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GEOSYSTEMS TRANSFORMATION IN EASTERN SIBERIA

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Abstract

The article considers the regularities of formation, development and transformation of geosystems. The article is an information synthesis of data and knowledge concerning the territory, drawings on V.B. Sochava's theory of geosystems, results from station-based investigations, cartographic information and on GIS technologies.

Key words*: geosystem, organization, considers regularities, transformation.*

INTRODUCTION

At the end of the XX century the mankind has entered a new era when, as the professor V. I. Vernadsky predicted, it had become the driving force of environmental changes that might lead to the ecological catastrophes. Currently economic and social development has faced the limits of biological resources. This very fact brings us to the necessity of environmental studies for evaluating and prognosis of regional ecological changes thus accumulating scientific data background for regional management and estimation of conditions for human vital activity, illuminating the ecological losses during industrial exploitation of new areas. The major part of data for solving these problems can be obtained based on the studies of geosystems composition, functioning, dynamics and evolution.

One of the major targets of this research is to obtain the knowledge of geosystems development regularities, their dynamics and transformation thus evaluating the changes that occur in the geosystems in this large region of Russia. Scientific approach is based on the temporary methods of synergetic geosystems' research.

RESEARCH OBJECTS AND METHODS

The object of the research is the territory of Eastern Siberia, which is a geographical bundle of contrast natural environments and a center of agro-industrial use in Asian Part of Russia.

The typical problems of this region are connected with the siting of major industries, low atmosphere cleansing potential and low environmental resistance.

Landscape research is based on the results of long-term studies of Siberian geosystems, terrestrial and aerial itinerary studies, interpretation of satellite images, GIS-technologies and literature data analyses. The work was supported by the Russian Fundamental Research Fund.

Discussion of the results obtained

Geosystem is a unity of interrelated natural components that comply with the regularities of geographical environment. The transformation of Geosystem is its transfiguration including the transfiguration of its' general properties. Transformation can be a result of the geosystems development, changes in its matter and energy flow and in its inner and outer interconnections.

The process of geosystems development is one of the leading mechanisms of transformations which influence the direction and inconvertibility of changes. The accumulating changes result in the geosystems evolutionary transformation. Mostly these processes depend on the climate changes and tectonic processes in the area.

The peculiarity of Eastern Siberia landscapes is defined by its location on the junction of three large tectonic elements (fig.1).

Based on the theory of tectonic plates, Baikal and Altai-Sayansky mountain area appeared as a result of the Indian and Eurasian tectonic plates collusion. Due to the pressure of the Indian plate, inner Asian area was divided into a series of micro-plates and blocks. Than the Amur plate separated from the Eurasian one resulting in the formation of Baikal rift zone. These processes were accompanied by the climate changes, lava intrusions and repeated glaciations along the borders of Siberian platform.

Development of the Baikal rift zone and Altai-Sayansky mountain area led to the formation of following climate tendencies: the air cooling, the strengthening of climate continentality and aridization.

