Current dynamics of aeolian processes in the mountain-basin relief of Russia and Mongolia (Lake Baikal basin)

I N Vladimirov, V B Vyrkin, D V Kobylkin and A P Sofronov
Sochava Institute of Geography SB RAS, Irkutsk, Russia

E-mail: agrembrandt@inbox.ru

Abstract. The paper deals with the study of the modern dynamics of aeolian processes within the mountain-basin relief of the Khubsugul region of Northern Mongolia and Southwestern Transbaikalia of Russia as exemplified by three key sections of the transboundary region united by the Selenga river basin. These studies are intended to reveal the nature of the development of aeolian massifs of different morphology and location in order to assess the ecological and geographic potential of various territories of the Lake Baikal basin. The study was carried out with a wide use of geomorphological, geobotanical, comparative-geographical methods, as well as the latest methods of remote sensing using unmanned aerial vehicles with the construction of orthophotomaps of aeolian massifs and three-dimensional models of overflying territories. Three key areas - on the eastern coast of Khubsugul, the valley of the Uure-Gol river in the Eastern Khubsugul region and at the western end of the Malkhan ridge (Mankhan-Elysu stow), differing from each other in many natural parameters, are assessed geomorphologically and geobotanically and their comparative geographical analysis was carried out. The current state of the studied sand massifs is estimated by the nature of the dynamics of aeolian processes and a preliminary forecast of their development is briefly given considering the intensity of the existing pasture load and its possible activation by analyzing the structure of the vegetation cover.

1. Introduction
The development of environmental management issues and the assessment of ecological and geographical potential of the transboundary region of Russia and Mongolia require knowledge of contemporary exogenous processes occurring against the background of the increasing human-induced impact on nature. The assessment of the state of landscapes within the mountain-basin relief of the Selenga river basin should be based on an analysis of the development of aeolian processes, which are the most widespread and active in the region [1]. Their negative impact is most pronounced in steppe and forest-steppe landscapes in areas where sand, sandy and sandy loam soils are spread [2, 3].

The most active current aeolian relief formation in the transboundary territory of Northern Mongolia and Western Transbaikalia of Russia occurs within the Selenga basin where the main centers of aeolian relief formation are sand massifs in intermontane basins, river valleys and the windward slopes of low mountains.

2. Materials and methods
By using the inputs received from the field work carried out in recent years (2018-2019) by the researchers of the Sochava Institute of Geography SB RAS, together with colleagues from the Institute...
of Geography and Geocology of the Mongolian Academy of Sciences, it is possible to assess the nature of the modern dynamics of aeolian processes in this territory, based on the analysis within three key study sites located on the eastern coast of Lake Khubsugul, the Uure-Gol river valley in the Eastern Khubsugul region of Mongolia and the western part of the Chikoy-Khilok interfluve of Western Transbaikalia of Russia.

We used unmanned aerial vehicles DJI Phantom 4 Pro and DJI Mavic Pro Platinum for detailed study of aeolian landforms and features of landscape distribution. Further processing of the obtained images was carried out in the Agisoft PhotoScan Professional, which resulted in orthophotomaps of aeolian massifs and three-dimensional models of overflying territories.

3. Research results and their discussion
In the morphological and dynamic sense, the mouths of the rivers on the Khubsugul are one of the most variable geographic objects. Here, along with coastal and fluvial processes, aeolian processes also occur, especially in large areas of sand accumulation. Hilly semi-fixed and bare sands are found in small massifs on the eastern coast of Khubsugul [4, 5] and are located in the mouths of rivers on the eastern coast of the lake (Ikh-Dalbain-Gol, Sevsulii-Gol, Noyon-Gol, Shognul-Gol and Tanyin-Gol). Semi-fixed and partially bare sands are observed here, inflated from the coastal beaches and terraces of Khubsugul, which have a thickness of up to 15-20 m, are well sorted and cross-bedded [6].

