Geosystems of the northeastern Hovsgol region

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Abstract. We examine the main natural features and the present status of geosystems across the territory of the northeastern Hovsgol region. The source of observational evidence concerning the state of the landscapes was provided by field expedition-based investigations, with emphasis placed on the study of the species and age composition of vegetation in conjunction with dynamical processes as well as geomorphological characteristics of the study area. The present status of geosystems across the study territory was analyzed by methods of visual interpretation and automated processing of spatial information using GIS technologies on the basis of Earth remote sensing data, field investigations of landscapes, topographic maps as well as literature sources. Special attention was paid to the analysis of the digital elevation model that was generated on the basis of SRTM 4 data in order to determine the morphometric characteristics of the location of geosystems, assign them to a particular type of classification of geosystems and compile the map legend. The legend to the landscape map was produced on the basis of a classification of a number of geomers as developed by V.B. Sochava in his theory of geosystems. As a result of the work done, we compiled the medium-scale landscape-typological map of geosystems (Sc 1:200000) on the level of groups of facies.

1. Introduction

The Hovsgol region is a peculiar mountain area of Mongolia, with Lake Hovsgol lying in its middle part. This area is located between Eastern Sayan in the north, the Tuva upland in the west, the offspurs of the upland ranges of Khangai and Sangilen in the south and south-west, and Khamar-Daban Range in the east. In the west, north and north-east, the Hovsgol region is delimited by the state border of Russia and Mongolia, in the south by the latitudinal segments of the valleys of the Egiin-Gol, Delger-Muren and Beltesiiin-Gol rivers, and in the east by the upper reaches of the left tributaries of the Uur-Gol river.

Structural features of topography permit us to identify two dramatically differing areas: the Western and Eastern Hovsgol regions, and the boundary between them is arbitrarily delimited along the valleys of the Khankh-Gol and Egiin-Gol rivers [1]. The lake basin itself is represented by the hollow of the western flank of the Baikal rift zone, with the water edge at 1645 m above the sea level and 262 m in depth [2].

Almost the entire northern region of the Eastern Hovsgol region is occupied by the Kheven-Zaluuri Uriiin Sardykh highland stretching over 80 km from north to south and reaching absolute heights of 2300–2550 m. It represents an ancient planation surface armored by basalts. Because of erosional
dissection, the marginal areas of the highland have the appearance of low and middle mountains, whereas the inner areas are weakly dissected. The low-mountain relief with insignificant relative heights and elevations as well as with smooth outlines of the slopes mostly occurs to the south of this highland in the Eastern Hovsgol region [3].

The area has an extreme continental climate, with the mean annual temperature of 4.5°C. The mean long-term precipitation amount is 300 mm/year, with its maximum corresponding to a warm period [2].

Altitudinal zonality is the main composition pattern of vegetation cover of the northeastern Hovsgol region. The nival, high-mountain, mountain-taiga and mountain-steppe belts are identified. The mountain-taiga and mountain-steppe belts occur from the level of Lake Hovsgol (1645 m above the sea level) to the lower boundary of the goletz belt (about 2000 m above the sea level); this belt is dominated by larch (Larix sibirica) and Siberian stone pine (Pinus sibirica) forests as well as by steppes and meadows.

The goletz belt occupies habitats at altitudes from 2000–2100 to about 2600 m above the sea level where there occur yernik shrubs (Betula rotundifolia and B. humilis) and mountain tundras. The above-lying nival belt is represented by glaciers of the Munku-Sardyk massif (3491 m) and alpinotype relief.

2. Models and methods

In investigating the present status of the geosystems of the northeastern Hovsgol region, we used information of different quality: remote sensing data, cartographic material, material of ground-based investigations, and GIS databases: 1) high spatial resolution images (Landsat 5 TM, Landsat 7 ETM+, and Landsat 8 OLI); 2) 1:100 000 and 1:200 000 topographic maps; 3) SRTM 4 data, and 4) expedition material.

To objectively reveal the specific features in the spatial occurrence of geosystems used a DEM on the basis of SRTM 4 data [4-6]. The steepness and aspect of the slopes were calculated. The resulting GRID models were exported to the MapInfo vector form, representing an array of points at regular steps of 90 m. As a result of an objective combination of GRID with the geosystem contours obtained from interpretation, it is possible to carry out a quantitative analysis.

Factual evidence concerning the structure and present status of geosystems of the northeastern Hovsgol region was obtained as a result of field work in the year 2018, with investigations made into the most important components of the geosystems: vegetation communities and geomorphological characteristics of the study area. The focus in the study of vegetation cenoses was not only on the species composition but also on the general status of cenoses, and on dynamical processes. Geobotanical descriptions were made by classical techniques [7, 8] complemented with brief characteristics of the status of cenoses along he routes as well as using photographic recordings.

3. Results and discussion

As a result of the research done, we compiled the medium-scale 1:200 000 map for the geosystems (table 1, figure 1). The map legend consists of 28 numbers of primary geosystems and 5 numbers of secondary communities. A classification of the geosystems was accomplished in accordance with the principles of Academician V.B. Sochava’s theory of geosystems [9], for the series. The group of facies was used as the main mapping unit.