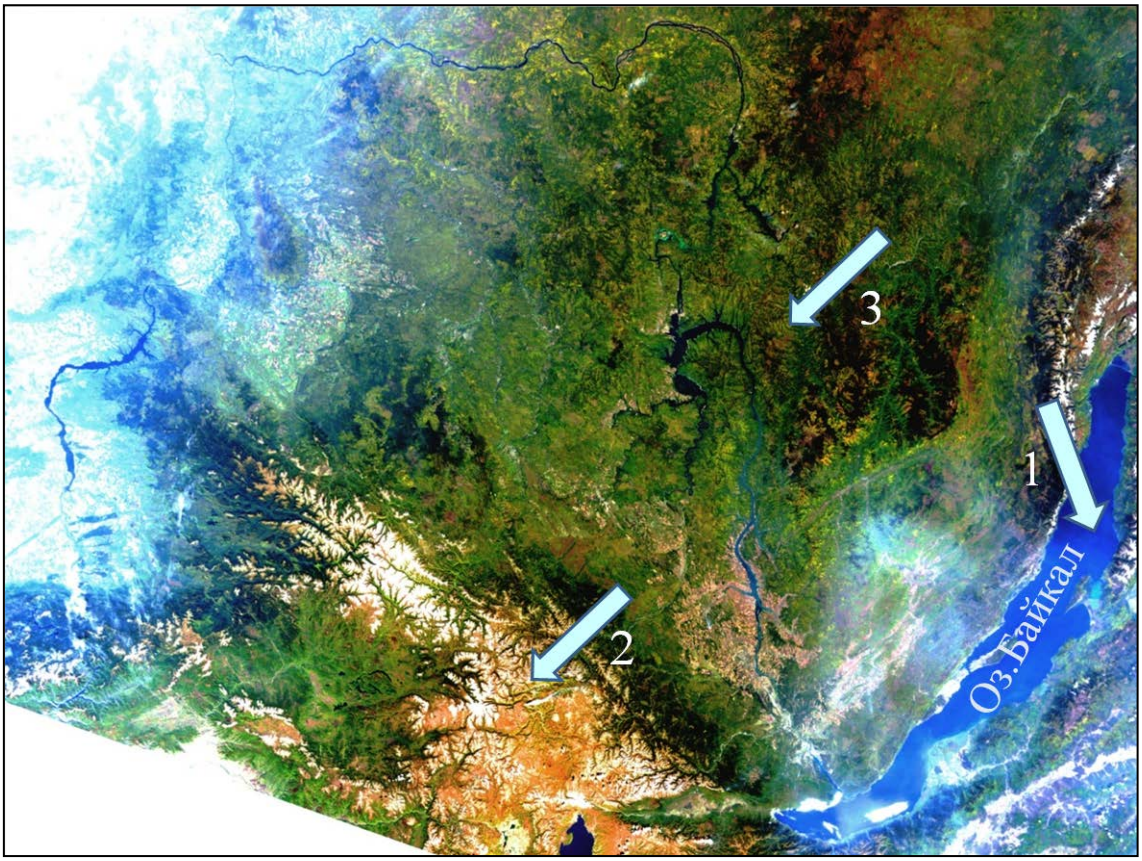


Fig.1. Eastern Siberia satellite image

EOS AM-1(Terra), USA (MODIS). 2012-09-27. GSD 250 meters.

1 – Lake Baikal rift zone, 2 – Altai-Sayansky mountain zone, 3 – Siberian Platform.

These tendencies were formed during the Oligocene (≈38-25 million years ago), when the intensity of mountain folding and climate changes rapidly grew and reached the maximum in the Quarternary period. This is a time when large risings are formed in the eastern and southern parts of the region and the first climate cold spell starts. During the cold spell the average temperature in January lowers by 3^0 Celsius and the annual precipitation lowers by 300 mm (Sinitsyn 1965).

Thus the moderately warm climate forms. The tropical vegetation that was formed on the territory of the region earlier in the former environment of Mediterranean climate transforms into broadleaf forests of hornbeam, elm-tree, birch, and chestnut with admixture of coniferous vegetation- mares-tail, swamp cypress (Belova 1985).

The unique ecological niches where the geosystems preserve the components of different thermal epochs are formed in the intermountain depressions of Baikal rift zone (fig.2).

Another cold spell and climate xerophytization starts in the Miocene epoch (≈25-7 million years ago). That time the climate indexes reach (t^0_I - 0^0 +3^0; t^0_{VII} +30^0; Σ_{mm} – 1200-1000 mm). A moderate climate with increasing aridity and distinct differentiation of seasons is formed on the territory of eastern Siberia (Volkova 1950). The lithogeneous sediments type transforms from acid to alkaline. The predominant species of wood are: oak, beech, hornbeam, elm, linden and fir tree (Sinitsyn 2001).



Fig.2. Pliocene relict Lycopódium clavátum

The Pliocene (≈5,5 - 3,5 million years ago) is characterized by intensive cooling and the strengthening of continentality. The rising of mountain chains on the east led to the formation of orographic barriers that influenced the atmospheric circulation. The Siberian anticyclone had turned into a major circulation center and had led to the transformation of the regions' geosystems. Thus the Pliocene became the main period of taiga geosystems differentiation. That time the climate was characterized by distinct seasonality, long and cold winters (t^0_{I} -5-10^0; t^0_{VII} +15+20^0; Σ_{mm} – 600-800 mm). The further climate processes had led to the dissociation of taiga geosystems: the western part of the region with remote moderating influence of the oceanic climate was occupied by dark taiga geosystems, while the major part of the region with continental climate was dominated by light taiga geosystems with Larix Sibirica. In the southern parts of the region the escalating of aridity had led to the desertisation processes and the forests there were replaced with steppe geosystems resulting in the formation of Baikal –Altaysky forest-steppe vegetation type (Dumitrashko 1946) (fig.3).



