

Assessment of landscapes transformed during the development of the Verkhne-Taluminskoye field using remote methods

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Abstract. Over the past decade, a significant increase in disturbed natural landscapes has been observed on the territory of the Aldan-Chulmanskoy coal-bearing region. According to our estimates, the area of the quarry-dumping complex here from 2014 to 2022 increased by 50.4% and reached 89 km². To assess the latest changes in landscapes in this area, the Verkhne-Taluminskoye coal deposit was chosen, on the basis of which in February 2018 coal mining began for the first time on the left bank of the river Chulmakan. To establish landscapes, the study area is zoned according to vegetation, which was determined according to satellite images of the Yandex and Mapbox databases. The areas have been divided into types of terrain as well. Thus, it was determined that the largest areas in the study area of the types of terrain are occupied by gentle slopes - 46.2 km² (52.6%), and plateaus are also common - 18.1 km² (20.6%) with elevations of 920-970 m. The contoured layers (vegetation and terrain types) were merged in QGIS3 software to obtain a landscape map of the Verkhne-Taluminskoye field. Further, a layer with the contours of the coal mine as of 2022 was superimposed on it. As a result, a map of the transformed landscapes of the Verkhne-Taluminskoy deposit was developed. Quantitative indicators of landscape change in the study area have been established. The most transformed were kurums (rock glaciers) on slopes of medium steepness and gentle slopes - 43.5 and 18.3%, respectively, were transformed, as well as closed 27.9% of forests on slopes of medium steepness were transformed. It was revealed that the slopes of medium steepness (10-30°), as well as kurums are disturbed to the greatest extent.

1 Introduction

Over the past decade, a significant increase in disturbed natural landscapes in the Republic Sakha (Yakutia) has been observed on the territory of the Aldan-Chulmanskoy coal-bearing region. According to our estimates, the quarry-dump complex area here increased by 50.4% from 2014 to 2022 with reaching an area over 89 km². To assess the transformation of various landscapes on the territory, the area of one of the modern intensively developed coal field of the Neryungri district – the Verkhne-Taluminskoye deposit was chosen. It is located to the

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north of the Chulmakanskoye deposit, on the left bank of the river Chulmakan and 36 km northeast of the town of Neryungri [1]. Coal mining here began in February 2018 and is designed for 10–15 years [2].

2 Materials and Methods

Study area: a territory on the basin of the Chulmakan and Verkhnyaya-Taluma rivers forming a regular rectangular, which made up 87.8 km² (Fig.1).

