The features of landscape mapping in the environmental assessment

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Abstract. Along with the General scientific methodology of mapping of geosystems, special cartographic models are developed for practical purposes, which take into account the needs of the industry for which they are created. The article deals with the main methods of mapping to solve the problems of environmental impact assessment of objects Verkhnechonskoye oil and gas condensate field and the system of external transport of oil. Due to the specifics of the Northern territory in the legend of the map reflects the geological and permafrost characteristics of each landscape, as well as the main processes taking place in them. Analysis of the set of factors displayed for each landscape made it possible to divide the latter into three degrees of stability (the ability to restore its original appearance after external influence). For convenience of perception of the cartographic image, each area is shown in the color scale with separate numbering of contours. Colors within each district differentiate according to certain basic typology landscape on different landforms, which alter hydroclimatic conditions. The article gives examples of legend maps and explanations to assess the transformation of landscapes in natural and anthropogenic conditions. The modern transformation of landscapes and the forecast of their changes are based on a detailed assessment of natural conditions, their dynamic and evolutionary transformations, ecology of plant species, and the nature of anthropogenic impact.

1. Introduction
Landscape map is basic in thematic mapping, including those that provide the solution of practical problems [1]. One of these tasks was the complex description of the landscape components of the Verkhnechonskoye oil and gas condensate field. This was caused by the need in environmental surveys in the area of pilot-industrial operation of the field and the oil transportation system 620 km long from the field to the city of Ust'-Kut. The landscape map, according to the technical requirements, was supposed to contain information about the types of landscapes, their current state, leading processes, sustainability and man-made transformation. The maps were compiled at a scale of 1:50 000 and 1:100 000 for the field and the pipeline route, respectively. The map for the pipeline territory was compiled in the form of a transect including a buffer zone 2 km wide.

The mapped territory lies within the Central Siberian Plateau at the junction of the Yerbogachen Plain, the Prilenskoe and Leno-Angarskoe Plateaux. The main features of the plateau resulted from neotectonic movements, which raised to different heights the reservoir plains, composed mainly of horizontally deposited sedimentary rocks, sometimes with the introduction of traps [2, 3]. The trace passes along the border of the catchment of the Lena and the Yenisei rivers. There is a latitudinal
differentiation of geosystems and variations in moistening due to minor orographic boundaries within the region. The climate in the north of the region is characterized as more sharply continental than in the south. Average annual temperatures range from $-7^\circ\text{C}$ to $-4^\circ\text{C}$. The northern part of the mapped territory is located within the zone of discontinuous permafrost, and the southern part within the zone of insular permafrost with a capacity of up to 20-30 m [4, 5]. This territory is the center of oil and gas exploration of the eastern regions of Russia (https://vcng.rosneft.ru). The Verkhnechonskoye oil and gas condensate field is the largest in the Irkutsk oblast.

2. Objects and methods
Landscape mapping was based both on traditional route and aerial surveys, as well on Earth space surveys.

The map's legend shows the subdivision of landscapes according to the relief forms: watershed, slopes (taking into account steepness and exposure), large and small river valleys, which determine the specificity of meso- and microclimate [6].

Hydrothermal features of soil grounds are essential for functioning and transformation of landscapes. In this respect, the legend maps also presents geological and permafrost features of each landscape section and the main processes. We analyzed a complex of factors and, therefore, subdivide landscapes in areas of anthropogenic impact on anthropogenically disturbed and anthropogenically modified. In the first case, there is the possibility of restoring indigenous landscapes after the removal of anthropogenic loads [7] (figure 1).

![Figure 1. Conventional symbols to the landscape map the Verkhnechonskoye field.](image-url)
The area of the Verkhnechonskoye field, which is located within the Yerbogachen plain, is reviewed below. The territory is composed of carbonate sediments, sandstones and clays. Dolerite intrusions of trap formation are presented fragmentarily. The most of the territory is characterized by a poorly dissected relief with absolute heights of 400-600 m, complicated by cryogenic microrelief [8].

The climate of the area is characterized as sharply continental. The mean amplitude of air temperature is 48°C, the absolute – 97°C. The absolute temperature maximum and minimum are recorded at the weather stations of Nepa (39° and -58°) and Yerbogachen (35° and -61°). Annual precipitation is 300 mm. Such harsh conditions have an effect on a slight increase in biomass, as well as on the decrease in yield and low density of stands [9].

Watershed areas are the "standard" of the landscape appearance of the territory. Middle taiga landscapes dominate here. Continental climate is particularly pronounced within small river valleys, where a lack of air moisture “coexists” with high water content in soil. These locations are characterized by the dominance of moss swamps and stagnant waterlogging processes. In the valleys of large rivers there is a slight decrease in the continentality of climate due to the impact of significant water mass. Therefore, there are landscapes characteristic of areas with less severe environmental conditions. The natural-territorial structure of the area is formed by the following landscapes: north larch-taiga (Larix dahurica) yernik with the undergrowth of Betula exilis grass-green moss with excessive moisture; middle larch-taiga (Larix sibirica) subshrub-grass-green moss, low forest (Betula ajanensis and Bétula pubéscens) grass-green moss swamped, transitional to peat bogs; peat-marsh yernik sedge-sphagnum. Drained and warmer habitats (areas of development of sandy and carbonate sediments) with seasonally freezing soils are characterized by larch (Larix sibirica) and pine-larch grass-cowberry and lichen landscapes. The region is dominated by bogging, thermokarst, frost swelling, solifluction, peat formation, and karst processes are also widespread [10].

