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## **AEOLIAN LANDSCAPES OF PREBAIKALYE AND TRANSBAIKALYE AREAS**

*key words:* aeolian relief forms, vegetation cover, Russia, Baikal

### **INTRODUCTION**

Aeolian landscapes are the most dynamic ones, characterised with fast transfer of the material, resulting in quick changes of relief forms. Such landscapes are also typical for the areas of Prebaikalye and Transbaikalye. They occur on both shores of the lake and at various distances from the lake. They were formed as a result of remodelling of lacustrine and lacustrine-river sediments of Late Pleistocene age, when the water level in Baikal lake was much higher than today (Obruchev, 1912; Osadchiy, 1995). According to B. P. Agafonov (2002), sediments accumulated by currents flowing along the Baikal shores are the recent source of aeolian material in the shore zone. The weathering products of rocks building mountain slopes are also of great importance in that case (Bazarov, Ivanov, 1957).

Currently occurring aeolian landscapes in Prebaikalye and Transbaikalye are of natural and anthropogenic origin.

This work is an attempt to present features of the above-mentioned landscapes, especially the anthropogenic ones. The characteristics of the landscapes are based on the results of the author's field investigations and further analysis of literature.

## NATURAL AEOLIAN LANDSCAPES

Natural landscapes are more characteristic for Transbaikalye, where they occupy vast areas, with old, variously formed dune forms and surfaces with wind blown sand – aeolian cover sands. They are currently preserved mainly by growing pine forests, or sometimes like in the Barguzin Valley, by steppe vegetation. Similar landscapes occur in Olkhon Island in Baikal. In a few places, lacustrine abrasion exposed internal formation of dune forms: fossil podzol layers are visible in the sand series, which prove significant interruptions in accumulation of the aeolian sand caused by domination of forest vegetation on the surface. Natural aeolian landscapes can be observed in many places in the vast Barguzin Valley. Various dune forms as well as flat or slightly wavy surfaces of blown sand have developed there on the immense surfaces of *kuyjtuns* (sand mass deposited by the pra-Barguzin in the Pleistocene period; Vyrkin 1986, 1998; Szczypek et al., 2002).

The origin of the landscapes goes back to the end of the Pleistocene and the Early, Middle and Upper Holocene, which has been proved by a radiocarbon dating, archaeological findings and other proofs (Kornutova, Khotina, Zamoruev, 1975; Bazhenova et al., 1997).

Currently developing a scarp barchan on the Argada River in the Barguzin Valley is quite an unusual phenomenon. It is the effect of sand blowing from a steep slope cut by the river, the result of side erosion. The front of the barchan is partly covered by steppe vegetation (Ovchinnikov, Snytko, Szczypek, 2002; Ovchinnikov et al., 2004).

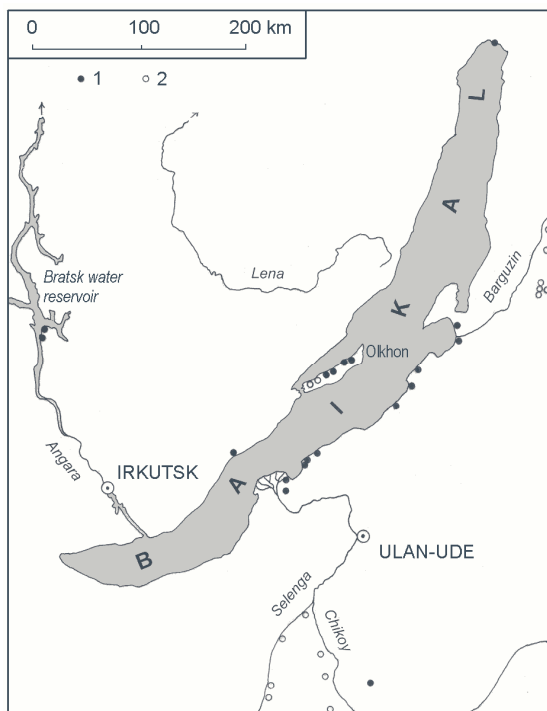
## ANTHROPOGENICALLY INDUCED AEOLIAN LANDSCAPES

Anthropogenically induced aeolian landscapes in the discussed area are much more apparent and visible due to currently undergoing geomorphological processes. They occur both on the shores of Baikal and in Transbaikalye. They result from various economic activities of man, which have been carried on for the last 200–300 years.

