# Geoplastics method as a tool for disturbed territories rehabilitation

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## Abstract

Disturbed territory is a landscape disordered in such a way that it cannot be used by society before it is reclaimed. In landscaping, relief is of crucial importance. Relief directs the flows of materials in natural landscapes. The ordinary way of reclamation in Russia is based on a level relief. The author's experience shows that the folded surface is more effective for the reclamation. Creating of a folded relief with the purpose of the disturbed landscape restoration is a special method which I call the geoplastics. This method allows us to direct the landscape material flows and concentrate them in accumulative cells, to balance the relationship of the warmth, moisture, and fine grains of soil minerals. Thus, this method creates proper conditions for bioproductivity and biodiversity. A series of the author's projects confirm the reliability and effectiveness of the geoplastic method as a tool in fighting entropy of the landscapes disturbed by man.
*Keywords: disturbed landscapes, folded restoration relief, control of the landscape material flows, order of the landscaping energy.*

## 1 Introduction

Disturbed territories are a result of economic activity that has changed this territory in such a way that it can't be used by the society unless they are reclaimed. The disturbed landscapes have a negative impact on the environment. Disturbed territories and urban territories have the same area in Russia. In the former USSR, it was more than 7 million hectares [1]. The general feature of disturbed territories is that the correlations of the landscape's components such as rocks, waters, soils, and vegetation, are changed critically. The technology of disturbed territories reclamation consists of two steps. The technical step is vertical alignment of the disturbed surface. The biological step is formation of the soil-vegetation cover.

The restoration terrain design is the point of a special attention. The ordinary technology of reclamation is directed at the leveling of the terrain. It means filling up of quarries, as well as lowering and the alignment of the dump. The problem is that this approach is not based on the natural laws of landscaping. When the soil-vegetation cover is destroyed, the flat relief provokes dissipation of the landscaping energy and does not facilitate the restoration of the disturbed landscape. The author has studied the natural landscaping processes and has designed reclamation of a number of disturbed plots. As a result, the reclamation method was worked out. The method is based on that the folded relief is more effective for the landscape restoration than the leveled flat one. This method I call geoplastics. The folded terrain is also the dominant factor of natural landscaping.

## 2 Geoplastics as the natural landscaping factor

Relief is the basic factor of natural landscaping. First, relief directs the movement, deposition and development of the landscape material. Second, relief distributes the landscaping energy. There are two forms of relief: the mountains and plains. Each form has three elements or the sites: top, slope and lowland.

The character and the intensity of the landscaping processes are distributed to elemental sites in the following way. On the top, the landscape material (sediment, soil, moisture, seeds, living substance) is formed by local sources and due to the outer space. Part of the landscape material moves from the top to the lower site. This movement consists of water flows, creep, air down flow and is triggered by the gravity. This process is called eluvial one, and the top is an eluvial landscape, i.e. a donor. The slope is a transit landscape. This site produces its own landscape material, receives the material from the top and passes it through itself to the lower site. This is a deluvial process, and the landscape of the slope is a deluvial one. The lowland both accumulates the material coming from up and generates its own material. This is an accumulative process and the landscape is an accumulative one.

The correlation of the warmth, moisture, thickness of the sediment and the humus depends on the sites and the slope exposition. The optimum correlation of these components creates conditions for the enhancing of the general bioproductivity of the landscape. In nature we observe that more bioproductive landscapes occur in valleys and plains and in such lower parts of the slopes, which are favorably exposed. The general natural law stating that geochemical activity of the landscape depends on the sites of relief was described by the Russian scientist Polynov B.B. in 1915 [2]. So, the general natural law of bioproductivity (crop) distribution among the sites is that it increases from up down, from the top to the depression.

Thus, the relief controls the distribution and the development of the landscape material on the earth surface in nature because of it has a free energy due to gravity and different elevation of the sites, as well due to the fact that exposition of slopes differ in warmth and moisture.

