conditions are restored, the relief forms and their morphology are also restored. If the intensity of matter discharge in *F*- and *D*-streams is changed for geologically significant time, in such case they perform the functions of master control, i.e. the relief form should be characterized by other morphometric and morphological parameters, or by another attractor, corresponding to the changed conditions.

However, some changes of quantitative parameters characterizing the material discharge in *F*-and *D*-streams, undoubtedly, occur, and consequently, morphometric parameters *H, S* and *V* of the relief forms also vary within some limits, i.e. fluctuate. With the balance of material discharges in the streams *(P=q),* the receiving of material and its denudation do not stop. Therefore the equilibrium is dynamic.

Regulated parameters in a relief are the current values characterizing the forms sizes: height *H (t),* area *S (t),* volume *V (t)*, etc. If the desired values for some fixed period of time *(t)* are constant, the regulated values vary in a direction of achieving equality with their ***limit values*** (desired values).

In conditions of tectonic elevation (*F> 0*), which intensity grows with time, the inclines of deformed surface (first of all, basic surface) are growing, and hence, grows the intensity of material discharge *q* in *D-stream,* which is expressed as a growing erosion and denudation. In this case $q \rightarrow P$, where *P* is growing. If the elevation became uniform *(P=const),* then *q* would be equal to *P,* as the increase of the surface steepness stops, and consequently, after some delay time, *q=const*. This condition would be externally expressed by morphologically complex surface of dynamic equilibrium, presenting mountains of a certain height, with prevailing combination of slopes of a direct profile.

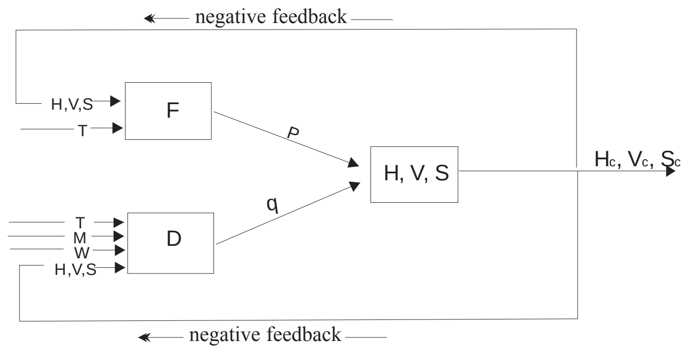

Fig. 4. Functional diagram of geomorphosystems. T, M, W – negentopic streams of MEI from the environment, forming F- and D-streams.

In the development of floodplains, the discharge *P* in *F*-litho-stream is presented by the detrital sediments deposited during high waters. The amount of deposited material (amount of warp) decreases with time and with the growth of the floodplain height *H,* because the total duration of floodings *(N)* of the floodplain, too being the function of *H,* decreases. At this, the discharge *q* of the negative litho-stream grows or remains constant. Therefore, the establishment of equality *P=q,* at invariable external conditions, is inevitable.

Formation of a longitudinal river profile in any section of the river valley is directed towards achieving the equality of forces dragging the fragments and the forces resisting the movement: $(V_l + \tau) - (T + C) = 0$.

At a constant incline (i) of the longitudinal profile the dragging force *(Vл)* is determined by the thickness *(h)* of the moving water layer. As *h* decreases towards the river head, then for moving fragments of the same size an increasing shear thrust *(τ)* is required. The equality of these forces is possible at the increase of *i,* as it is observed in natural processes of longitudinal river profile formation - its steepness is growing towards the river head. The incline *i* is growing even more, when the size of fragments increases upstream, and in order to move them, the dragging force $V_л$ must grow (whereas it decreases). Therefore, to keep the forces equal, the shear thrust *τ* should grow, which is spontaneously achieved at increasing *i*.

On the contrary, in the downstream direction, at *i=const* and *d=const (d* - the fragments size) the dragging force $V_л$ increases proportionally to the increase of water layer thickness $u=c(hi)^{1/2}$. Hence, the speed of removing the detrital material considerably increases towards the river mouth, and the rivers run intensively, approaching their limit - horizontal surface. This is the cause for the natural bending of longitudinal profiles. Due to the fact that the average size of detrital sediments decreases downstream, the river profile flattens out even more (the equality of forces is achieved at a very small *i*).

Tectonic movements break the equality between the dragging forces and friction by changing *i;* climatic factors - by changing *h,* lithogenic - by the speed of washing out and the size of detrital material. Therefore, the uniform elevation at the preservation of constant water content in rivers is compensated by the speed of incision, and after any decline from the equilibrium, the process is directed towards its restoration.

Litho-stream *F,* "initiator" of relief forms creation, and litho-stream *D*, of an opposite relief forming orientation, both have their limits of action, so to say, relief forming amplitude. For example, the relief forms, created due to the elevation and incision of rivers, if denudation processes were absent, would increase their height with some delay until the weight of the rising massif would balance the force of endogenic pressure, i.e. isostatic equilibrium would be established. The growth limit of barkhan dune or a storm bank, in the absence of denudation, could be determined by the height at which detrital particles of a certain size could be still brought onto it at existing speeds of wind (or water). The action limit of all relief forming litho-streams q is a horizontal surface related to the sea level, when speaking about the relief of land.

Interaction of *F*- and *D*- litho-streams forms a new, uniform limit for them, externally expressed as an equilibrium surface of different morphological complexity. This limit exists in reality and is observed in a modern relief or in the relicts of the past, whereas the above described top and bottom limits are idealized abstract notions, and never exist in the nature. Achieving of the top limit would be possible only in the absence of exogenic processes, and the bottom limit - in the absence of endogenic processes.

5. Conclusions. Achieving the condition of dynamic equilibrium, as well as realization of any other regularity or law in the material world development, is possible only at preserving constant external conditions during the time, sufficient for the full development of the given process. In reality, this necessary condition is practically unsatisfiable. In the development of relief forms, we can observe only different degrees of approximation towards this condition.

In a relief, there are no, and, probably, there cannot be ideally equal horizontal denudation plains, described by the equality $q=P=0,$ as for their formation it is necessary that $P=0$ during the time estimated in millions of years; there are no mountains presented by a combination of ideally direct and equal slopes, characterized by the continuous existence of equality $q=P=const$.

Relief forms arise, exist and collapse, being replaced by others, in the result of never stopping interaction of litho-streams. This interaction proceeds also at the moment of achieving the dynamic equilibrium, when both components in the balance of masses and energy reach their maximal values determined by concrete conditions.

Thus, in nature, naturally formed systems have no special regulating organs to determine the size of mismatch between the target and current conditions of the system. Regulating functions in them are performed by their own sizes $H,$ connected in a negative and positive feedback cycle with the processes of receiving matter and energy in such a manner that with the increase of $H,$ the amount of energy brought into the system decreases.

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