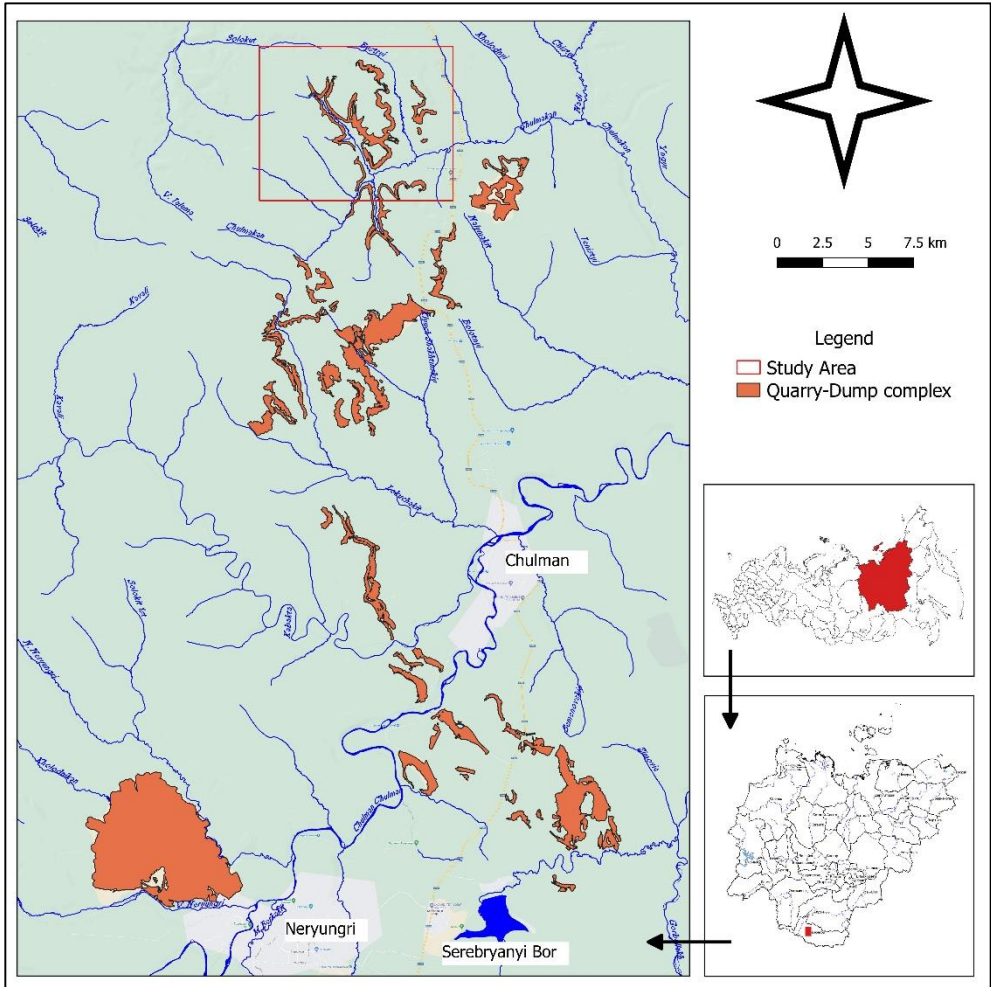


Fig. 1. Study area on map of quarry-dump complexes (based on Sentinel-2 space imagery) of Aldan-Chulmanskoye coal-bearing region as of 2022 Q3.

Using the definition of slopes of an open access SRTM imagery elevation data in the QGIS 3 program, slope complexes of the study area were contoured in ESRI Shape format. The slopes are differentiated into gentle ($2\div10^\circ$), medium ($10\div30^\circ$) and steep (more than 30°) [3]. As a result, the calculated areas of steep slopes were less than 1 ha, which made it possible to neglect this subgroup.

The remaining areas are subdivided according to the identified types of terrain: plateau-top, basement plateaus, mountain-valley, mountain-valley terrace (Fig. 2)

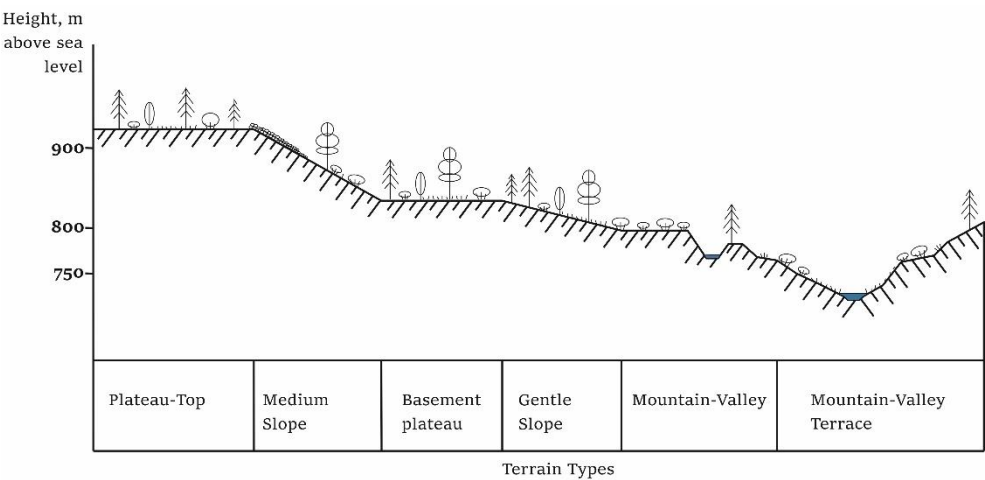


Fig. 2. Transverse diagram of the study area’s terrain types.

