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MONITORING OF NATURAL COMPLEXES WHILE DEVELOPING AND OPERATING THE FIELDS OF TIMAN-PECHORA OIL AND GAS PROVINCE

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МОНИТОРИНГ ПРИРОДНЫХ КОМПЛЕКСОВ ПРИ РАЗРАБОТКЕ И ЭКСПЛУАТАЦИИ МЕСТОРОЖДЕНИЙ ТИМАНО-ПЕЧОРСКОЙ НЕФТЕГАЗОНОСНОЙ ПРОВИНЦИИ

Abstract. Landscape monitoring is organized to monitor the state of natural complexes and their transformation. Monitoring of landscapes should ensure the identification of anthropogenic load, the dynamics of areas of anthropogenic impact, the degree of degradation of natural complexes. The Timan-Pechora oil and gas province is located on the territory of the Republic of Komi, the Nenets Autonomous Okrug and the adjacent water area of the Pechora Sea. The area of the province is 600 thousand km^2. Currently, the development and extraction of mineral resources, mainly oil and gas, is actively underway in the territory under consideration. This is a complex process that requires the collaboration of many specialists, including ecologists. In the Bol'shezemel'skaya Tundra, the dominant part of tundra landscapes are extremely sensitive to anthropogenic influence and the unorganized use of the available space will soon lead to the complete loss of their own functions, and their restoration will take a huge amount of time. In this paper, a basic field study method was chosen as the main method to study the landscape. Thanks to route observations, a complex landscape characteristic of the territory was compiled.

Key words: man-made landscapes; landscape complexes; landscape monitoring.

Аннотация. Мониторинг ландшафтов организуется для наблюдения за состоянием природных комплексов и их трансформацией. Проведение мониторинга ландшафтов должно обеспечивать выявление антропогенной нагрузки, динамики площадей антропогенного воздействия, степени деградации природных комплексов. Тимано-Печорская нефтегазоносная провинция расположена на территории Республики Коми, Ненецкого автономного округа и прилегающей акватории Печорского моря. Площадь провинции составляет 600 тыс. км^2. В настоящее время на рассматриваемой территории активно ведется освоение и добыча полезных ископаемых, главным образом нефти и газа. Это сложный процесс, который требует совместной работы многих специалистов, в том числе экологов. В Большеземельской тундре преобладают крайне чувствительные к антропогенному влиянию тундровые ландшафты, и неорганизованное использование имеющегося пространства в скором времени приведет к полной утрате их собственных функций, на восстановление которых потребуется огромное количество времени. В качестве основного метода исследования ландшафта в данной работе выбран базовый метод изучения в полевых условиях. Благодаря маршрутным наблюдениям была составлена комплексная ландшафтная характеристика территории.

Ключевые слова: антропогенные ландшафты; ландшафтные комплексы; ландшафтный мониторинг.

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Introduction

Landscape monitoring is an important part of environmental monitoring and is organized to monitor the state of natural complexes and their transformation. Landscape monitoring should ensure the identification of anthropogenic load, the dynamics of areas of anthropogenic impact, the degree of degradation of natural complexes [5; 7].

The tundra zone occupies one-fifth of Russia. Tundra landscapes stretch along the northern strip of the mainland. Currently the northern territories of the Russian Federation are being actively developed by man. Economic activity is associated with geological exploration and development of hydrocarbon deposits. One of the major centers of oil and gas accumulation is the Timan-Pechora oil and gas province, which is located on the territory of the Komi Republic, the Nenets Autonomous Okrug and the adjacent water area of the Pechora Sea. In 2019 a total area of 215 100 hectares, which is located within Bolshezemelskaya tundra in the north-eastern part of Khoreyverskaya depression, has been studied and according to botanical-geographical zoning of the Arctic belongs to the strip of the middle (typical) tundra Eastern European Subprovince East-West Siberian province. Active exploration of hydrocarbon deposits in the territory dated from the end of the XX century to the beginning of the XXI century; however, the landscape-ecological study of the area is extremely insufficient. For landscape assessments, they rely on the experience of similar studies of zones with similar climatic conditions, mainly the Yamal Peninsula and Canada [1; 2; 3; 9].

Material and research methods

The field study was carried out in two stages. The first was to identify landscape - forming processes developed in the study area, according to literary and stock sources. In the field study, it was performed the machine situational modeling and the actual measurement and observation [9].