Locations of the investigated sites of aeolian landscapes are presented in fig. 1. They have been divided into taiga and steppe sites.

### The taiga landscape sites

The landscapes developed in direct vicinity of taiga vegetation, quit often interfering with them. They are relatively varied in relief and vegetation due to local conditions.



**Fig. 1.** Location of investigated site of aeolian landscapes in Prebaikalya and Transbaikalya: 1 – taiga sites, 2 – steppe sites.

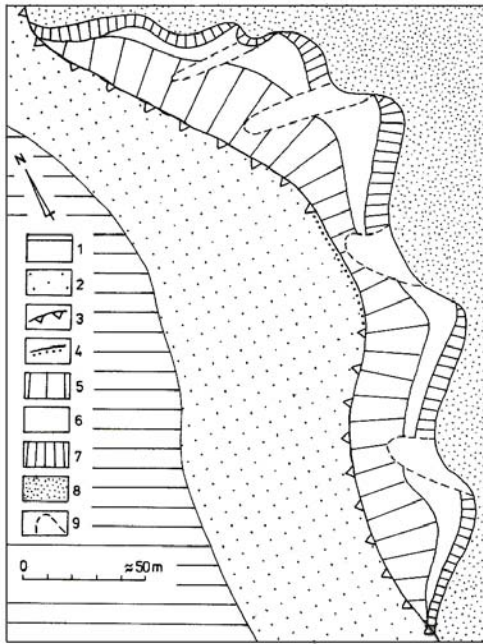
*Nelkhay site* is located on the right shore of Bratsk Reservoir on the Angara river (fig. 1). Development of the aeolian landscape is connected there with abrasion processes and fluctuation of the water level in the reservoir. When the water level is low, a sandy shoal is exposed. W and NW wind, which is dominating in that area, blows sand away from the shoal along the distance of 50–70 m, developing aeolian forms (Ovchinnikov, 1998; Wika et al, 2000; cf. Chak, 2006). They have been developing there on an old abrasion slope on the border of young birch taiga (fig. 2, phot. 1) and they are represented by not fully developed barchans 1–3 m high with an asymmetric transverse profile.

Psammophilous grass vegetation with *Corispermum sibiricum* has developed on the surface of the dispelled shoal, which should be treated as a deflation surface, while the dunes themselves are covered with a community of *Betula pendula*-*Poa angustifolia*.

*Yarki site* covers a small sandy spit on the N side of Baikal. It is an accumulation result of lake waves and the Verkhnyaya Angara River activity.

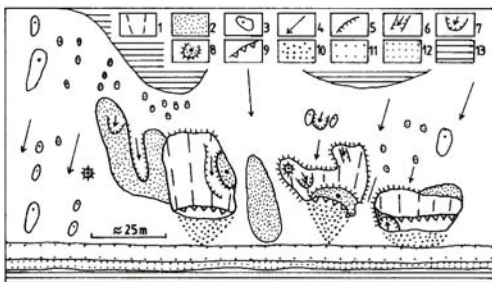
Previous aeolian relief was partly damaged by abrasion. The process became more intensive after completing the construction of the water dam on the Angara River in Irkutsk in the middle of 1950's, which resulted in rise of the water level in Baikal by over 1 m. Tourism impact is also an important factor contributing to damages of Yarki dunes. The current aeolian relief has been developing mainly under the influence of NE and partly SW winds. It is represented by relatively small deflation remnants 4–5 m high (fig. 3, photo 2), in the north the forms are almost completely blown away by wind, while in the south they are seriously damaged by waves.