## 3 Geoplastics as a method of the disturbed territories restoration in the author's projects

The author has designed a number of projects on reclamation in disturbed territories of the Baikal region, Russia. The general methodology of the design is the following. First, disturbance factors are revealed in the plot. Second, the direction of reclamation and further usage of the territory are defined. Third, the concept of geoplastics is worked out, i.e. the shape of the restoration relief that controls the movement and deposit of the landscape material in proper places and at a proper ratio. Fourth, the concept of the artistic image and design of the territory for its functional usage are worked out. Fifth, the biological stage of reclamation that adds to the geoplastic concept and meets the functional and aesthetical requirements of the territory is worked out. Let us consider concrete examples of geoplastics application in the author's projects carried out during the last ten years.

### 3.1 Reclamation of a dump in Bolshoye Goloustnoye

The dump in Bolshoye Goloustnoye is located on the coast of Lake Baikal 120 km southeast from the city of Irkutsk. In the 50-s in B.G. on the shoreline of Lake Baikal, timber industry storage was placed. It was used for timber-rafting. The logs were tied together and the rafts were towed by a tugboat to the consumers. For rafts, a channel was dug out on the coast. The mineral soil extracted from the channel was put in a dump on the coast. The original coastal landscape was meadow step, with a thick layer of humus. Under the dump, the topsoil was buried. The total area of the plot is 34 ha. The average thickness of the dump was two meters. Later, the surface was leveled and equipped with gantry cranes. The banks of the channel were fortified with the protection walls. In 1987, the timber enterprise was closed. In its place, the national park was established. The timber storage was abandoned.

In 1993, the author has worked out the reclamation project. The following disturbance factors were revealed. 1) Under the dump, the topsoil is buried. 2) The substratum of the dump is overcondenced, containing 70% of gravel and 30% of silt and sand. 3) The surface is not connected with the ground water. 4) There is no vegetation on the plot. 5) The visual image of the Baikal coast is roughly distorted by the shape of the dump. 6) The old building of the Orthodox Church that is situated close by is half-destroyed. Besides, the climate of the region is dry and windy.

In accordance with the master plan (Figure 1), the landscape park has been designed on the plot. The landscape park includes the church garden around Saint Nicolas Church, the harbor, the sport area, the landscape garden, the tourist camp, the children playground, and administrative area.

The geoplastic concept is the following. The dump is moved from the buried soil by detached parcel hollows rather than on the total area. The excavations form a network on the dump surface. The excavations should free the buried soil. The cut material is moved to the periphery of the excavations.

From this material, closed and partly opened screens are formed around the excavations. The micro-relief of the natural coastal landscape is a combination of hills, gullies, dunes and hollows. That is why the excavations are shaped as hollows; the banks are shaped as dunes. According to the general idea of the relief impact on the bioproductivity of the landscape, there are designed eluvial cells protecting the oases-hollows from the Aeolian deflation as well as slopes directing the moisture and sediments to the hollow and accumulative cells catching the fine mineral particles, seeds, snow and rain. Thus, for the purpose of reclamation of the dump in Bolshoye Goloustnoye, the dune-hollow restoration micro-relief is designed.

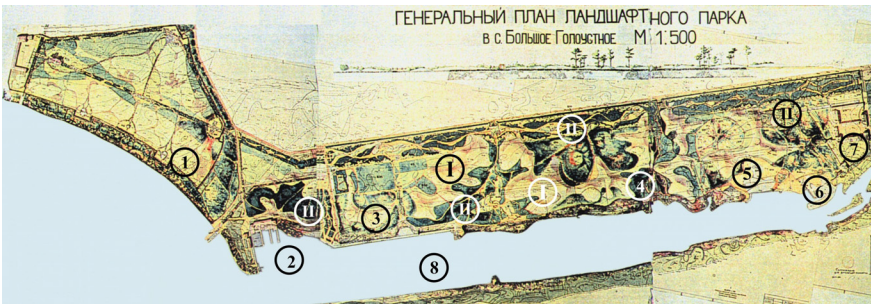


Figure 1: Master plan of Bolshoye Goloustnoye Park. Restoration relief: I banks; II – extractions. Functional zones: 1) Church garden, 2) Harbor, 3) Sport ground, 4) landscape garden, 5) Camping ground, 6) Children playground, 7) Administrative zone, 8) Channel.