Fig. 3. Pliocene relict Baikal –Altaysky vegetation type.

The border of Neogene and Quaternary period was characterized by another climate cooling that was related to the increasing area of the polar ice sheet. This cold spell had led to the mountain glaciation. The continentality

of the region strengthened: the temperature fluctuations had increased; relative air humidity had decreased as well as the annual amount of precipitation. Another typical feature of this period is the formation of snow cowering which contributed to the air dehumidification and air cooling (t^0_I –25^0; t^0_{VII} +15^0; Σ_{mm} – 400-600 mm). The taiga geosystems were completely formed by that time, which is also associated with the degradation of eastern border of Larix Sirica area and the spreading of Dahurian larch to the west and to the south (fig.4).



Pic. 4. Pleitocene - the spreading of Dahurian larch (*Larix dahurica*)

During the Sartansky ice age (27-18 thousand years ago) the permafrost was widely spread. The climate became warmer, but the aridity was on the same level. The Holocene was marked by the activation of tectonic processes. It was also the time when the Eastern Siberian sub-region of light coniferous forests which occupied the area to the east from the Yenissei river (to the south from 60^0 northern latitude). The end of the Holocene – the time when the present day landscape structure was formed (fig.5).



Fig. 5. Holocene – present day landscape structure

The present day landscape borders are mainly defined by the tectonic structure and therefore correspond to the large earth's crust blocks and the direction of spreading (fig. 6).