Concave deflation forms of various sizes have been developing among them, quite often marshy as their bottoms are at the lake water level. Apart from the high remnant forms there are low dune transverse forms – also blown away – up to 2 m



**Photo 1.** General view of Nelkhay site.  
Source: by G. I. Ovchinnikov, 1999.

← **Fig. 2.** Geomorphological sketch-map of Nelkhay site at Bratsk water reservoir:  
1 – water, 2 – shallow, 3 – abrasion bank modified by aeolian processes, 4 – unabraded bank, 5 – windward slopes of dune, 6 – transite slope of dune, 7 – leeward slope of dune, 8 – other landforms of older substratum, 9 – depressions between dunes.



**Fig. 3.** Geomorphological sketch-map of Yarki site:  
1 – destroyed windward slopes of dunes, 2 – aeolian cover sands, 3 – sand shadows, 4 – deflation plains, 5 – deflation undercuts, 6 – deflation corridors, 7 – blowouts, 8 – deflation remnants, 9 – abrasion undercuts, 10 – sandy screens, 11 – zone of “osush-ka”, 12 – beach, 13 – water.

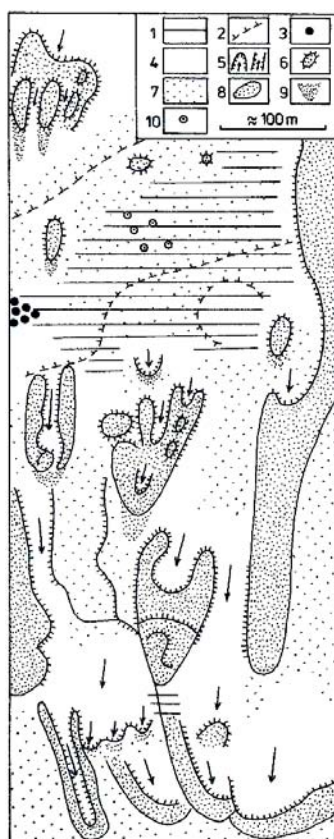


**Photo 2.** General view of Yarki site.  
Source: by S. Wika, 2006.

high, with asymmetric slopes and wavy surfaces of aeolian sand covers and tiny deflation forms on the surface.

The aeolian forms, and accompanying them marshy surfaces in Yarki dunes, are covered by a group of *Craniospermo-Leymetum secalini* and numerous vegetation communities: *Betula pendula*, *Calamagrostis langsdorfi-Carex acuta*, *Carex iljinii*, *Carex limosa-Menyanthes trifoliata*, *Climacium dendroides-Vaccinium uliginosum*, *Eleocharis ovata*, *Elytrigia repens-Artemisia mongolica*, *Elytrigia repens-Iris laevigata*, *Empetrum nigrum*, *Festuca ovina ssp.-Ceratodon purpureus*, *Padus avium*, *Persicaria lapathifolia*, *Pinus pumila*, *Rosa acicularis*, *Rumex acetosa-Tanacetum vulgare*, *Salix triandra ssp. nipponica*, *Spiraea dahurica* (Wika, Kozyreva et al., 2006).

*Peschanoye site* represents an aeolian landscape in the northern part of Olkhon. Taiga felling, cattle, and sheep grazing have caused excessive activity of sand, lasting for several dozens of years.



**Photo 3.** General view of Peschanoye (Sandy) site.

Source: by M. Rzetala, 2007.

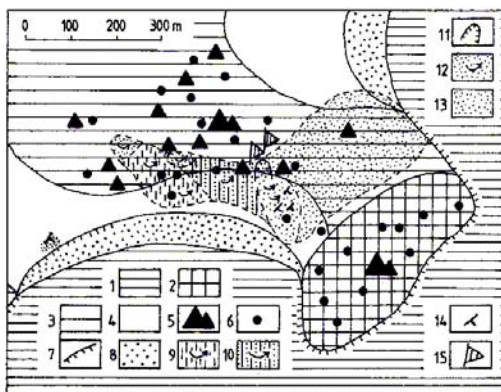
← **Fig. 4.** Geomorphological sketch-map of Peschanoye (Sandy) site on Olkhon Island:

1 - outcrops of crystalline rocks, 2 - knickpoints of crystalline substratum, 3 - granitoid boulders with corrasion microforms, 4 - deflation plains, 5 - deflation basins and ditches, 6 - deflation remnants, 7 - aeolian cover sands, 8 - dunes, 9 - modern aeolian covers, 10 - sand shadows.