The landscapes are disturbed by human activities related to the exploration and exploitation of oil fields. As a rule, most landscapes, due to their instability, cannot be restored to their original condition, or will be restored over a long period of time (several hundred years). These are yernik moss or sphagnum derived communities, large-hilly peat or moss sedge-yernik bogs, which have occurred at the places of taiga-like frostland landscapes after burning and logging (figure 2).

Figure 2. The area of the Verkhnechonskoye field on a satellite image taken by Landsat-8 satellite (OLI tool, spectral range 0.630–0.680 microns). Taken 07.16.2017.
The area is characterized by the introduction of tundra elements, namely, peat bogs in the north-taiga larch permafrost types of landscapes. The taiga landscapes of the region are complicated by the landscape elements of the northern and southern taiga, which determines their transitivity. Transition zones are characterized by increased mobility of the processes. This is clearly manifested in the rapid expansion of those or other contacting landscapes with changing the ratio of heat, atmospheric moisture, geological structure, topography, and local runoff [11]. Anthropogenic impact leads to a significant destabilization of the geographical environment. Below is a fragment of the legend to the landscape map of the Verkhnechonskoye field.

3. Results and discussion

Dividing landscapes

1. Of planate weakly dissected surfaces of watersheds with slopes less than 2° on Cambrian dolomites, limestones with groups of karst depressions down to the first ten meters deep, and larch forests with inclusion of pine juniper lichen-cowberry-green moss with soils seasonally freezing up to 3-5 m deep. Karst processes.

2. Of depressed sites of watersheds on Jurassic clays with permafrost up to 150 m thick, with seasonal thawing layer of 0.5-0.8 m thick large and flat-hilly peaty, with a system of troughs up to 1.2 m deep sedge-ernik troughs up to 1.2 m deep with andromeda, cassandra, cranberry, sphagnum (Sphagnum fuscum) marsh cryosolic with isolated suppressed pines and birches. Bogging, thermokarst, swelling, and solifluction processes.

3. Gentle (2–5°) well-drained slopes of northern and eastern exposures on Cambrian dolomites, larch limestones (Larix sibirica) with pine, Dusheki cowberry-moss, partly with karst depressions with seasonally freezing soils to the depth of 5 m. Karst processes.

4. Steep slopes (up to 10-15°) on early Triassic intrusions of dolerites of trap formation rarely-larch moss-lichen, sometimes with blocky scree. Frozen bedrock with cracks and voids filled with ice predominates. The thickness of the frozen strata is up to 100 m, the seasonal freezing layer is up to 3.0 m. The processes of solifluction, frost cracking, and slopes (debris and downfalls).

Landscapes of the local hydrographic network (small rivers and catchment areas)

5. Swampy troughs with a flat bottom and a trough-shaped transverse profile on the Upper Quaternary alluvial loams, gravel-pebble material hilly-ridge swamp yernik from dwarf birch grass with a permafrost up to 120 m thick, with a thickness of a seasonal thawing up to 1 m of permafrost swamp regime with thermokarst saucer-shaped depressions up to 50 m in diameter and up to 2 m deep. Thermokarst processes, bogging, frost swelling, and solifluction.

Landscapes of transit river valleys

6. Flat low-drained surfaces of terraces with (1-4°) on Upper-Quaternary alluvial loams, gravel-pebble with long-term permafrost up to 120 m thick, seasonal-thawing layer thickness of 0.5-0.8 m, large and flat-hilly peaty, sedge-yernik with andromeda, cassandra, cranberry, sphagnum mosses, permafrost with rare suppressed pines and birches with thermokarst relief and single swelling hummocks. Widespread development of thermokarst, bogging, frost swelling and solifluction.

Stable long-derived types of landscapes (fires and old logging)

7. Depressed areas of watersheds large-hilly peaty sedge-yernik with andromeda, cassandra, cranberries, sphagnum marsh, thermokarst in larch forests after fires with a wide development of bogging, thermokarst and frost swelling.

8. River valleys shrub (spirea and briar), herbaceous at the fire site, floodplain forests with bogging, solifluction and water erosion.

4. Conclusion

Thus, we elaborated special legends of landscape maps for practical purposes, which, on the one hand, are based on the theoretical knowledge of formation and development of integral geographical systems; on the other hand, they take into account the needs of a particular target industry. These maps are also developed on objective grounds, but differ depending on their purpose. The features of
landscape functioning are considered and an example of a map legend is given that contains information about the types of landscapes, their current state, leading landscape-forming processes, and directions for transformation.

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