Most of the landscapes of the study area are at the different stages of self-restoration (naturally or after remediation activities). The total area of disturbed landscapes is 28% of the total study area. This indicator is the result of the active development of the Timan-Pechora oil and gas province. The largest area of the oil infrastructure is occupied by processing areas – 11%, landscapes within this territory are degraded. Corridors of communications (including corridors of electric power transmission lines and underground pipelines) occupy an area of 5%, degradation of landscapes with natural self-restoration processes is observed; complex roadside disturbances (flooding) cover an area of 1%, this type of disturbed landscape is being degraded; coated roads (filling) occupy an area of 2%, degradation of landscapes with natural self-restoration processes is observed; clearing for temporary roads (winter roads) occupies an area of 6% – landscapes are being restored; peat and sand exploited and reclaimed quarries occupy an area of 2%, degradation of landscapes with natural processes of self-restoration is observed; complex bite disturbances occupy an area of 1% – landscapes are being restored [4; 6].

Results and discussion

There are 16 major groups of landscape complexes on the study area, which are characterized by an overall orientation of processes of development: hilly steeply-slope, lake-hilly, watershed-slope, flat steeply-slope, flat, lakeside terraced, laida, flat hilly bogs, polygonal bogs, lowland and mesotrophic bogs, khasyrey, valley-slope, delta, floodplain, valley, hollow [1].

To date, the landscapes of the Bolshezemelskaya tundra undergo the greatest anthropogenic transformation as a result of economic activities aimed at the extraction of hydrocarbon raw materials. Anthropogenic transformations that have arisen under the influence of traditional types of economic activity for this region (deer farming) are insignificant. Landscapes are exposed to anthropogenic pressures as a result of geophysical and geological exploration, construction and operation of areal objects (well clusters, main transfer pumping station, booster pipeline pumping station (BPPS), etc.), as well as linear objects (roads, winter roads, pipelines, power lines) [9].

The emergence of industrial geotechnical systems is associated with the almost complete transformation of all landscape components. The components of the geotechnical system are made of materials created in the process of technological production. The functioning of the geotechnical system depends on the production cycles established by man. The restoration of such complexes is possible provided that the structures are completely dismantled and deep remediation measures are carried out [2; 5].

In anthropogenic systems, the transformed components self-restore and subsequently function according to natural laws. During remediation work, the disturbed landscapes also return to an approximate natural state.

On the territory of the Timan-Pechora oil and gas province, the geotechnical system formed as a result of oil fields development and operation, with a predominance of natural complexes degradation processes includes:

1. Oilfield geocomplexes – technological platforms of existing facilities (field bases, BPPS, flare devices, well clusters, etc.);
2. Linear transport – sprinkled roadbed and/or paved roadway;
3. Quarry – developed deposits of common minerals.

In the industrial anthropogenic class of landscapes, with the predominance of the processes of restoration of natural complexes, the following are distinguished:

1. Oilfield anthropogenic landscapes – remediated oil-contaminated lands; exploratory wells with complex disturbances, etc.;
2. The linear oilfield type of anthropogenic landscapes represented by complex roadside disturbances, clearing for temporary roads (winter roads), electric power transmission lines, pipelines with underground laying, etc., including land transformed as a result of the construction of linear structures (flooding, etc.);
3. A quarry type of anthropogenic landscapes with remediated quarries.

All objects of field development are rather complicated technical structures with their design features, technological mode of operation, and associated technogenic flows, which differ in composition and dynamics of the release of pollutants into the natural environment. The individual contribution of objects to environmental pollution varies and depends on the operating mode (technological or emergency), the composition of pollutants, as well as the morphological and geochemical structure of the original landscapes. Technogenic disturbances, even of the same type inherently, can subsequently cause uneven secondary disturbances of natural systems, depending on the type of landscape complex that places them into. The transformation of the natural environment already begins during the search and exploration of the field and continues at each stage of its development and operation [10].

The formation of most exogenous geological processes occurring in the study area is significantly affected by permafrost, which has a massive occurrence here.

Most often in the tundra zone, frost mount hillbocks occur at the freezing place of overmoistened rocks, which contributes to an increase in their volume due to the formation of ice. On average, frost mount hillbocks are 1-2 meters high, although at times they can reach 30-40 meters (hydrolaccolithes). They are characterized by flat peaks, broken by frost cracks. Their life span is from several months to several years [2].

Khasyrey (drained lake) (Yakut-Alases) is a slightly sloped and flat-bottomed oval-shaped hollow, with a diameter of several kilometers and a depth of 30 meters. They are formed during the thawing of underground ice, soil shrinkage, etc. Their lowlands are usually covered with swampy lakes, and the slopes are meadow-steppe communities [3].