Near the Khubsugul coast, in the estuarine part of Shognul-Gol, the hilly aeolian relief is covered with sparse larch forests, with a gradually increasing forest stand density higher up the slope. The vegetation is represented by sparse (projective cover about 10%) herbage with a predominance of Carex nervis, Pulsatilla turczaninovii and Potentilla sericea. Other species are present singly. The projective cover of the herbage is about 10%, the density about 5%, traces of active aeolian activity are not noticeable. The low values of the projective cover and crown density are possibly associated with grazing, which decreased after the establishment of the Khuvsgul National Park, but did not disappear. For more reliable conclusions, monitoring of vegetation is required.

Within the Eastern Ciskhubsugulia, massifs of bare, fixed and semi-fixed sands are observed on slopes and terrace above the flood-plain of the Uure-Gol river valley, where there were dammed lakes in the past [7]. Hillocks and ridges of aeolian sands reach several tens of meters. Here, on the left bank of the Uure-Gol river below the village of Tsagaan-Uure there is a massif of bare and semi-fixed sands with aeolian ridges and dunes up to 5 m high, facing a west-eastern direction. It was formed as a result of aeolian transfer of sand from floodplains and riverbanks of the Uure-Gol onto the flat areas of a small intramontane basin during the Holocene and now.

The vegetation cover of this stow is represented by Pinus sylvestris, Rhododendron dauricum, mostly dead-cover forests with single specimens of Vaccinium vitis idaea, Maianthemum bifolium, Poa botryoides, Lathyrus humilis, Pulsatilla patens, other species, in places with exposed sandy deposits. The projective cover of the grass layer is less than 5%; the nature of needle litter and the general appearance of this habitat indicate a sluggish process of deflation, especially on glades, etc. However, an analysis of the general condition of the vegetation cover indicates a fairly stable existence of the sandy massif.

Within the adjacent stow the vegetation is represented by an open herbage of Carex korshinskkyi, Oxytropisplanata, Dostostemon integrifolius, Chamaerhodoserecta, Pulsatilla turczaninovii, Thermopsis lanceolata, Thalictrum squarrosum on sands. The projective grass cover is about 5%. We can speak of stabilization of deflation according the nature of the composition of the herbaceous layer, of the absence of active sand transfer and burial of plants. However, projective cover and grass cover density remain at a low level probably due to active grazing, as evidenced by the concentration of herds and camps in the area, as well as traces of trampling.

Widespread development of sandy massifs is a distinctive feature of many regions of Western Transbaikalia. The sands determine the specific appearance of landscapes developed on them. A significant source of modern moving sands are ancient aeolian deposits (up to 200-500 m thick) of the Upper Pleistocene and Lower Holocene age on ancient hilly and aeolian-ridge forms, widespread in
the Chikoi – Khilok interfluve [8]. Both ancient, currently fixed by vegetation and modern aeolian forms are widespread here, associated with economic activities and currently actively developing under the influence of aeolian processes. V.N. Olyunin [9] reported in 1978, that on the right bank of the Chikoi river, the height of the dunes reached 25 m, and at Lake Chernoe on the periphery of the Mankhan-Elysu stow is 20-50 m. The sands composing these forms are characterized by a relatively high degree of roundness of grains and the character of bedding, typical of aeolian deposits.

Aeolian relief formation in this region refers to the focal uneven seasonal transport of dune-type sands. It is characterized by transport of loose lacustrine, alluvial and proluvial mass, weakened in humid depressions and intensified in individual foci in absence or suppression of vegetation (on river banks, fires, windbreaks or ancient dunes).

Aeolian processes are especially active and expressive within the Mankhan-Elysu sandy massif located at the western end of the Malkhan Range, as well as in the adjacent parts of the Chikoi-Khilok interfluve (figure 1). The edges of the existent Mankhan-Elysu aeolian massif are limited by aeolian ridges, which are currently covered with woodland [10]. Such ridges are widespread in other parts of the aeolian massifs and emphasize the former distribution of active aeolian forms and the repeated activation of deflation processes. The bare sands of the stow are stretched to the south for 6 km, with a width of 1.5 km. They are expressed in relief by several dune chains and individual dunes up to 10-15 m high.