A typical deflation relief with morphological traces of accumulation (fig. 4, photo 3) can be observed in the discussed site. Blown away dunes and deflations of various sizes dominate it. Accumulation forms are usually small. The relief has been formed by the influence of N and NW wind and the source material comes from recent beach sediments and older dune sediments. In many places, deflation has exposed the granite bedrock, which rocks have been intensively modelled by corrasion.

The described moving sand is closely surrounded by taiga. The surface of the sand is very rarely preserved by a forest community *Pinus sylvestris-Larix sibirica* with *Artemisia cuspidata* and *Ceratodon purpureus*. Shrub communities with *Padus asiatica* and with *Bromopsis inermis* can be found there. The dominating communities are psammophyllous ones with *Alyssum microphyllum*, *Astragalus bifidus* and an endemic *A. olchonensis*, *Carex argunensis*, *Chamaerhodos grandiflora*, *Patrinia sibirica*, *Poa attenuata* (Wika, Snytko, Szczypek, 1997).

**Bukhta Peschanaya (Sandy Bay) site** occurs on the western shore of Baikal opposite to the Selenge River delta (cf. fig. 1). The aeolian landscape appears there in the



**Photo 4.** General view of Bukhta Peschanaya site  
Source: by T. Szczypek, 2008.

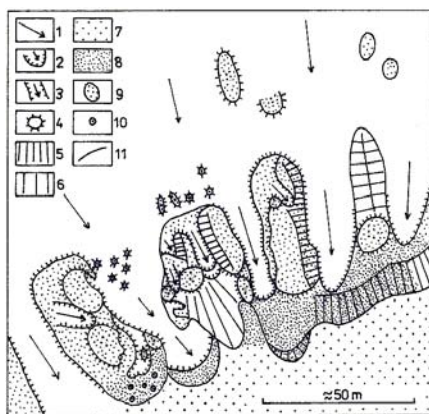
**Fig. 5.** Geomorphological sketch-map of Bukhta Peschanaya (Sandy Bay) site:

1 – water, 2 – remnants of rapakivi granite, 3 – crests composed by desintegrating granite rocks, 4 – gentle slopes formed by desintegrating granite rocks, 5 – big crags, 6 – small crags and detached boulders, 7 – abrasion steep shore, 8 – sand-gravel beach; fixed deflation areas: 9 – with dominance of coarse-grain sand, 10 – with coarse-grain sand and small boulders, 11 – deflation basins, 12 – modern blown sand cover, 13 – aeolian cover sands, 14 – “walking” trees, 15 – wind-shape trees.

lower part of the mountain slope overgrown with pine-larch taiga. Fine particles of weathered granitoid rock are the main source of moving sand. Strong anthropopression resulting from touristic-recreational activity is the main reason of the material blowing. Small deflation surfaces with many stones are dominating forms there. Sand blown away from the surfaces has formed the aeolian cover (fig. 5, photo 4). It is also blown away and very characteristic „walking” trees, with roots exposed down to 2.5–3 m, appear on its surface (photo 4).

The aeolian landscape neighbours the taiga. Two psammophilous vegetation communities *Scrophularia incisa*-*Polygonum angustifolium* and *Festuca lenensis*-*Carex rupestris* occur on the surface of the blown sand *Scrophularia incisa*-*Polygonum angustifolium* and *Festuca lenensis*-*Carex rupestris*. There is a shrub community with dominating *Rhododendron dauricum* and with *Cotoneaster melanocarpus*, *Spiraea media* and *Lonicera coerulea* in the transition zone to the real taiga (Wika et al., 1999).

