Spatio-temporal organization of geosystems of the central part of Barguzinskii range

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Abstract. The paper presents the results of the ecological study, with the analysis of landscapes and mapping of the area of the testing ground (80 km²). The testing ground is located in the Eastern Transbaikalia, covering the part of the Urbican basin and its mountainous frame. For the analysis of the structure of geosystems and the estimation of disturbance, the basic geosystem approach is applied to modern geoinformation-cartographic and remote methods. Based on V. B. Sochava theory of geosystems it is assumed for use in processing and ordering a large volume of information. In the paper we analyzed the regional background and main factors of the landscape differentiation of the study areas. It is established that the main factors influencing the landscape diversity are the aspect and steepness of the slopes, the composition and structure of rocks, the absolute height, the amount of atmospheric precipitation, and anthropogenic impacts. It is determined that the influence of the lithomorphic factor is widespread throughout the study areas, the hydromorphic factor is also important, the cryomorphic factor occurs additionally in the alpine and goletz zones. There are structural-dynamic characteristics of landscapes of a topological level. Structural features of topological geosystems are revealed, and large-scale maps of key areas are compiled. Map of the landscape-typological structure was created on the basis of the structural-dynamic and facies analysis of landscapes.

1. Introduction
The study area is located in the northeastern part of the mountainous area of Lake Baikal, that is difficult to access, and covers a territory of 80 km² within the basin of the Urbikan river with coordinates 54.7-54.60 N, 106.6-106.90 E. The Urbikan river basin is located in the northern part of the Barguzin Range (location 3 at figure 1). The range extends over 280 km, has an asymmetric structure: whereas, its western and eastern (facing Lake Baikal) slopes are significantly different. The first slope is strongly dissected, and the eastern one to a lesser extent. The northern high part of the range is represented by stepped watersheds, with a high alpine-type relief and heights from 1300-1400 to 2800 m. The highest peak of the range is Mount Baikal (2841 m). Erosion-denudation low-mountainous relief at altitudes from 1000 to 2000 m with flattened flat watersheds prevails in the south. The southern section was considered in papers on integrated landscape surveys in 2016-2017 [1, 2].

Topographic surveys and first studies of the natural systems of the Barguzin Range were carried out for the first time in 1914-1915 during the expedition of the Ministry of Agriculture of Russia with an objective to preserve sables in the habitats on the range. In 1917, the Urbikan basin was included to the hunting area of the Barguzin Reserve (nowadays a part of “Zapovednoe Podlemorie”), in the post-
war period it was withdrawn, and in 1989 issued as part of the biosphere testing ground of the reserve, where certain types of traditional nature management are allowed.

Figure 1. Hypsometric map of the Baikal Natural Territory. Based on the map of A.V. Bardash [2]. Location of the key testing grounds. Ranges: 1 – the southern part of Barguzin, 2 – Primorski, 3 – the central part of Barguzin.

2. Objects, data and methods
The main approach to the study and GIS mapping of geosystems was the regional-typological approach, which was tested in different regions of Siberia [3-6]. In response to our analysis and landscape-typological mapping on a large scale we focused on topogeosystems of the level of facies and groups of natural complexes that are characterized by a homogeneous internal structure in their natural state [6, 7]. Local variations of deviations are taken into account, including the influence of active cryogenic and gravity-slope processes specific to the region.
We created a field database of 70 points of a comprehensive description of the fifty-kilometre observation route.

The geoinformation base of the study was field descriptions in representative locations with reference, as well as remote data: radar topographic survey SRTM 4.1, multispectral medium-resolution satellite images from Landsat 8 (OLI, channel combinations 4-5-1, 4-3-2, 7-3-1), and synthesized images of GeoEye 1-2, RapidEye of high and ultra-high resolution. A data sample provides coverage of the area with current space information for 2000-2018. Based on the ALOS radiometer data (DAICHI, resolution of 30 m) we created digital elevation models: according to exposure, slope steepness and absolute heights within the range from 456 to 2500 m.

According to the zoning of the Baikal natural territory (BNT), the coastal research area is located within the Baikal basin subprovince and its northeastern coastal foothill and mountain taiga area [7, 8]. The mountain range is attributed to the Baikal-Dzhusdzhor mountain taiga region, and the Pribaikalski goletz-mountain-taiga and basin province, which includes the Barguzin highmountainous and goletz region and the Middle (Central-Barguzin) alpine-type goletz and subalpine. The climate of the Barguzin Range is sharply continental, the temperature can reach -40°C in winter and 40°C in summer, there are few sunny days in the highlands, cloud cover alternates with cool cloudy foggy weather, frosts are possible in any month of the year. July and August enjoy high rainfall and snow usually falls from September and is on the ground until June. The thickness of snow cover in taiga is usually 1.3–1.4 meters, in mountains and on shores of Lake Baikal 0.7–0.9 meters, and in the subgoletz and goletz zones up to 1.6–2.0 meters.