Table 1. Geosystems of the northeastern Hovsgol region.

| Geosystem | Number on the map |
|-----------|-------------------|
| Suite of landscape types | Landscape of the northern extratropical belt |
| Landscape type | Nival |
| Geom Nival deprived of vegetation |
| 1. Glaciers | 1 |
| 2. Rock ridges | 2 |
Landscape type Goletz
Group of geoms Lichen
Geom Bushy lichen (Cladonia alpestris and Cetraria cuculata)
Facies class Flat interfluves
(South-Siberian bushy-lichen flat interfluves and flat summits)

3. Lichen tundras with grass microgroups (Kobresia myosuroides and Dryas oxyodontata) with gley tundra skeletal immature soils of habitats of goletz planation at 2200 m above the sea level and higher.

Facies class Slope

4. Subshrub (Rhododendron adamsii, R. adamsii, Phyllodoce caerulea, and Ledum palustre)-lichen tundras in combination with shrub (Betula rotundifolia, B. humilis and Salix glauca) grass vegetation with gley tundra immature soils of slopes of medium steepness and different aspects in the upper and middle parts of the goletz belt.

5. Blockfields with areas of subshrub-lichen cover and areas of Kobresia myosuroides meadows on immature skeletal soils on steep slopes of different aspects in the middle part of the goletz belt.

Group of geoms Shrubs
Geom Yernik vegetation (Betula rotundifolia and B. humilis)
Facies class Summit surfaces (flat interfluves)

6. Yernik grass (Dryas oxyodontata)-moss (Dichranum polysetum, Hlycomium splendens, and Pleurozium schreberi)-lichen (Cladonia alpestris and Cetraria cuculata) vegetation in combination with alpinotype meadows (Trollius asiaticus, Veratum lobelianum, Sanguisorba officinalis, Aconitum barberam, Bergenia crassifolia, and others) with gley, tundra podzol and mountain-meadow soils in the lower part of the goletz belt at about 2000 m above the sea level.

6a. Young growth of communities in places of burns.

Facies class Slope

7. Yernik grass (Calamagrostis langsdorffii, Sanguisorba officinalis, Aconitum barberam, Trollius asiaticus, Bergenia crassifolia, and Ranunculus repens)-moss lichen vegetation with tundra podzols in the lower and middle parts of gentle slopes of different aspects in the lower part of the goletz belt.

8. Yernik subshrub (Vaccinium vitis-idaea, V. uliginosum, Rhododendron parvifolium, R. adamsii, Phyllodoce caerulea, and Ledum palustre)-moss vegetation with tundra podzols on slopes of medium steepness of different aspects in the lower part of the goletz belt.

Landscape type Taiga geosystems
Class of geoms Mountain-taiga
Subclass of geoms South-Siberian
Group of geoms Arboreal
Geom Larch (Larix sibirica) forests and open woodland
Facies class Flat interfluve

9. Siberian stone pine (Pinus sibirica)-larch shrub (Betula rotundifolia, B. humilis, Rhododendron parvifolium, Daschekia fruticosa, Pentaphylloides fruticosa, and others) grass (Carex sp., Trollius asiaticus, Ranunculus repens, Bergenia crassifolia, Pyrola asarifolia, and others)-moss open woodland with cryogenic-taiga soils in the upper part of the mountain-taiga belt.

10. Larch shrub (Vaccinium vitis-idaea, V. uliginosum and Ledum palustre)-dead soil cover forests with soddy forest podzols in the lower part of the mountain-taiga belt.

11. Siberian stone pine-larch shrub subshrub (Vaccinium vitis-idaea, Arctous erythrocarpa and Ledum palustre)-true moss (Ptilium crispa-castrensis, Aulacomnium palustre and Pleurozium schreberi) forests with podzols and podburs (cryogenic-taiga) in the middle part of the mountain-taiga belt.

Facies class Slope

12. Siberian stone pine-larch yernik subshrub (Vaccinium vitis-idaea, V. uliginosum and Ledum palustre)-grass-moss open woodland on cryogenic-taiga soils of northern slopes of medium steepness in the upper part of the mountain-taiga belt.

13. Steppizated (Koeleria cristata, Carex duriuscula, Iris humilis, Primula farinosa, Poa attenuata, Festuca lenensis, and Rhodiola rosea) larch open woodland with soddy forest and soddy meadow soils of southern slopes in the middle part of the mountain-taiga belt.

14. Larch shrub (Betula rotundifolia, B. nana, Rhododendron parvifolium, and Pentaphylloides fruticosa) open woodland on soddy taiga soils of gentle shadow slopes in the upper part of the mountain-taiga belt.
14a. Young growth of larch forests in places of burns.

15. Larch and Siberian stone pine-larch shrub (Dušekia fruticosa, Spiraea media and Pentaphylloides fruticosa) grass (Carex sp., Talitrum foetidum, Poa sibirica, Chrysanthemum zawadskii, and others) forests, often with steppizated areas, with soddy forest and soddy meadow soils of southern slopes of medium steepness in the upper parts of mountain valleys.