**Katkova site** is located in the central part of the eastern shore of Baikal opposite to the northern end of Olkhon. An aeolian landscape has been formed there as a result of blowing of contemporary lacustrine sand, mostly old lacustrine-river sediments, transported to the shore by a water current. The landscape has been formed



**Fig. 6.** Geomorphological sketch-map of Katkova site:

1 – deflation plain, 2 – deflation basins, 3 – deflation ditch, 4 – deflation remnants, 5 – steep slopes, 6 – gentle slopes, 7 – aeolian cover sands, 8 – modern aeolian covers, 9 – modern accumulative aeolian hillocks, 10 – sandy shadows, 11 – crest lines.

**Photo 5.** General view of Katkova site.

Source: by T. Szczypek, 2001.

because of taiga devastation. A deflation type of relief, formed by N and NW wind; large deflation surfaces and high remnants of blown away dunes up to 4–5 m are dominating there (fig. 6, photo 5). They are variegated with deflation depressions and small deflation remnants.

The aeolian landscape borders with Baikal in the north and taiga in the south. Blown sand is overgrown with psammophilous grass-like vegetation: it is a group of *Craniospermo-Leymetum secalini* with an endemic *Craniospermum subvillosum* along the lakeshore and further communities including *Alyssum obovatum*, *Artemisia pubescens*, *A. sericea*, *Bromopsis inermis*, *Festuca rubra* ssp. *baicalensis*, *Oxytropis lanata*. There are chamaephyte communities with *Arctostaphylos uva-ursi* and *Empetrum sibiricum*, and a shrub community of *Pinus pumila* with accompanying species: *Rhododendron dauricum*, *Empetrum sibiricum*, *Vaccinium vitis-idaea* and *Linnea borealis* on the border with taiga (Wika et al, 2002, 2003).

**Enkheluk site** is located in NE direction from the Selenge River delta, close to Proval Bay. It represents an aeolian landscape of a deflation character formed by

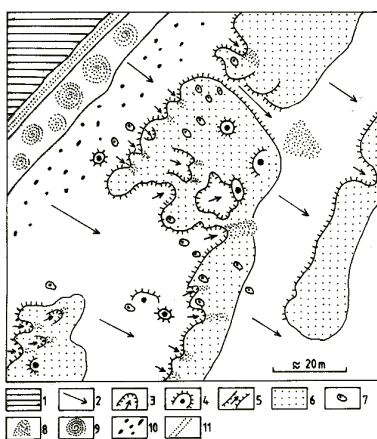


Fig. 7. Geomorphological sketch-map of Enkheluk site:

- 1 – water, 2 – deflation plains, 3 – blowouts, 4 – deflation remnants, 5 – deflation corridors, 6 – aeolian cover sands, 7 – sandy shadows of nebkha type, 8 – contemporary sandy aeolian covers, 9 – aeolian cover in zone of “osushka” (miniature of seaside mud flats), 10 – zone of “osushka” with pebbles, carried by waves in the storm period, 11 – beach.

Photo 6. General view of Enkheluk site.

Source: by V. A. Snytko, 2004.



small amount of blown lacustrine material from the beach and so called „osushka” zone. The landscape occupies small area where taiga trees were partly cut quite recently. Tourist anthropoppression also plays some role in activity of the moving sand. There are small deflation remnants there, up to 70–80 cm high (fig. 7, photo 6). They are the result of devastation of the belt of aeolian sand cover parallel to the shoreline. Narrow deflation passages have developed between remnants and a deflation surface appeared behind them.

Moving sands in the Enkheluk site are partly overgrown by sparse taiga and psammostepe *Craniospermo-Leymetum secalini* near the shoreline. There are various communities further from the water, including *Empetrum nigrum*, psammostepe *Festuca baicalensis-Artemisia ledebouriana-Kitagawia baicalensis-Aconogonon* sp., psammostepe *Koeleria cristata-Festuca baicalensis* (Wika, Imetkhenov et al., 2006).