For the subsequent determination of landscapes, the study area was differentiated by vegetation, according to satellite images of the Yandex and Mapbox databases using landscape descriptions of the Permafrost-landscape map scale 1:1500000 (2018) [4] and the Landscape map of the USSR scale 1:2500000 (1982) [5].

To determine such characteristics of territories as a seasonally thawed layer, a seasonally frozen layer, contoured layers were superimposed in QGIS 3 software (Merge Function). Then, a layer with the contours of the transformed lands as of 2022 Q3 was additionally superimposed on the resulting map. We used a definition of transformed lands from [6].

3 Results and Discussion

The largest areas in the study area are occupied by gentle slopes (52.6 %), and extensive plateaus (20.6%) located on interfluvial area of the Chulmakan and Solokut rivers with elevations of 920-970 m above sea level, the biggest one of which has area of 1348 ha. A map of terrain types of the study area of scale 1:200000 presented on figure 3.

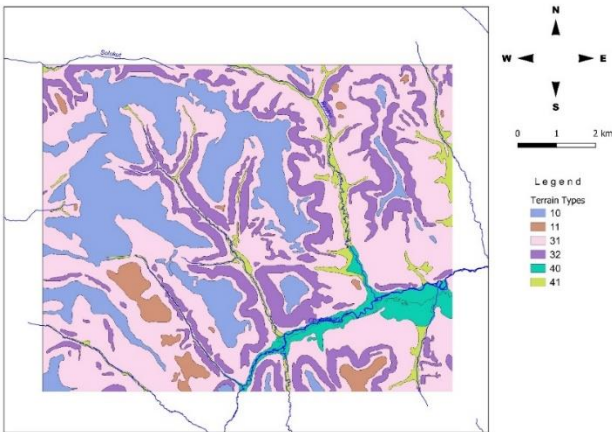


Fig. 3. Terrain types of the study area (Scale 1:200000). Legend: (10) plateau-top, (11) basement plateau, (31) gentle slopes, (32) slopes of medium steepness, (40) mountain-valley terraced, (41) – mountain-valley.

As a result, in the study area, taiga with blueberries occupied more than 60% of the area, mountain sparse forest – 25%. Kurums which are flow of stone blocks and rubble (colluvium) are also represented in the study area as narrow transverse strips on slopes (Fig.4).

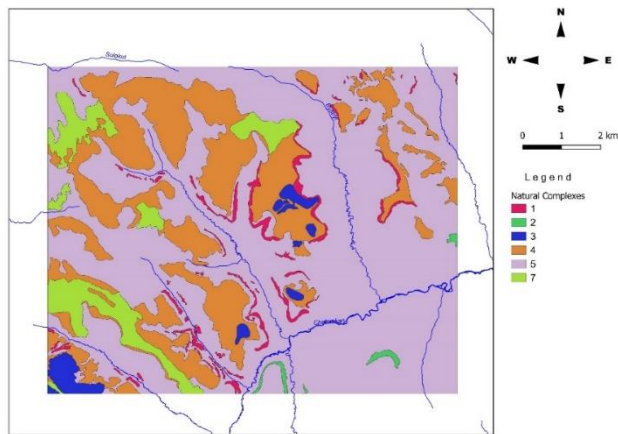


Fig. 4. Natural complexes of the study area (Scale 1:200000). Legend: (1) kurums, (2) fully transformed territories by 2017, (3) mountainous tundra, (4) mountainous sparse forests, (5) taiga and blueberries, (7) dwarf Siberian pine.

Contours of merged terrain types and natural complexes allowed to define landscapes groups of study area and to calculate areas of each one (Table 1).

Table 1. Landscape groups of the study area.

Terrain types	Natural complexes							Total
	1	2	3	4	5	6	7	
10	0.90		83.98	1094.42	334.81		290.91	1805.01
11				80.37	87.39		67.00	234.76
31	63.21	5.30	67.98	843.15	3432.09		210.88	4622.62
32	136.23	0.26	0.21	46.01	1286.39		6.73	1475.83
40				92.95	55.88	126.67		275.50
41	0.15			40.41	295.71	29.60		365.87

A schematic map of the transformed landscapes of the Verkhne-Taluminskoye field was obtained, which represent landscapes fully transformed as of 2022 Q3 (Fig.5).