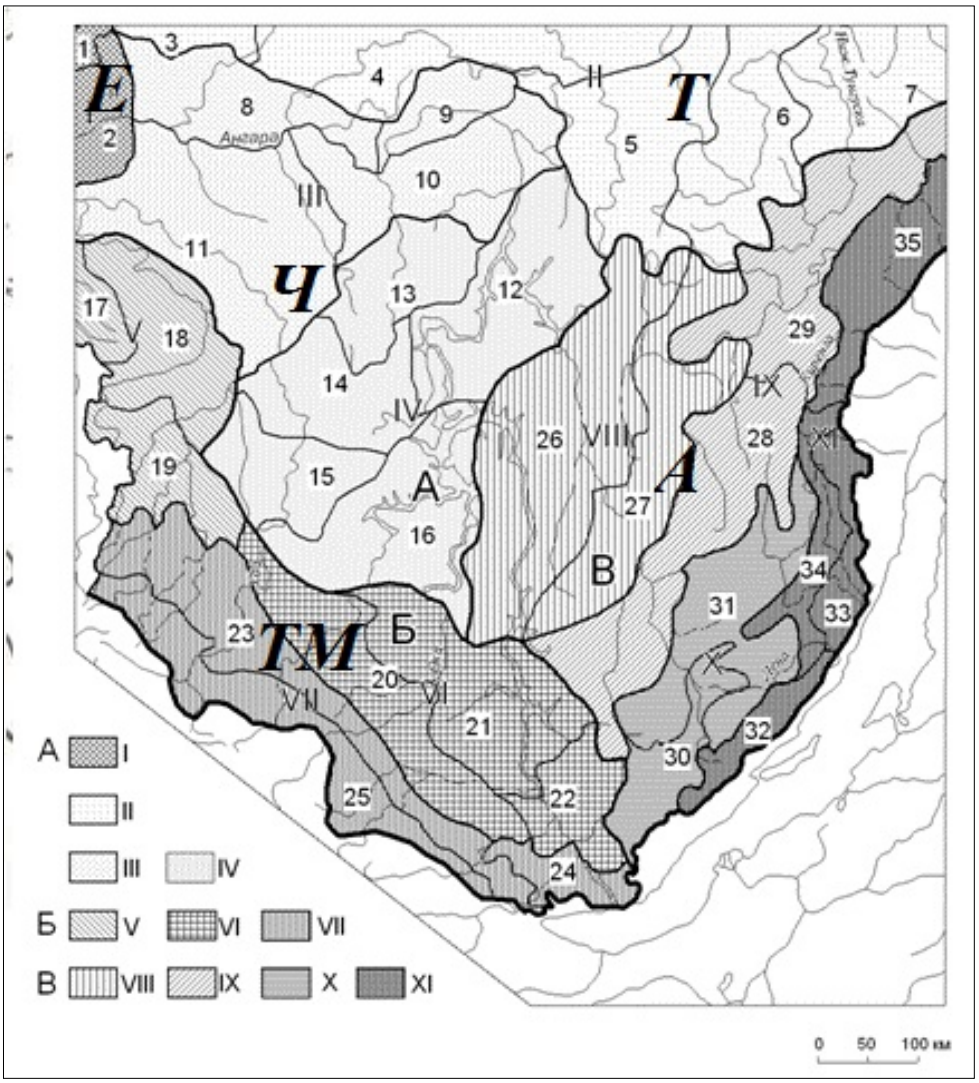


Fig.6. the correlation of regional landscape borders with the Earth's crust blocks

Earth's crust blocks: **Е** - Yenisseisky; **Т** - Taymyrsky; **Ч** - Chonsky; **А** - Angarsky; **ТМ** - Tuva-Mongolian (Mitrophanov 1987).

А,Б,В – physiographic regions; I-XI – physiographic provinces;

A. CENTRAL SIBERIAN PLATAU REGION:

I. Yenisei range dark-taiga mountain province; II. Tungussky central-taiga valley province; III. Lower Priangarsky valley southern- taiga dark coniferous province; IV. Middle Priangarsky upper valley southern-taiga pine and dark coniferous province;

Б. SOUTHERN SIBERIAN MOUNTAIN REGION:

V. Kansko-Achinsky steppificated forest-steppe province; VI. Upper Priangarsky piedmont forest-steppe and steppe province; VII. Predsayansky mountain-taiga dark coniferous province;

B. BAIKAL-DZHUGDZURSKY MOUNTAIN REGION:

VIII. Ilimsky dark-coniferous taiga highland province; IX. Lensky highland dark-coniferous taiga province; X. Onotsky steppificated piedmont taiga province; XI. Predbaikalsky mountain-taiga dark coniferous province.

With the region of Eastern Siberia we can observe the transformation of geosystems which is connected with the Baikal rift zone development and further strengthening of climate continentality. The analysis of literature sources on this subject points at the great influence of the Earth's crust movements on the current orography formation. The whole area from the Tibet Mountains to the south of Siberia acts like a toros or ice-drift zone, where the micro-plates move due to the sub-meridianal press, which causes the activity in the Baikal rift zone (Timofeev, Bronguleev & Bulanov 2001). So the orography of transitional type is formed near the borders of platform valleys as a result of orogenic processes that are more typical to the mountain regions. The transitional character is typical not only to its' orography but to its' tectonical processes, geological structure, soils and vegetation and therefore to its' landscapes. These transitional zones are defined by the enchased mobility of all processes which leads to the expansion of the contacting geosystems assuming environmental changes.

The abovementioned peculiarities of spatiotemporal organization and transformation of geosystems are complexified by the strengthening of aridization processes that are mostly dangerous for taiga geosystems especially in the areas with high climate continentality.

The coefficient of continentality here varies from 60 % on the west to 85 % on the east of the region: K=120 $\frac{A}{\varphi} - 20$, where A – annual air temperature fluctuations, φ - latitude.

The existing tendency deepens by the anthropogenic impact. The resonance of natural and anthropogenic processes of aridization facilitates the structural changes in the majority of taiga geosystems (fig.7).