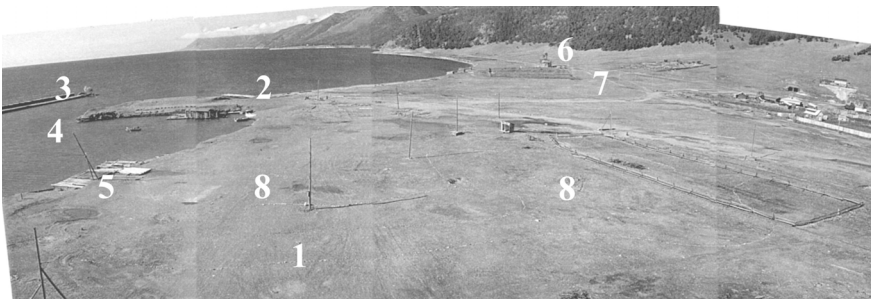


Figure 2: State of plot before reclamation, 1994. 1) mark line of future relief, 2) moorage, 3) dyke, 4) channel, 5) inner damaged moorage, 6) Saint Nicolas Church, 7) plot of grass cover, 8) dump surface.

In 1994-1996, the first step of the project was carried out by a small enterprise under the guidance of the author. The results exceeded the expectations. The initial state of the plot is shown in Figure 2. The first step reclamation results are shown in Figure 3. In autumn 1994, the soil under the

press of the gravel dump was freed with the help of hollows. It was already in spring 1995 that the opened surfaces got covered with grass. As soon as the buried soil was exposed to the sunlight, the rhizome and seeds which had stayed for forty years under the gravel dump started growing. In the wintertime, the snow is blown off the surface of the whole plain because of the strong winds. The only exceptions are the hollows of the park where the snow is trapped and accumulated through the winter till the spring start of the vegetation. In 1996, the recreation embankment was built on the coastal edge of the dump. Thus, the experimental results confirm the correctness of the geoplastics concept in the plot.

Figure 3: General view of park after the first step of reclamation, 1996.

### 3.2 The reclamation of the quarry project in the city Usolye Sibirskoye

The quarry for the sand-gravel soil is located on the border of the dwelling area and the chemical factory territory, 500 m from the Angara River bank, in the city of Usolye Sibirskoye. Nearby, there is a rubbish landfill. The disturbance factors are the following. The depth of the quarry is about 3 m. After the mining, because of the high water-table, the bottom of the quarry is going to be a few centimeters higher than the level of the underground water. This provides a sure forecast of a swamp formation in the quarry. The plot is a little higher than the flood plain. Inclination of the plot is 3 m in height per 500 m in length.

As the plot is situated on the green belt of the city and on the border of the Angara River water protection zone, the master plan defines the reclamation as water protection, nature protection and recreation. Figure 4. In order to avoid the swamp formation, to create the biodiversity of the landscape, including the water surfaces, meadows and tree plant, the concept of the geoplastics means shaping a special restoration relief that should meet the above aims. In order to create tree plant, the level of the topsoil should be elevated to a height above the water-table. Only the local resources should be used. The solution is the following. Over the bottom (and the water-table), the banks should be raised up to 1.6 m high. The material for the banks should be taken from the same bottom. For this purpose, the 50-80 m-wide and 1-1.5 m-deep channels are dug as drainage valleys. The underground water discharges to these valleys and moves along them directing to the drainage well in the lowest place of the plot. To improve

water filtration the proper conditions are created in the well. The material extracted from the valleys is used to build banks-islands with the total area 18 ha. To elevate the islands, the rubbish from the city landfill is used as a filling material. Of course, this material should be isolated from the underground water by a clay cover. The soil taken from the channels is put above the rubbish, and then the original fertile soil is put on the top. According to the project, before mining quarry, the original topsoil is cut off and stored nearby.