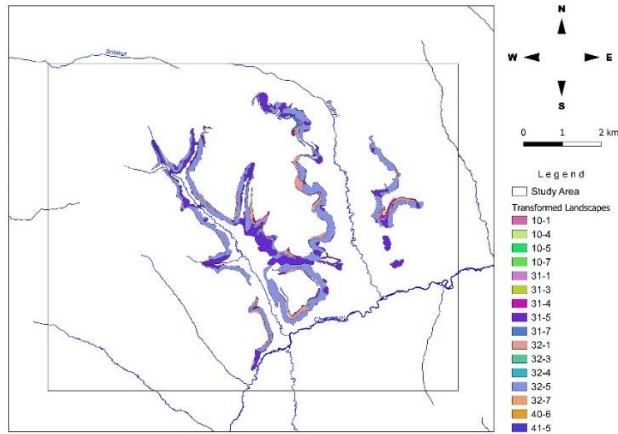


Fig. 5. Natural complexes of the study area (Scale 1:200000). Legend as on fig. 3 and 4.

Quantitative indicators of landscape transformation during coal field development had been calculated. Figure 6 shows the proportions of transformation of each individual landscape in the study area.

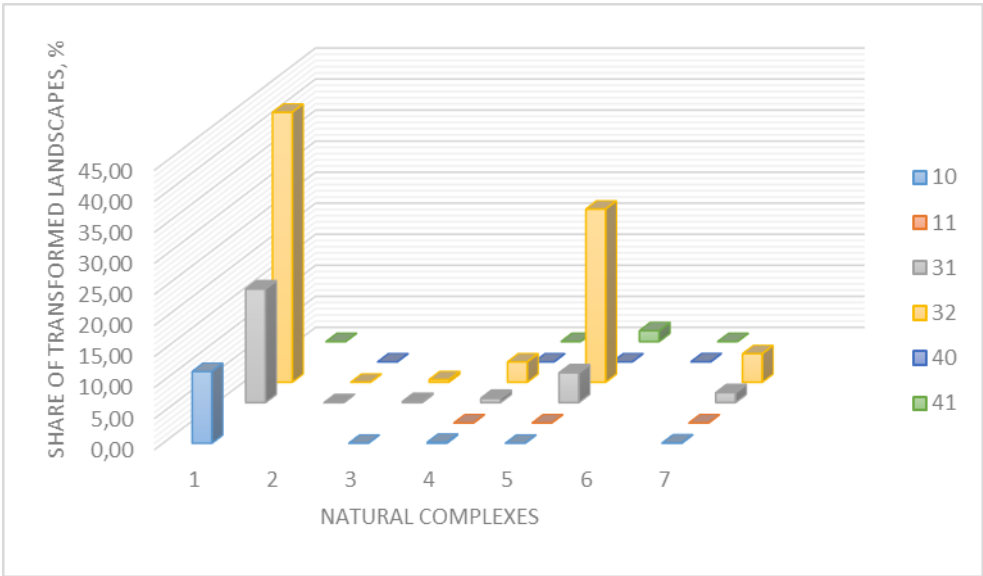


Fig. 6. Share of transformed landscapes of the study area. Legend as on fig. 3 and 4.

The most transformed were kurums on slopes of medium steepness (1-32) and gentle slopes (1-31) – 43.5 and 18.3%, respectively, were transformed, as well as closed forests on slopes of medium steepness (5-32) – 27 were transformed, 9%.

The data obtained indicate those landscapes that are more susceptible to transformation during the development of the deposit, which is due, among other things, to the technologies used by the subsoil user. A greater transformation of slopes of medium steepness ($10\div30^\circ$) was revealed, which are initially characterized by less stability due to lower rates of self-overgrowing by vegetation [7], as well as kurums.

4 Conclusion

A map of natural landscapes transformed by development of the Verkhne-Taluminskoye coal deposit as of 2022 had been compiled by means of space imagery and remote sensing. It is shown that share of medium slopes ($10\div30^\circ$) area that are disturbed is more considerable than those of another terrain types. On the other side, kurums, or rock glaciers, as one of deciphered natural complex were transformed more often on the study area.

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