The main exogenous geological and cryogenic processes in the study area are cryogenic sliding landslides and currents, slow solifluction, seasonal and perennial rock heaving, polygonal relief forms, and related processes of thermokarst, channel processes along the banks of small and medium rivers, deflation, and cryoturbation (spot medallions). Attention is paid to the formation of a structural (block) relief, which is widely developed on mineral soils by soil veins, resulting from nivation and slow solifluction.

One of the most widely developed processes in the area of work is polygonal rock shattering and associated landforms. The transformation of polygonal surfaces occurs in various ways depending on lithological, geocryological, geomorphological, zonal, and regional conditions. Varieties of the transformation of polygonal surfaces are structural soils, erosion-thermokarst forms, thermo-erosional and thermoabrasional formations. Depending on the composition of soils, the intensity of the processes is different.

With an increase in the surface slope, the rate of formation of structural relief forms changes. With sufficient drainage, surface slope, and the presence of an erosion basis, thermo-erosional gullies are formed. On the banks of rivers and lakes, when the banks are washed away, thermo-erosion and thermal denudation form an ordered relief pattern [8].

On the flat hill crests, there are polygons of considerable size (150–200 m). In the lowlands and depressions that divide watershed hills and ridges, block relief is usually very pronounced. Mounds with flat and gently convex peaks, with rather steep slopes, 1.5–4 m high and 40–150 m in diameter, are separated by wide, often boggy, or overgrown with dense willow interblocks. The width of the interblocks is 60-80 m. At the junction of several interblocks, several deepened basins are formed, often occupied by lakes. Large blocks and interblocks are well distinguished in the area by the nature of the vegetation and are well identifiable in aerial photographs. They, in turn, are divided into polygons measuring across the order of 10–15 m with a regular network of very narrow, barely noticeable depressions. In most cases, especially on drier surfaces, the micropolygonal structure of large blocks is not morphologically expressed [5; 9].

Flat watershed spaces composed of the surface by cover loams or sandy loams can be ordered into several geomorphological forms. Most often, these are uniformly distributed round or oval shapes.

On the slopes, there is a significant development of interblock depressions by slope processes, such as erosion, solifluction, with the participation of thermokarst and nivation. Under conditions of good humidification and deep snow accumulation, depressions overgrow with high, dense willow. The length of the runoff hollows reaches 3 km, the width is up to 0.5 km.

On steep banks of rivers and lakes, coastal, channel, and accompanying slope and cryogenic processes often occur. Channel processes are manifested in channel deformations with erosion of coasts composed of sand and sandy loam rocks. River bottoms are often composed of coarse clastic material and pebbles. Depending on the geomorphological and geological conditions, channel processes on the banks of small rivers have different activities. At a high geomorphological level, exorheic (open) and drainage lakes, between which flow, are widespread. The activity of channel processes depends on the basis of erosion between the lakes. The stock is as regulated as possible [8].

Thermokarst in the area of work is developed for various types of ice. Currently, there is an active thawing of ice-wedge casts, which is part of polygonal peatlands. On ice-wedge casts, subsidence relief forms are formed along polygons. Inside the polygons, with a large ice content of the rocks, thermokarst subsidence along segregation ice also forms [10].

Polygonal landforms are one of the most common in the study area. The thickness of the peat layer in peatlands reaches 2–3 meters, which reliably preserves permafrost from the warming influence of the climate. During thermal abrasion, peatlands on the shores of thermokarst lakes are actively destroyed and form outcrops with the structure of peat deposits visible in the section.

Under conditions of climate warming, the development of the polygonal network does not occur on most peatlands. Ice-wedge casts are in a degradation stage.

Perennial and seasonal frost mount hillbocks are typical for the study area. Perennial frost mount hillbocks are formed during the influx of moisture on bogs and on the bottoms of boggy valleys. The diameter of the examined perennial heights of frost mount hillbocks is 5–10 m, they do not exceed 1 m in height.

Seasonal frost mount hillbocks are observed on moistened and boggy surfaces composed of dusty, heaving sandy loams and loams. The diameter of seasonal frost mount hillbocks is 0.3–1.2 m, and a height of 0.5–0.7 m.

Conclusion

Thus, the study of the given territory will predict and avoid the adverse effects of man-made disasters on the identical physical-geographical conditions of the area that are exposed to oil and gas industry. Working in this direction will allow the process to properly plan an economic activity to natural landscapes not become unsuitable for any activity.

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