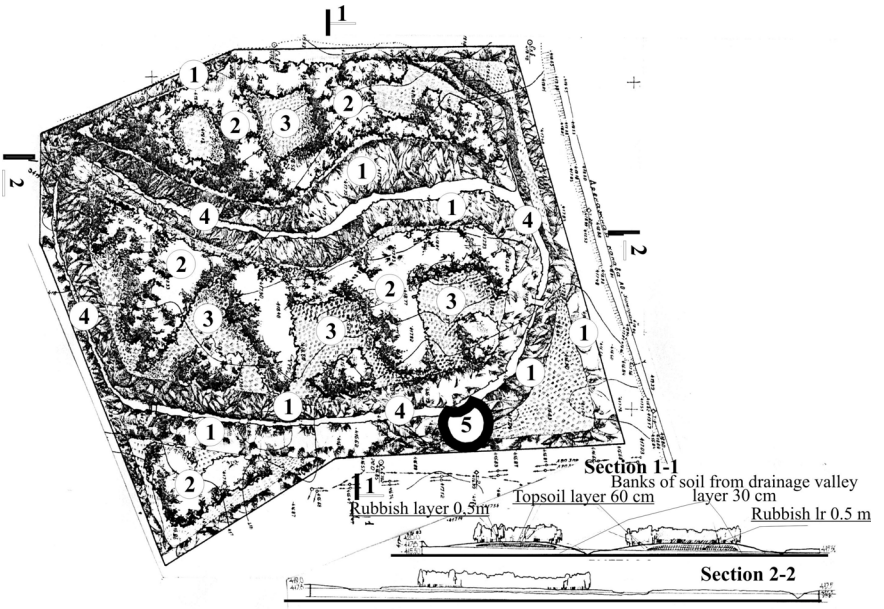


Figure 4: Master plan of quarry in Usolye Sibirskoye. 1) Slopes of islands – coasts of valley, 2) Birches plants, 3) Meadows, 4) Drainage channels, 5) Drainage well.

Thus, to the reclaim the quarry with a high water-table, a valley-island relief is used. In comparison with the surface used in the dump reclamation project in Bolshoye Goloustnoye, this surface is kind of turned inside out.

### 3.3 The quarry reclamation project in Angasolka

The granite quarry (23 ha) is located on the slope of the mountain valley. Here, granite is mined and broken up into the road-metal. This excavation is a terraced slope. The low terrace or the horizon is on the level 795 m, the high border is on the level 890 m. By the beginning of the design in 1998, it had six terraces 15 m high and up to several hundred meters wide. When the mining finishes, the shape of the quarry is going to change. The bottom is going to remain at the same height, but to become wider (from 4 ha to 12 ha). The number of terraces is going to decrease two times, their width decreasing to 10 m.

The disturbance factors are the following. 1) The natural slope is cut by an excavation with wide bottom (12 ha) and three terraces with the total height 75 m. 2) The bottom and terraces are covered by friable granite-dust soil (siftings) which do not retain moisture. 3) The surfaces are too open to winds. The deflation of the soil or the Aeolian movement is too active. 4) There is no vegetation on the terraces, although some of them are 30 years old.

At the bottom, we can see a different picture. It is overgrown with trees and bushes. The age of the bottom and low terrace is the same, however. The reason is the following. The bottom (4 ha) is closed by the walls of the quarry along almost the whole perimeter. There is no wind there. The water from the rock cracks discharges here. So, the bottom is an accumulative cell.

