Exogenous processes and problems of rational nature management in the Selenga river transboundary basin

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Abstract. The problem of soil degradation as a result of deflation remains particularly relevant for the territory of the Selenga midland. Based on historical data, it led to huge losses in agriculture, the dust storms, sand filling of settlements and roads. The problem of desertification is closely connected with the processes of aeolian relief formation. Therefore, the development of effective policies and practices to prevent desertification requires investigations of geomorphological systems response to climate change and anthropogenic impact. The necessary data can only be obtained in the course of interdisciplinary research involving geography and geology methods and historical materials. This paper presents the data on the dynamics of aeolian relief formation during the Holocene and historical era in the central part of the Selenga midland. Based on the study of soil-sedimentary sections and its radiocarbon dating the stages of soil formation corresponds with an relatively favorable climatic conditions were distinguished. Arid phases correspond to activation of aeolian processes and manifest themselves as horizons of loess and sand deposits overlying the buried soils. The most intense, they were proceeded at the Late Glacial – Holocene border (12.9 – 11.7 kyr BP) and Early Holocene (10.5 – 9.4 kyr BP), in the Atlantic (8.6 – 6.9 kyr BP), beginning (~ 5.4 – 4.8 kyr BP) and the end (~ 3.4 – 2.9 kyr BP) of Subboreal period of Holocene. Analysis of historical and literature data revealed the process of farmland degradation into desert landscape, unsuitable for further agricultural use. For this territory results of investigation of the morphological structure, the rate of aeolian landforms formation and particle size distribution of the constituent of sand are presented.

1. Introduction
The development of issues of rational nature management requires knowledge of modern exogenous processes taking place on the background of the growing influence of human activity on nature. The most important element in studying the relationship between relief formation and features of land use is the assessment of various exogenous processes in connection with the problems of soil fertility conservation and protection of land resources.

The restructuring of the entire system of socio-political and economic relations in Mongolia, which has not yet been completed, has largely devalued the previously accumulated statistical-economic, land-use and demographic materials, has led to the aggravation of a number of traditional economic and economic problems for the region (pasture degradation and breaking traditions their optimal use, the abandonment of foci of agricultural development and irrigated meadow-growing, the intensification of land erosion, desertification etc.). On the background of global warming and intensified anthropogenic impact on landscapes in the modern era tendencies of desertification of
some territories have been outlined, the traces of which have clearly become apparent in Northern Mongolia. Therefore in the new situation increased the need to assess the current state of steppe and forest-steppe landscapes of transboundary territories, careful consideration and study of environmental management processes in Russia, as well as Northern Mongolia, the most well-endowed with water and pasture resources, and which can become the backbone of the country’s economy for the coming years [1].

This problem can be most fruitfully solved on the example of the comprehensive analysis of exogenous processes and issues of rational nature management of the Selenga river transboundary basin.

2. Objects, data and methods

In the Selenga river basin covering much of northern Mongolia and Western Transbaikalia, the most common among the exogenous processes are aeolian, slope water-erosion, slow hydrothermal movements of soil masses on the slopes (creep), as well as fluvial [2]. Creep processes despite widespread distribution do not have a significant impact on landscapes due to the slow (centuries) displacement of the loose sediments cover. Fluvial processes although they can actively influence landscapes but their impact is limited mainly by riverbeds and less flood plains (during flood periods). Among the exogenous processes in the region, slope water-erosion and aeolian processes are the most dangerous from the point of view of protecting land resources and preserving soil fertility under the conditions of a sharply continental climate the flat and mountain-hollow relief of Northern Mongolia and Western Transbaikalia. Their negative impact is most pronounced in the forest-steppe and steppe landscapes in the areas of distribution of sand, sandy and sandy loamy soils [3, 4]. The increasing human impact on the environment often leads to their activation.

Historical chronicles, literary sources, archival materials, various cartographic material, and remote sensing data were used to study exogenous processes. Reconstruction of the intensity of various exogenous processes during the Holocene was carried out as a result of an analysis of the analytical data of subaerial and lake deposits in various regions of the Selenga middle mountains. For representative sites maps reflecting geomorphological elements were made with the separation of the main relief-forming process. An example of such a map for aeolian processes is the section of the Khudan basin where aeolian processes have a high activity (figure 1).

3. Results and Discussion

During the late Pleistocene and Holocene the exogenous processes experienced repeated activation and decline, followed by other leading processes, as evidenced by the presence of aeolian, deluvial and polygenetic loess-like deposits on the slopes, watersheds, in the valleys of temporary streams separated by buried soils. For this period of geological time there are several phases of the shift of the leading processes in the central part of the Selenga middle mountains, depending on global climatic changes.

The earlier investigations of the soil-sedimentary sequences (see figure 1) have allowed us to reconstruct the dynamics of sediment accumulation and pedogenesis in this territory during the last 15 kyr BP [5]. Multiple changes of sedimentation regimes has been distinguished. The deluvial and deluvial-proluvial sands are replaced by carbonate-rich sandy loams, the particle size composition of which is dominated by fractions of fine sand and coarse silt. Similar composition changes of the deposits reflect a change in the leading exogenous process. There is a decrease in the intensity of erosion-accumulative processes and the main role in sedimentation begins to play the aeolian processes. The longest and most intense periods of activation of aeolian sedimentation occurred on the study territory at the boundary of the Late Glacial and Holocene (12.9 – 11.7 kyr BP) and in the early Holocene (10.5 – 9.4 kyr BP). Less prolonged phases of an increase in aeolian activity were manifested in the Atlantic (8.6 – 6.9 kyr BP), in the beginning (~ 5.4 – 4.8 kyr BP) and the end (~ 3.4 – 2.9 kyr BP) of Subboreal periods [5].
Figure 1. Map of the distribution of aeolian sands on the key section of Khudan depression. Geomorphological elements: 1 – ridge slopes, 2 – alluvial fans and valleys of temporary streams, 3 – floodplain and river terraces. Sands: 4 – mobile, 5 – semi-fixed, 6 – fixed by grassland-steppe vegetation, 6 – fixed by forests.