**Mankhan Elysu site** is located in West Transbaikalye, east from the Chikoy River. It is a sandy island covering the area of 11 km<sup>2</sup> (fig. 8A), surrounded by East Siberian taiga. The main reason causing movement of aeolian sand from Mankhan Elysu massif was most probably 18<sup>th</sup>–19<sup>th</sup> century anthropogenic intrusion i.e. uncontrolled tree cutting in taiga and accompanying forest fires. The aeolian relief, in the form of compact sequences of small parabolic dunes, transverse or barchan ones have been formed by north wind. Currently the relief is deflation in character. The dunes are 15–20 m high and they have been blown by wind from the same direction. Their downwind slopes are well preserved, while the upwind ones are damaged and deflations have developed there (fig. 8B, photo 7). The dunes are moving and their heads enter taiga at the speed of 0.22 m/year.



**Photo 7.** Blown dunes of southern part of Mankhan-Elysu.  
*Source:* by T. Szczypek, 2004.

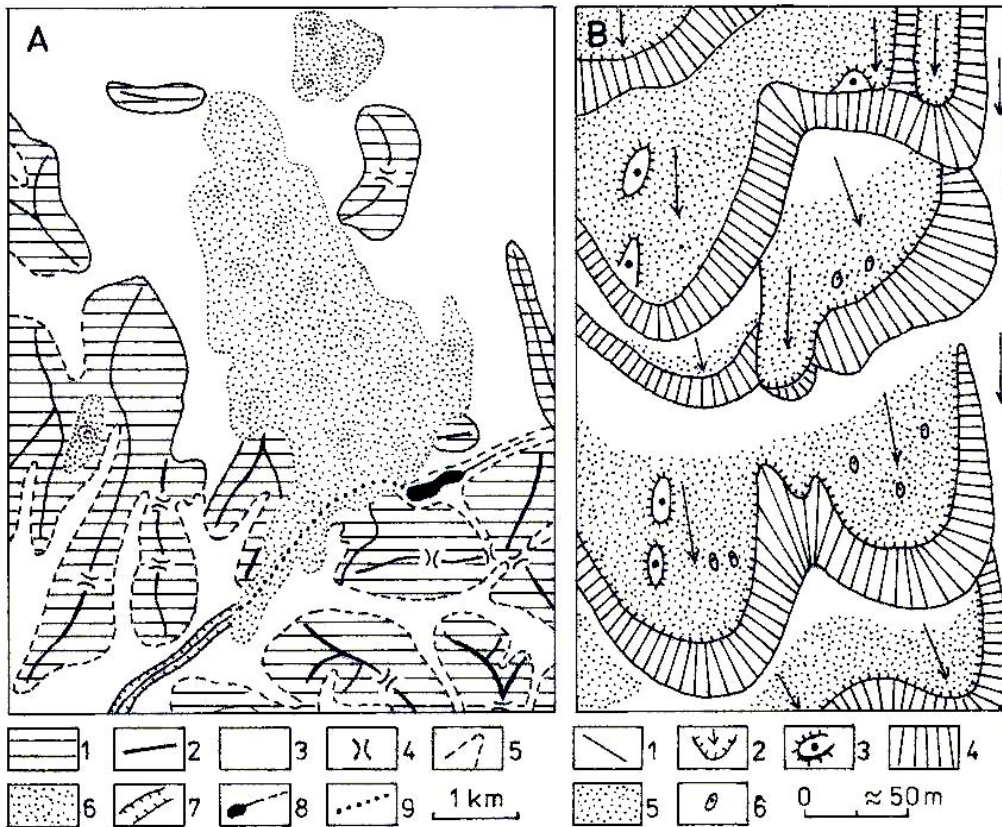


Fig. 8. Aeolian relief of sandy complex Mankhan Elysu:

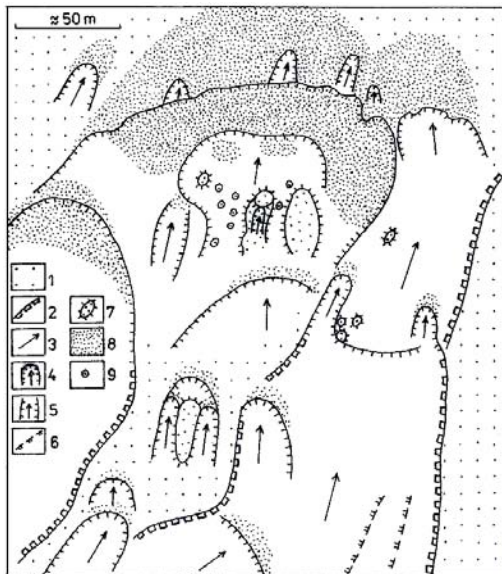
A – Mankhan Elysu against a background of older elements of relief (1 – slopes of hills, 2 – crest lines of hills, 3 – bottoms of concave structural landforms, 4 – pass, 5 – valleys, 6 – aeolian landforms of Mankhan Elysu, 7 – erosional undercuts, 8 – hydrographic net, 9 – probably course of upper part of stream valley), B – geomorphological sketch-map of a southern fragment of Mankhan Elysu (1 – deflation plains, 2 – deflation basins, 3 – deflation remnants, 4 – leeward slopes, 5 – contemporary aeolian covers, 6 – sand shadows of nebkha type).

The moving sand is overgrown in certain places with poor taiga vegetation, similar in species to the neighbouring taiga. Shrub communities, for example the ones with *Padus avium* and *Salix microstachya* also accompanying them *Pinus sylvestris*, *Swida alba*, *Rosa dahurica*, *Cotoneaster melanocarpus*, *Spirea media* and others are important to the aeolian landscape. However, the most important is grass psammosteppes vegetation. Three main communities should be mentioned among them: *Hedysarum fruticosum-Leymus racemosus ssp. crassinervius*, *Agropyron michnoi-Leymus*

*racemosus* ssp. *crassinervius*-*Festuca dahurica* oraz *Oxytropis lanata*-*Koeleria cristata*-*Carex* sp. (Szczypek et al., 2005).

### The steppe landscape sites

*Argada site* is located in the southern part of the Barguzin Valley. Aeolian landscapes have formed there on *kuytun* mainly because of excessive grazing (Imetkhenov, 1994). The main relief forms are substantial erosion ravines with close to vertical walls, a vestige of previous periodical or episodic activity of creeks. Later they were remodelled by wind; therefore, there are many deflation and small accumulation forms in them (fig. 9, photo 8). Wind activity has deepened the ravines; hence, concave forms 6–7 m deep occur there.



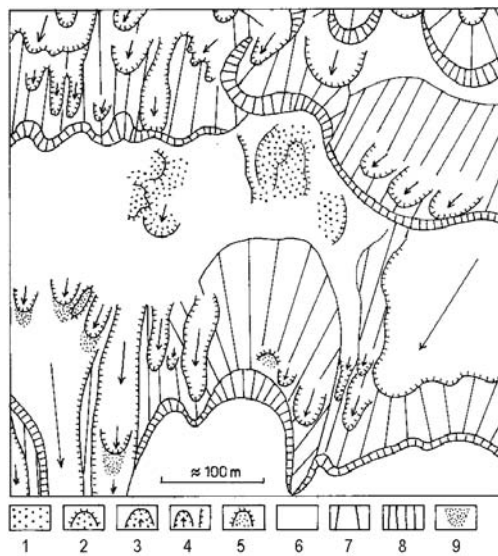
**Photo 8.** Argada site – general view.  
Source: by V. A. Snytko, 2001.

←**Fig. 9.** Geomorphological sketch-map of Argada site: 1 – area of *kuytun*, 2 – erosional scarps, 3 – deflation plains, 4 – deflation basins, 5 – deflation ditch, 6 – deflation scarps, 7 – deflation remnants, 8 – modern aeolian covers, 9 – sandy shadows.