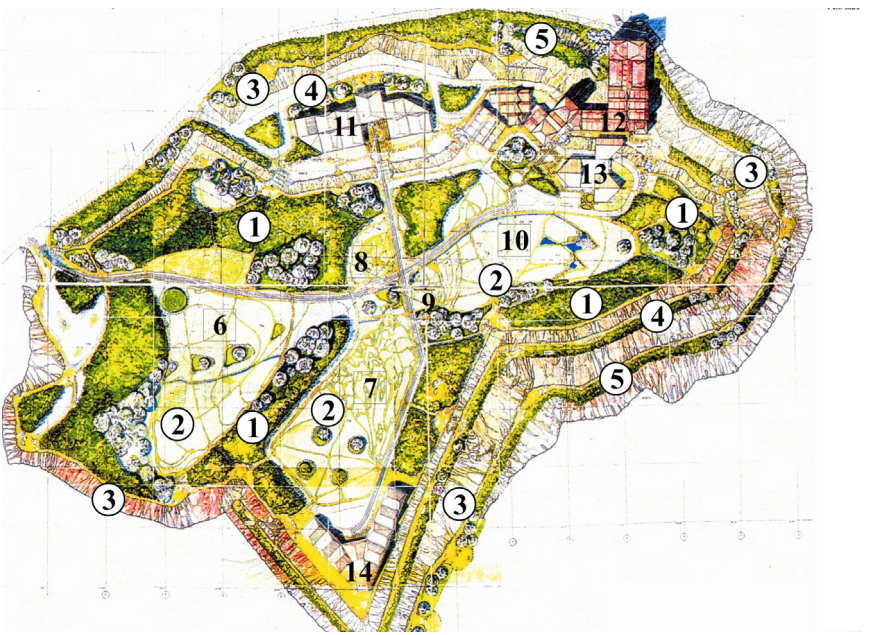


Figure 5: Master plan of Angasolka quarry reclamation. Geoplastic elements: 1) Wide banks – barriers, 2) Narrow banks, 3) Walls of Quarry, 4) Terrace of 810 m horizon, 5) Terrace of 840 m horizon; open spaces: 6) Parterre of Sun, 7) Parterre of Grass Roots, 8) Parterre of Tree, 9) Parterre of Man, 10) Parterre of Water; Buildings: 11) Health-care complex, 12) Hotel, 13) Multifunctional complex, 14) Technical building.

According to the master plan (Figure 5), after mining is finished a park and the tourist centre are designed. A health-care complex is designed on the terrace of the 810 m horizon that remains much wider than the mining project suggested. A big hotel is built on the slope of the quarry. The idea to build the tourist center arose because the place is a junction of three popular itineraries in the region.

The geoplastics concept is the following. The quarry surfaces and its siftings cover have a transit property that should be overcome. Stabilization of the deposition of the soil, the retaining of the soil moisture and the limitation of the soil Aeolian movement, are the main tasks of the landscape restoration. For these purposes, two types of the bank networks are created. The banks 20-30 m wide and 3 m high form the first network of the cells with the area about 4 ha. The barriers of this network enclose the open parterres of the same size as the overgrown old bottom. There is a network of the tectonic cracks of the granite body. The first type barriers repeat this crack network. The tree zones are created on the top of the barriers. Then, the big open parterres are covered by a network of narrow banks (2 m wide and 1 m high) with small cells (6-20 are). Due to their closed perimeters, the small cells accumulate the deposition and moisture. On the border of these cells the pioneer vegetation crops. It is confirmed by the observations in this quarry. The narrow banks network is also shaped as an art object. The design of the parterres creates the artistic images such as Grass Roots, Sun, Water, Tree, and Man.

In addition to the geoplastics, it is suggested that to create pioneer soil, compost is formed from the sawdust and the lignin that can be found in the settling tanks of the Baikalsk wood-and-pulp mill. More detailed information on the projects is presented in [3].