![Figure 1](image.png)

**Figure 1.** Morphological characteristics of the Mankhan-Elysu stow [11]. 1 – three-dimensional model of the stow, 2 – profile along the line A-B, 3 – profile along the line C-D, 4 – photograph of dune chains in the central part of the stow.

The Mankhan-Elisu is characterized by a rather variegated and complex combination of plant communities, from xerophytic pine forest to psammophytic steppe, depending on location, exposure, local location and other natural conditions.

Communities of open steppe fescue-hedysarum (*Hedysarum fruticosum* and *Festuca dahurica*) with the participation of *Leymus racemosussub* sp. *Crassinervius*, *Aconogonon sericeum* and *Artemisia ledebouriana* and other species dominate here. The projective cover and density is less than 5%, in some places there are areas of several tens of square meters of sand with single specimens of plants. The activity of sandy material transport is also expressed in the state of the boundaries of the
massif, where traces of sand movement are clearly visible, and in the crawling of the massif onto a developed stand and the inclination of trees under its pressure.

It is in the Mankhan-Elysun massif of all the listed aeolian habitats, which has the most active process of sand transport, and does not allow the formation of a dense vegetation cover here.

4. Conclusion
A preliminary analysis of the current state of the relief and plant communities of the considered regions of Northern Mongolia (Khubsgul) testifies that at present, in the climatic situation in the main part of the habitats, some stabilization of aeolian processes is observed due to the wide development of vegetation cover and relatively high moisture content of the coastal sands of Khubsugul. As a preliminary forecast scenario, we can assume here a stable development of plant communities with a decrease in pasture load.

The least developed vegetation cover is observed in the Mankhan-Elysu stow as the most significant in area of all considered. Plants here have no time to form a sustainable community where they could hold the drift of sandy material. It can be expected that, the state of vegetation cover in this stow will probably keep the current structure without a pronounced trend towards development or degradation.

Acknowledgements
The research was funded by RFBR according to the research project No. 17-29-05089.

References
[1] Ecological Atlas of the Baikal Basin 2015 (Irkutsk: Publishing house of the Sochava Institute of Geography SB RAS) p 145
[2] Ivanov A D 1966 Aeolian Sands of Western Transbaikalia and the Baikal Region (Ulan-Ude: Buryat publishing house) p 232
[3] Vyrkin V B and Kobylkin D V 2017 Modern exogenous processes and issues of rational nature management in the transboundary basin of the Selenga river Proc. of the 3rd Int. Conf. on Specificity of Territorial and Natural Conditions in the Socio-Economic Development of the Country (Ulan-Bator) vol 2 (Ulan Bator: Mongolian Academy of Sciences) pp 260-3
[4] Atlas of Lake Khovsgul 1989 (Moscow: Gugk) p 120
[5] Rogozin A A 1993 The Coastal Zone of Baikal and Khubsugul. Morphology, Dynamics and History of Development (Novosibirsk: Nauka) p 168
[6] Geomorphology of the Mongolian People's Republic 1982 (Moscow: Nauka) p 259
[7] Selivanov E I 1972 Neotectonics and Geomorphology of the Mongolian People's Republic (Moscow: Nedra) p 296
[8] Szczypek T, Wika S, Snytko V A and Buyantuev A B 2000 Facies of Waving Sands of the Chikoi-Selenga Interfluve in Western Transbaikalia (Irkutsk: Institute of Geography SB RAS) p 71
[9] Olyunin V N 1978 The Origin of the Relief of the Revived Mountains (Moscow: Nauka) p 276
[10] Szczypek T, Wika S, Snytko V A, Ovchinnikov G I, Namzalov B-Ts B and Dambiev E Ts 2005 Aeolian Stow Mankhan-Elysu in Transbaikalia (Irkutsk, Ulan-Ude: Sochava Institute of Geography SB RAS, IZK SB RAS, BSU) p 62
[11] Kobylkin D V, Vyrkin V B and Frolov A A 2019 Development of landscapes of sandy massifs in the western part of the Malkhanskii Range (Western Transbaikalia) Bulletin of the Buryat State University. Biology, Geography 4 41-54