16. Siberian stone pine-larch shrub (Ledum palustre, Rhododendron parvifolium, Vaccinium vitis-idaea and V. uliginosum)-true moss forests on soddy taiga soils of gentle northern slopes in the lower parts of the mountain-taiga belt.

Group of geoms Shrubs
Geom of the Rhododendron parvifolium community
Facies class Intermontane depressions and valleys
17. Vegetation of R. parvifolium with willows (Salix glauca and others) and yerniks, grass, with soddy meadow cryogenic soils in the upper part of the mountain-taiga belt.

18. Valley parvifoliate-rhododendron forests with willows grass-sedge communities on soddy meadow soils of lower parts of the mountain taiga belt.

Geom Siberian stone pine forests and open woodland
Facies class Flat interfluve
19. Larch-Siberian stone pine shrub (Dušekia fruticosa and Lonicera caerulea) subshrub (Vaccinium vitis-idaea, V. Uliginosum and Ledum palustre)-true moss forests with soddy-ferrous soils in the middle part of the mountain-taiga belt.

19a. Young growth of larch forests in places of burns.

Facies class Slope
20. Larch-Siberian stone pine shrub (Dušekia fruticosa and Lonicera caerulea) subshrub (Vaccinium vitis-idaea, V. Uliginosum, and Ledum palustre)-true moss forests with soddy forest soils and podzols of northern slopes of medium steepness in the middle part of the mountain-taiga belt.

20a. Young growth of larch forests in places of burns.

21. Siberian stone pine Duschekia subshrub (Vaccinium vitis-idaea, V. Uliginosum and Ledum palustre)-moss forests with podzols and soddy forest soils of northern slopes of different steepness.

21a. Young growth of larch forests in places of burns.

Group of geoms Grass
Geom Forb meadows
Facies class Slope
22. Kobresia myosuroides, (Carex dichroa and C. orbicularis) meadows, often with bush encroachment (Salix glauca, Betula rotundifolia, and Rhododendron parvifolium), with immature mountain-meadow soils of gentle, largely shadow slopes in the upper part of the mountain-taiga belt.

Facies class Intermontane depressions and valleys
23. Grass (Carex dichroa, Trollius asiaticus, Ranunculus repens, Sanguisorba officinalis, Calamagrostis langsdorffii, Aconitum barbatum, Geranium pseudoibericum, and others) mesophytic communities, often with duschekia and yernik, with soddy-meadow soils in the middle part of the mountain-taiga belt.

24. Meadows of grass (Calamagrostis langsdorffii, Poa attenuata and Festuca lenensisis)-forb (Trollius asiaticus, Ranunculus repens, Parnassia palustris, Pedicularis longiflora, Potentilla anserina, and others) wet habitats with soddy-meadow soils.

25. Grass (C. dichroa, C. enervis, Trollius asiaticus, Ranunculus repens, Parnassia palustris, Potentilla anserina, Polygonum sp., Primula farinosa, and others)-moss bogs of near-lake and near-river habitats with soddy-bog cryogenic soils of the lower part of the mountain-taiga bent.

Landscape type Steppe
Class of geoms Mountain-steppe
Subclass of geoms South-Siberian
Group of geoms Grass
Geom Forbs
Facies class Slope

26. Mountain grass mesophilic (*Koeleria cristata, Carex duriuscula, Agrostis trinii, Iris humilis, Primula farinosa, Poa attenuata, Festuca lenensis*, and others), often with sparse larch trees of the steppe with meadow-chernozem soils of gentle southern slopes in the upper parts of mountain valleys.

27. Mountain xerophilic (*Agropyron cristatum, Carex enervis, Stipa krylovii, Pulsatilla turczaninovii, Androsace incana, Oxytropis sp., Potentilla acaulis, Artemisia sericea*, and others), often with sparse larch trees of the steppe with zhernozem cryoarid soils of gentle and moderately steep southern slopes.

Facies class Intermontane depressions and valleys

28. Aeolian forms with sparse vegetation cover (*Carex enervis, Pulsatilla turczaninovii, Potentilla sericea*, and others) with no mature soil cover.

*Figure 1.* Fragment of the map of geosystems of the northeastern Hovsgol region (Sc 1:200 000). Geosystems: see table 1.
4. Conclusion
The analysis of vegetation cover showed a high degree of disturbance to the Siberian stone pine facies by fires that occurred across the territory more than 20 years ago. Reafforestation processes are occurring fairly actively. No bacterial or other diseases were observed in Siberian stone pine stands. The status of larch facies is assessed as satisfactory, and the area of disturbed areas occupied by this type is relatively small. The steppe and meadow facies are characterized by a high degree of disturbance as a result of overgrazing giving rise to communities impoverished in species composition and consisting of species that are resistant to mechanical α, обедненные в видовом отношении, состоящие из видов устойчивых к механическому воздействию и мало поедаемых скотом.

The information obtained regarding the present status of geosystems and expressed in terms of cartographic GIS modeling provides a basis for a system assessment of vegetation: the resource, environment-forming, environment-protective and other types [10] and can serve as a framework for assessing the ecological potential of a territory [11].

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