### 3.4 Architecture and ecology compensation project for a historical landscape, The Star Grove

The Star Grove is a historical green block (15 ha) on the riverside of the Angara River in the city of Irkutsk. In 1861, this plot of pine forest was allotted to the Eastern Siberia Governor-General as a dacha. Much earlier, in Paleolithic 7000 years ago, there was an early man site. The area is an archeological monument of a federal status. The green block is surrounded by a built-up area and is located on the third terrace of the Angara River. The terrain of the plot is an erosion valley with a very small stream named Star.

The disturbance factors are the following. In 1955, on the edge of the stream valley in the low third of it, a sewage station was built and across the stream, a sewage collector was laid. The stream was placed in a storm pipe. Two upper thirds of the deep valley was gradually filled up. The sewage collector crosses the valley inside the landfill. First, the “hot” point of disturbances is the contact place of the stream and sewage collector inside the soil banks. The leakage from the pipes causes the formation of a ravine in the dump. Every year the ravine is filled by the soil and rubbish, but it renews steadily. Second, the low third part of the stream valley that is 150 m long (up to the place where the stream flows into the Angara River), is the site of landslide processes. Third, the accidental sewage is poured out of station into the stream. Then the sewage gets into the Angara River, a national-status source of potable water.

The master plan (Figure 6) is the following. The plot is given to the State University of the Communications as a campus place. The landfill above the stream is chosen for the open sport and recreation facilities.


Figure 6: Master plan of the Star Grove Park. 1) Sport Palace. 2) Sport ground. 3) Building-bridge, 4) Anti-landslide frame, 5) Angara River embankment.

The recent landfill (50 years old) does not contain any archeological material. Construction is not banned there. The pedestrian boulevard along the stream leads to the embankment of the Angara River where the passengers' platform, recreational facilities and walkway are going to be. The monuments of architecture and history are protected. Instead of the ramshackle wooden houses along Gogol Street the Palace of sport is designed. A new green network is shaped, which corresponds to the landscape potential.

The geoplastics concept is the following. 1) A building-bridge is designed instead of the soil bank including the sewage and potable water pipes and the stream in the storm collector. The stream flows under the bridge, the sewage and the potable water (in the pipes) are placed on the technical floor of the building-bridge. The pedestrians go on the top of the bridge and along the stream under the bridge. So the flows are divided. The leakage from the pipes is under control. There is a ski pavilion on the first floor of the building. 2) An anti-landslide frame is designed to prevent the landslides in the low part of the stream valley. Retaining walls at the foot of the slopes are constructed. Then both walls are connected with transversal diaphragms. As a result, the pressure of one slope is counterbalanced by the pressure of the opposite one. 3) At the same time the anti-landslide frame is used as a bed for a pound–collector to treat the dirty water. Sand filters and biological treatment with the help of the swamp vegetation are suggested.

## 4 Conclusion: entropy and geoplastics method

Geoplastics is a method for restoring disturbed landscapes by means of controlling the movement and deposition of the landscape material. Restoration

relief is a tool of control. Restoration relief directs the water and sediment movement, controls their deposition and accumulates these materials. The optimal combination of the sunlight, warmth, moisture, mineral and organic substratum give the positive effect – under these conditions, living substance develops and general bioproductivity and biodiversity of the landscape increases. Restoration relief creates a long-term unequal distribution of the free energy used for landscaping. The flows of energy are concentrated by the relief in proper directions and in proper cells chosen by a designer. This energy organization prevents its dissipation, i.e. entropy. Many kinds of the economy activity are accompanied by landscape deterioration and dissipation of the landscape energy. Geoplastics is a reliable tool that allows us to overcome these problems.

## References

[1] Lazareva I.V. Охрана территориальных ресурсов градостроительства.- Киев: Будивельник, 1986.- 128 с., ил.
[2] Polynov B.B. Избранные труды. - Москва: Наука, 1956. - 751 с.
[3] Bolshakov A.G. Геопластика в архитектуре и планировке ландшафта.- Иркутск: Изд-во института географии СО РАН России, 2000.- 171 с.