The prevalence of slope water-erosion and aeolian processes in the structure of the modern exogenous relief formation of the Selenga river basin is observed in some depressions and low mountains of the Khangay-Khantei and Transbaikalian climatic and geomorphological regions.

By comparison of lake sedimentation corresponding to the humid period with adjacent regions it is most correlated with Northern Mongolia. High lake levels are recorded here after the Early Holocene low level. This time corresponds to the basal deposit layers of bottom sediments of the Rybnoe Lake with lake sedimentation regime. After boundary of 7000 years gradual and asynchronous decrease in levels begins.

The 5000-year boundary from which the gradual decline in the levels of Mongolia's lakes begins is reflected by interlayers of aeolian sandy deposits, indicating a pulsating character of level fluctuations. The temporary increase in the levels at the Middle and Late Holocene boundary (3000-2000 years) corresponds layer of 40-70 cm in the study section. The further regime of existence of the lake (later 2000 years) was apparently close to the modern one.

Modern aeolian relief formation in Northern Mongolia and Western Transbaikalia is widely distributed in intermontane basins, as well as within individual plains and lowland plots with arid and semiarid climate. The main centers of aeolian relief formation are sandy massifs in intermontane basins and windward slopes of low mountains facing them. The slopes of the ridges of the Selenga middle mountains (Malkhansky, Zagansky, Tsagan-Daban, Burgutui etc.) are among the latter. Aeolian processes occurring here together with slope water-erosion, providing dominance in the morphogenesis of aeolian processes in dry, and water-erosive in wet years.

The predominance of aeolian processes in the structure of the modern exogenous relief formation of the study territory noted in individual valleys, basins and low mountains is due to the combined influence of relief morphology, features of the lithological structure of the Cenozoic deposits and the climate. In the Selenga middle mountains, the genetic and spatial connection of zones of deflation and
aeolian accumulation, dune-hollow and hummocky relief, aeolian sands and loess-like deposits are most distinctly traced.

Aeolian relief formation is actively continuing mainly within the mobile sand massifs. Deflation of many areas of agricultural land in the 21st century weakened due to the decrease in anthropogenic pressure and carried out in the second half of the 20th century phytomelioration [6]. The relationships between the nature of land use and exogenous processes in the studied region can be characterized by the example of key sections located in the Kuitunka river basin and the southern part of the Gusinoozersk depression.

In the Kuitunka river basin aeolian-deluvial loess-like sandy loam is widely distributed with a capacity of 2–40 m. For this territory topographic maps of 1911 and 1972-1973 were analyzed [7]. It turned out that in the beginning of twentieth century the arable land was located on gentle slopes, low watersheds and wide valleys of the upper and middle reaches of this river. In the 60-70s of the last century, the areas of cultivated land have grown substantially due to the plowing of the lower part of the valley, which is most dissected by permanent and temporary watercourses.

The growth of arable areas, the use of heavy mechanisms, plowing bottoms and slopes of wide valleys caused activation of erosion-accumulation processes. The potential erosion of soils from arable land was estimated at 1080-19090 km / km2, the density of the basin is 0.89 km / km2, the vertex density is 3.9 units / km2 [8]. Annually from the gullies an average of 190 tons / km2 of loose sediments is carried out. If their movement during the washing away of soils on the slopes occurs over a distance of the first tens of meters the watercourses in the gullies are able to carry suspended and entrained particles many hundreds of meters to floodplains and river beds. In the bottoms of the valleys, at the foot of the slopes and on the floodplain there is an accumulation of flushing and washing products. The active development of erosion processes led to the predominance of the basin component in the sediment and the formation of mudflows in strong showers. For example, such a phenomenon on the Kuitunka River was recorded on July 13, 1968.

The plowing of soils of light mechanical composition (sandy, sandy loamy) in combination with strong winds and arid conditions of the spring period led to the appearance of eroded (deflated) soils and areas of waving sand in the lower reaches of the Kuitunka river.

One of the most pronounced examples of human intervention in natural processes is the degradation of the soil cover and the formation of a foci of moving sand that is not suitable for economic use. It is located on the southern sides of the Gusinoozersk depression on the right side of the Selenga River and has a name for the former village of Old Nomokhonovo. By the beginning of the 20th century, there was a thriving settlement with pastures and plots of arable land [9]. Gradually, all large territories were involved in economic circulation, which ultimately led to the complete destruction of the soil cover and the appearance of dune ridges. Despite the fact that the Nomokhonovo place has not been used for a long time, the movement of the dunes continues actively. In the winter of 2013, to measure the speed of motion, we set the benchmarks for the largest and active dunes. The movement of sand in their front area was 1.6 m during the spring period of the most active winds, and 2 m in the whole year [10].

4. Conclusion

In the steppe and forest-steppe landscapes Selenga river basin activity of aeolian and slope water-erosion processes during the study period varied significantly depending on climatic parameters. Several time intervals synchronous to the global climatic cycles of the Holocene are distinguished in terms of the structure of the leading exogenous landforming processes.

During the period of active economic development of the territory, their activation arise with an increase in anthropogenic pressure on landscapes (felling, fires, expansion of arable land, overgrazing). Huge areas were deprived of natural vegetation and the plowing of the granulometrically light deposits led to a disturbance of the soil cover that promoted the broad development of the processes of water and wind erosion.
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