Psammosteppes community *Oxytropis lanata*-*Bromopsis pumPELLIANA*, developing within the scope of a real stipa steppe on chestnut soil, is an element of the described aeolian landscape. Apart from the mentioned psammosteppes species *Agropyron cristatum*, *Carex sabulosa*, *Chamaerhodos erecta*, *Thymus mongolicus* also occur there (Szczypek et al., 2002).

*Nomokhonovo site*, its aeolian landscape occurs in West Transbaikalye close to the place where the Chikoy River flows into the Selenge (cf. fig. 1). Contemporary aeolian processes, like in the neighbouring areas, have been occurring there with different intensity for 200–300 years, and the last intensive stage of their development

occurred in 1930 and 1940 due to increase of human impact (excessive agricultural and livestock raising activities). It has caused such increase of intensity of aeolian processes, that some settlements e.g. Staroye Nomokhonovo have been completely buried with sand and abandoned (Bazarov, Ivanov, 1957; Melnik, 1999). Currently, there are barchan dune systems in the described region. They reach the height of 8–10 m, move gradually to the south and bury steppe surface in the described area. It should be added that at present, most of the forms are quite intensively scattered by wind (fig. 10, photo 9).



**Photo 9.** General view of Nomokhonovo site.  
Source: by T. Szczypek, 1999.

**Fig. 10.** Geomorphological sketch-map of Nomokhonovo site:

1 – surface of Selenga river terrace, 2 – remnants of terrace, 3 – deflation basin in fluvial deposits, 4 – deflation basins and cuts, 5 – deflation remnants, 6 – terrace surfaces with thin aeolian cover, 7 – windward slope of dunes, 8 – leeward slope of dune, 9 – modern aeolian covers.

Psammophylous vegetation, mainly as communities of *Oxytropis lanata*-*Corispermum elongatum* and for example with *Agropyron cristatum*, *Artemisia scoparia*, *Convolvulus fischerianus*, *Dontostemon perennis*, *Elytringia repens*, *Leymus buriaticus*, *Thymus asiaticus*, *Vincetoxicum sibiricum* has developed on the Nomokhonovo site. Some parts of the dunes are preserved by willow shrubs (Szczypek et al., 2000).

## FINAL REMARKS

Analysis of contemporary aeolian relief in different points of Prebaikalye and Transbaikalye shows it is varied in size and the contents. Obviously, it results from the local anemological regime and shape of the bed. Deflation character is the common feature of the relief, as almost all old forms are blown away. Aeolian accumulation processes are generally of secondary importance, which is proved by relatively small size and variation of such forms. The only exception is Nelkhay site on the Bratsk Reservoir, where accumulation is more intensive than deflation.

Local vegetation, with its psammophylous character, adapts to the aeolian processes. Most of the vegetation is of grass, less frequently dwarf-shrub or shrub type. It forms a number of communities and groups of plants, showing unique character and specific features helping the plants to adapt to difficult living conditions.

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## **SUMMARY**

Aeolian landscapes are typical of the area of Prebaikalye and Transbaikalye. They occur both on the shore of Baikal and at various distances from the lake and they are related to areas of boreal forest and steppe. They are characterized by both natural and anthropogenic origin. The former are more typical of Transbaikalye, where they represent old dune forms at different stages of formation, stabilized by pine forest vegetation. These landscapes probably originated at the end of the Pleistocene and the beginning of the Holocene.

Anthropogenic aeolian landscapes are more clearly visible and noticeable because of the geomorphologic processes occurring there at present. They occur in both of the regions and they are related to diverse economic activities of man in the past hundred, up to two hundred, years. The dominating type of surface features is that of wind erosion, which is related to old forms being blown away. The accumulative effect of wind is definitely of minor significance there; this can be seen in minor size and diversity of forms.

Vegetation, which is clearly psammophilous, adapts itself to these contemporary aeolian processes. This is mostly herbaceous vegetation, or less often shrubs or undershrub. It creates a range of plant communities and associations, frequently of unique nature and with peculiar features of adaptation of plants to life in heavy habitat conditions.