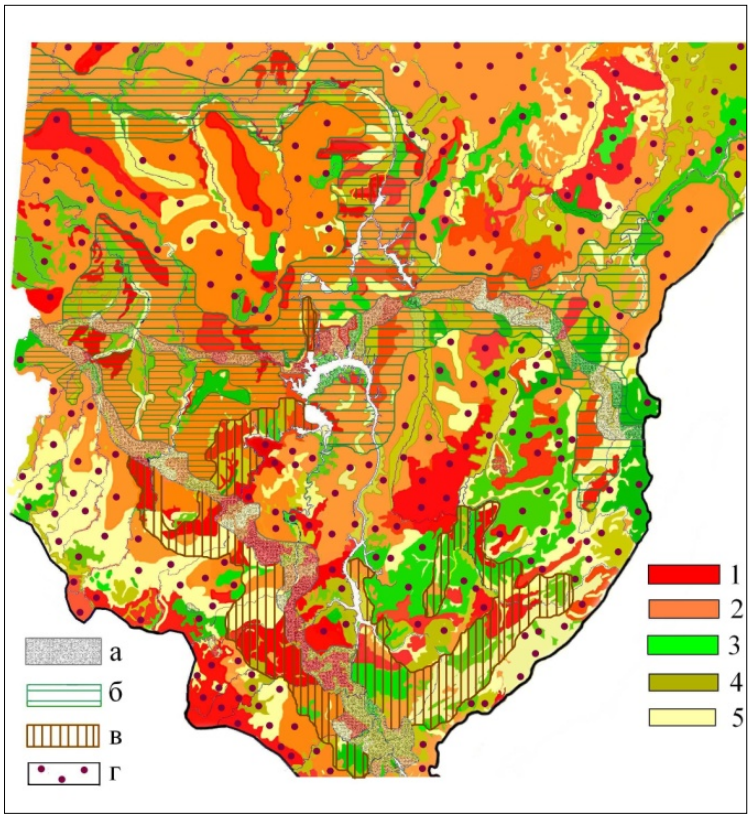


Fig.7. Stability and disturbance of the geosystems on the south of Central Siberia

The form of disturbance: а – technogenic; б – forestry; в – agricultural; г –localized forestry.

Category of stability: 1 – extremely high; 2 – high; 3 – average; 4 – low; 5 – extremely low.

As an example we can name the area on the right bank of the Angara river where despite the dryness index which equals 1 we can find dark coniferous taiga geosystems that confine to the permafrost location. The

existence of these geosystems in the area is assured by the permafrost melting which provides the trees with necessary water during the dry beginning of the vegetation period. The described processes help the geosystems to maintain independence form the surrounding natural conditions. "The dark taiga with its thick moss carpet holds the permafrost close to the surface thus leading to the formation of bogs on the plateau. Sinking of the permafrost leads to the development of podsolization processes and drainage of the area and forms quite different environmental conditions" (Vasiliev 1956).

When the environmental conditions reach the critical point for the geosystem existence the rigid types of correlations are formed. The removal of any element from of this rigid ties leads to the catastrophic damages in the elements of geosystem lose their connections so the whole geosystems enter an unstable state and is likely to be transformed (fig.8).

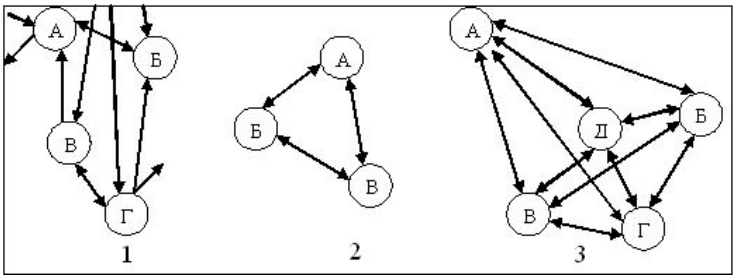


Fig 8. Models of geosystems with different elements coherence

Types of interconnections: 1 – discrete type (the elements and subsystems have weak ties) – ecotons (transitional communities) and young geosystems; 2 – rigid ties - factorial geosystems (depend on the action of a certain factor) and old geosystems; 3 – balanced coherence of different subsystems.

А - Д – system elements. Pointers – directions of ties.

The intensive timber exploitation had led to the natural xerofitization processes as well as to the anthropogenic speppification resulting in the increasing dryness of air and soils, river shallowing and dissipation of water streams with the catchment area smaller than 5 km^2. Along with anthropogenic disturbance of forest type geosystems the typical transformation factor is the fire-induced changes. (fig.9).