The study area in the Urbikan river basin with adjacent watersheds can be differentiated as a low-mountain and coastal landscape belts (456-900 m), as well as mid-mountain (900-1400 m) and high-mountain (1400-2500) (figure 2). The low-mountain part covers the lateral spurs and Baikal terraces with mountain taiga geosystems and floodplain-bog and mountain-valley taiga geosystems in the lower reaches of the Urbikan.

The mid-mountain part covers the lateral spurs, summits and slopes of the lower stage of the secondary watersheds of the range, where thickets of dwarf Siberian stone pine are represented from the height of 1300 meters. In its middle reaches, the valley of Levyi (Left) Urbikan expands, and the sides of the valley are mainly convex and straight. The boundaries between mountain blocks in the middle part of the basin, composed by different rocks, are usually rigidly separated by contemporary faults, and manifested in relief. On the right side, Upper Proterozoic intrusions of the Barguzin complex (granites and granosyenites) are common. On the bottom of the Urbikan valley and its left source, rocks of the Urbikan Formation of Archean age are exposed.

3. Results and Discussion.

3.1. Goletz highlands of the Urbikan basin

The sources of the Levyi Urbikan are located in a relatively closed alpine region (at an altitude of 1450-1600 m), in the postglacial trough “Valley of 12 Lakes”, which is of glacial-tectonic origin. The Upper Pleistocene glaciation on the Barguzin Range had a mountain-valley character (35–10 thou years ago). A line of reliable tectonic contact, caused by active Cenozoic faults runs along the bottom of the trough valley [9].

The postglacial region has a U-shaped transverse profile, oriented from northeast to southwest, has a hilly bottom with step-crossbars and steep sides with cirques. The hogback watershed of the Barguzin Range with heights of up to 2188 meters rises in the east.

Presented are subalpine-type forb meadows (with a more-layered grass cover) on alluvial permafrost-humus soil (soils are given according to D. Lopatina [10]) on the plane terraces on the bottom of the valley along the shores of lakes at marks 1480-1510, in a high floodplain with single suppressed fir and spruce, willow, duschekia, ashberry, with rhododendron and cotoneaster. The grass cover has 2–3 layers; an abundance of rare and Red Data List species is noted. In the low floodplain of
the source, there are swampy yerniks, along the channels and swampy hollows – aconite-sedge meadows with snowdon rose (*Rhodiola rósea*).
3.2. Mid-mountain part
At the exit from the mid-mountain terrace of the Barguzin Range (900-950 m), mountain taiga slope and valley landscapes become more diverse, but also disturbed by fires in the mountain-taiga zone up to the confluence of the Levyi Urbikan and Oktakit (the left-bank tributary). Subhorizontal surfaces and gentle slopes of the southwestern exposure are occupied by the facies of Siberian stone pine -pine cowberry- moss (5P4SP1E + F, where P means pine, SP – Siberian pine, F – fir, B – birch, E – spruce, L- larch), and on burned areas a pine willow-herbaceous fire-damaged forest is represented. The right shaded sloping side (prevaleently northern slopes) is covered with sparse larch forests with dwarf Siberian stone pine and rock glaciers.

The bottom of the river valley in the interfluve of the Pravyi (Right) and Levyi Urbikans expands to 500-900 meters. The high floodplain of the interfluve is covered mainly by aspen in the old fire places. Birch-aconite facies, as well as willow currant herbaceous on humus stratified alluvial soils are common in depressions with shallow tributaries of the Urbikan, having their rise from the lateral spurs of the ridge.

The undisturbed high floodplain is characterized by Siberian stone pine-pine with spruce and fir, cowberry-small-grass with dwarf undergrowth and duschekia on the stratified alluvial soil. On the continental slope in the old burnt areas, a sere of aspen-birch and willow-duschekia-shrub is presented. The deplanated summits of the lateral spurs on this plot reach 1000-1200 m, the subgoletz belt is fragmentary, and the upper forest border often reaches the summits.

In the middle reaches of the Urbikan, the valley is more expanded in width and depth with erosion, the excesses between the water line and the edges of the continental slopes reach 100 m, and between the water line and the summits of the nearest watersheds 300-400 meters. Between the left and right channels, there are lowland swamps covered with shrubbed sedge-moss with fragments of tall herbaceous intersected by lateral channels.