The satellite images analyses has shown that almost 25% of the regions area are disturbed by the fires. The significant amount of fires repeats annually or at an interval of several years. These areas are mostly inhabited by semi-stable geosystems with low adaptation ability.

The itinerary studies and remote sensing have indicated that most typical geosystems to the locations with intensive anthropogenic exploitation near the Angara, Ilim and Lena rivers are the secondary permanent ones that mostly correspond with the current environment conditions and do not restore to the original state even when the anthropogenic impact stops. As a result we can observe the increase of light-coniferous geosystems areas and the edging of dark-coniferous geosystems to the higher altitudes.

In the areas of large industries locations, large forestries and arable lands there we can observe the transformation of material and energy flow, in particular –formation of the islands of heat and environmental pollution. The research has shown that the difference of summer temperatures between the natural light taiga geosystems and anthropogenically transformed areas reaches 20^0 C. The pollution makes this situation worse: even the small increase of SO_2 concentration leads to the dehydration of plants. The technogenic impact also results in the lower accretion of pine, local drying outs and the absence of geosystems restoration.

Piedmont grass and low-grass geosystems are likely to be exposed to the negative anthropogenic impact due to agricultural and mining activities. Poorly broken relief of lower lands does not prevent the spreading of pollutants.

The synthesis of obtained data proves that the geosystems of eastern and south-eastern part of Siberia are susceptible to structural reorganization therefore the special protection and reserve status measures and standards of land use should be elaborated for this area (fig.10).

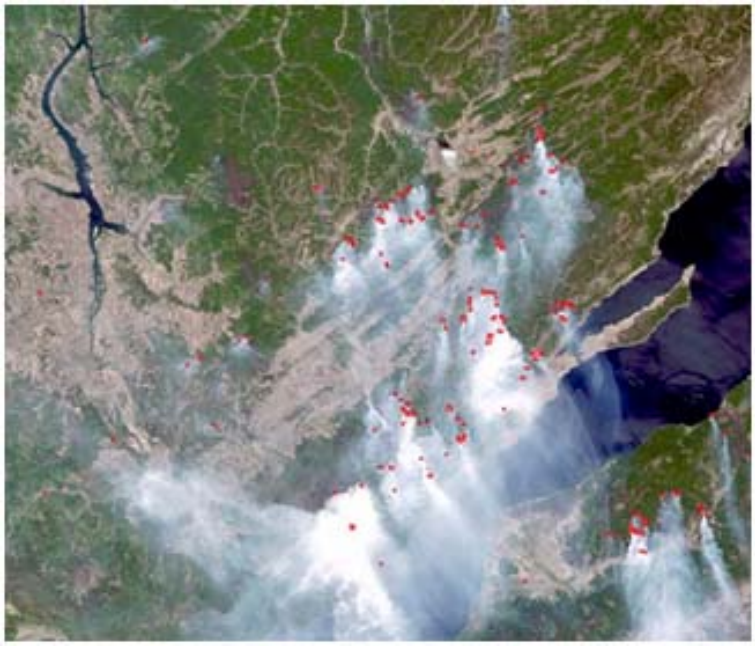


Fig. 9. Fire seats in the south-eastern part of Angaro-Lensky interstream area 5.06. 2013
Red points – fire seats; Dark blue points – burned-out areas.