The Barguzin research expedition in 1914-1915th allocated a reference plot (concerning the vegetation bioproductivity and sable habitats) with a description: units 4SP, 4E, 1F, 1B) with a height of SP – 30-35 arshins (appr. 21-25 m), a thickness of SP – up to 20 vershoks (appr. 1m), and E to 10 vershoks (appr. 0.5 m). In the undergrowth there is dwarf Siberian pine, blueberries and ledum on moss cover. Imaginary indigenous fir-Siberian stone pine facies belonged to the South Siberian coniferous-mountain-taiga geome of reduced development. Currently, on the southern gentle and acclivious slopes, larch-pine facies cowberry-moss with ledum and blueberry-moss with rare Siberian stone pine (Siberian stone pines up to 20 meters high are rare here) and rare undergrowth of Siberian stone pine are common. Such a replacement of the South Siberian mountain Siberian stone pine facies occurred in the middle and lower reaches of the Urbikan due to frequent fires during the past hundred years, and fresh traces are restored by the birch-aspen seres.

Green moss-cowberry pine forests appear on the southern gentle and acclivious slopes of the river valley. Prevalently on the western shaded slopes, there are pine landscapes with larch and birch, duschekia-green moss with sparse Siberian stone pine undergrowth, and dwarf Siberian stone pine undergrowth of with blueberry.

Bushy-tall herbaceous facies with the first poplar tier are common on the high floodplain in the middle reaches, and the second tier is composed by spruce-fir with birch. In the middle reaches of the Urbikan, the floodplain is partially swampy, channelled by lateral courses and streams. In low places of the expanding river valley, there are facies on the hummocky-kettle microlief of birch-larch (6L2B1F1SP1) cowberry-moss with sparse Siberian stone pine undergrowth.

On the low gentle terrace of the Pravyi Urbikan, larch-pine with Siberian stone pine, spruce and fir, cowberry-small grass with dwarf undergrowth and duschekia on stratified alluvial soil are described.

3.3. Low-mountain and coastal parts
In the lower reaches of the Urbikan, the bottom of the valley expands to 1.4 km. Facies of low terraces are common here: namely larch-pine cowberry-ledum moss on alluvial humus soils, pine-larch ledum cowberry-small grass on podzols. Spruce and mixed facies, such as birch and spruce with fir in the
undergrowth with alder, cowberry-fern and reed-horsetail-sedge, occur in floodplain depressions. The high floodplain corresponds to facies with larch and birch, spruce in the undergrowth of blueberry-cowberry-sedge on sod-podzolic and illuvial-ferruginous soils.

At the foot of the lateral spurs, subhorizontal surfaces elevated regarding the water level are presented on the upper Quaternary glacial deposits. Here facies of pine-larch cowberry-moss facies with undergrowth of dwarf Siberian stone pine, as well as larch-pine cowberry-ledum moss facies on gray soils and sodded illuvial ferruginous podzolized brown soils are common.

The lower reaches and the mouth of the Urbikan river are located in the northeastern physical-geographical region of the Baikal basin. Here the cover consists of Upper Quaternary glacial deposits (loams, boulders, pebbles, alluviums of ancient valleys), often with permafrost islands. The layers of loose sediments overlap contemporary active faults on the side of the basin.

Larch cowberry-ledum facies appear on peat cryozems, owing to the prevailing frozen soils, on the second terrace pine-larch cowberry-ledum on peat lithozems after a smooth transition to the third Baikal terrace.

In a concave of the first lake terrace, permafrost is developed at a depth of 35-50 cm up to the natural levee. The cover is presented here by yernik swamp with cloudberries and swamp ledum and renewal of larch on peat cryozems. The Urbikan alluvial cone and the coastline between Capes Urbikan and Chukag, 4.3 km long, are surrounded by a narrow pebble beach. A continuation of the continent here is a shallow shelf zone with a depth of up to 20 m and a width of 250-800 m, apparently formed by loose water-glacial deposits.

4. Conclusion
Field investigation with further landscape-ecological analysis covered the main part of the river basin of northern Baikal with a rather wide range of altitudinal-belt types of geosystems from high-mountain to low-mountain and depressions, as well as their variations. The postglacial alpine zone on the terraced subalpine and floodplain meadows of the “Valley of 12 Lakes”, is characterized by its biodiversity, although it develops in severe temperature and radiation conditions on permafrost soils.

Within the mountain-taiga zone, there are several small areas of forests prevailing in the past, of the South Siberian mountain Siberian stone pine subshrub-moss and mountain Baikal-Dzhusgzhur of Siberian stone pine with larch with yernik and dwarf Siberian stone pine undergrowth. Moreover, in the upper part of the mountain-taiga zone, such forests have burned down recently, and the issue of restoration is debatable. Old burnt places on subhorizontal surfaces and on gentle slopes are restored through small-leaved succession into pine subshrub-moss facies with sparse Siberian stone pine undergrowth.

The research plot is a part of the biosphere testing ground of the “Zapovednoe Podlemorie” and that is important in applied management. Limited nature management is allowed here, but territory isn’t accessible to tourists. Planning of this mountainous area should be based on objective features of the modern structure of geosystems, updated every year and current practice in landscape planning.

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