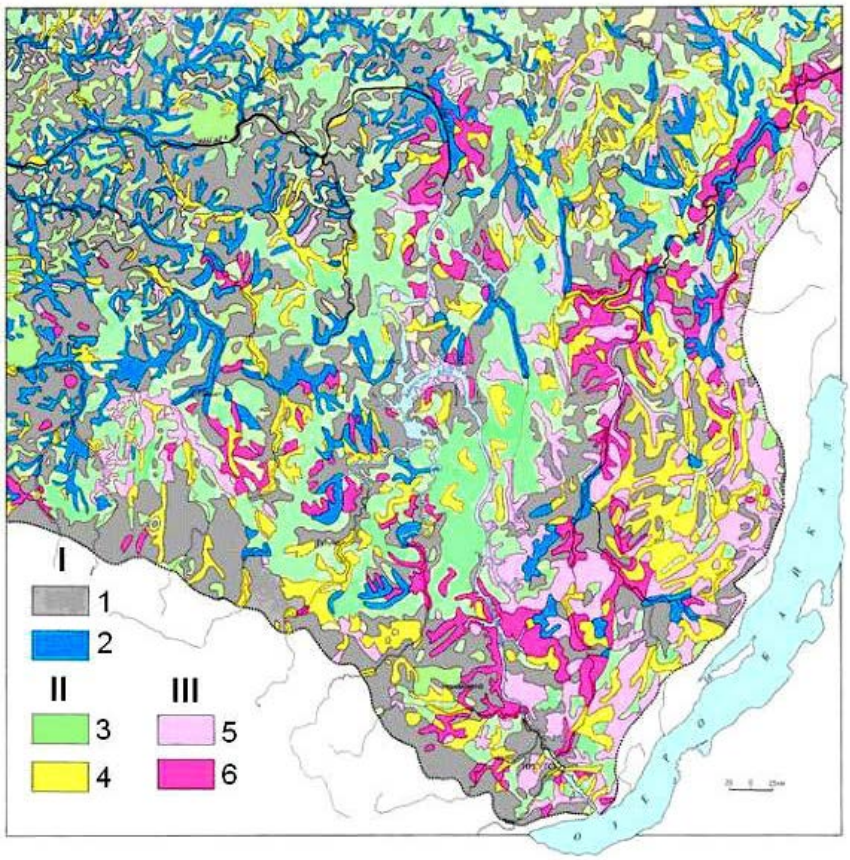


Fig. 10. The direction of geosystems transformation
I-III – stages, 1-6 – transformation changes

I – development: 1 – improvement of ties; 2 – preservation and recreation of a geosystem;

II – structure support: 3 – changes of the old subsystems to new ones; 4 – changes of internal ties;

III – new geosystems formation: 5 – formation of 2 geosystems; 6 – destruction and formation of new ties.

CONCLUSION

The studies of geosystems transformation are a progressive way of scientific research that helps to find a solution to current geo-ecological problems generally and the in the region of eastern and south-eastern Siberia in particular.

The synthesis of data, obtained during the itinerary studies, and satellite images reveals the transformation of original geosystems which results in the tendencies of steppification and aridization of geosystems. Such tendencies occurred both due to the technogenic impact and natural environmental transformation which is inherited from the Holocene climate and tectonic processes.

The conducted research has identified the high disturbance character and low stability of the regions ecosystems. Therefore the research recommends the implementation of limited industrial exploitation and governmental regulation of any land use in this region.

This research may become the ground for the creation of a model for the regional sustainable development. Its' key point lies in the preservation of self-regulated geosystems development by the accurate managing of anthropogenic impacts.

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REFERENCES

Belova, VA 1985, *Vegetation and climate of the late Cenozoic era in Easter Siberia*, Nauka, Novosibirsk. (Russian).

Dumitrashko, NV 1946, 'Palaeogeography of Mid Siberia and Pribaikalie, Proceedings of the institute of geography USSR Academy of science', USSR Academy of Science, Moscow-Leningrad, no.37, pp. 21-31. (Russian).

Mitrophanov, GL ГЛ, 1987, *Tectonics of Eastern Siberia*, VSNIIGGandMC, Irkutsk, 104 c. (Russian).

Sinitsyn, VM, 2001, *Ancient Climates of Eurasia*, Part.I, Leningrad State University, Leningrad. (Russian)

Timofeev DA, Bronguleev VV & Bulanov SA, 2001 'Mega-geomorphology of Asia: the results of orography studies', News of Academy of Science, geography series, no 4, pp 8-13. (Russian).

Vasiliev, VN 1956, 'Origin of Far Eastern and Eastern Siberian flora and vegetation', Proceedings of flora and vegetation history, USSR Academy of Science, Moscow-Leningrad, no.3, pp. 361-457. (Russian).

Volkova, VS 1980, 'Pliocene and early Pliocene climate changes in the Northern Asia, Geology and Geophysics', no 7, pp. 43-52