Features of aeolian relief formation of the sandy massif
Suvinskii Kuitun in the Barguzin Depression

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Abstract. The principal objective of the article is the determination of the main features of the aeolian relief formation of the Suvinskii Kuitun sand massif, one of the regions of active modern aeolian morphogenesis in the Barguzinskaya Depression. A brief description of the morphology of the aeolian relief, characterized by the predominance of deflationary forms over accumulative ones, is given. Among the forms of active deflation, deflation basins dominate here, separated by elongated deflation inselbergs, composed of sands of lacustrine, alluvial, deluvial-proluvial, and aeolian genesis. The mineralogical and granulometric composition of sandy deposits in the southern part of the Suvinskii Kuitun, characterized by poor roundness of sandy grains, has been analysed. A distinct northeastward eolomotion was revealed towards the foothills of the Ikat Range and its accumulation there. The age of the aeolian sands, mainly related to the formation of the Tagar culture (the end of the Bronze Age) was determined. The phytomelioration carried out in the second half of the 20th century led only to a partial fixation of sands, without affecting their overall deflation in most areas of the Suvinskii Kuitun.

1. Introduction
The Barguzinskaya Depression is the most expressive example of the dominance of aeolian processes in the ancient and modern subaerial morphogenesis of the Baikal region. The history of process understanding goes back over a century [1-6]. In many works, the authors addressed the issue of studying the patterns of formation and development of the so-called kuituns – accumulative uplands in the depression, composed of Quaternary sands and tending towards the western slope of the Ikatskii Range. The greatest attention was paid mainly to the study of the largest kuituns – Verkhni (upper), Nizhnii (lower) and Lesnoi, and much less of the relatively medium-sized Suvinskii. Therefore, the study of some development features of aeolian relief formation within the Suvinskii Kuitun seems to be very relevant, and that is the subject of this article.

2. Materials and Methods
The work is based on contributions received by V B Vyrkin [4, 5] in 1981-1986 in geomorphological field studies, and supplemented by D V Kobylkin in 2021 after studying the relief and granulometric and mineralogical composition of aeolian deposits in the southern part of the Suvinskii Kuitun. In 2021, we studied the morphological structure using aerial photography from an UAV (Mavik Pro 2), followed by data processing in Agisoft PhotoScan and QGIS 3.16 software packages (Figure 1).
We took samples of loose sediments in the bottom of the deflation basin and in the section of the deflation scarp formation to study the structural features of the deflated material. For the analysis, we used a *LEO-1430VP* scanning electron microscope (Carl Zeiss, Germany) with an *INCA Energy 350* energy dispersive microanalysis system (Oxford Instruments, Great Britain), as a result of which high-quality raster images and X-ray spectra of elements were obtained, as well as a qualitative and quantitative microanalysis of the substance without applying a conductive coating.

3. Results and Discussion

Morphologically, the Barguzinskaya Depression can be divided into three areas. The upper (northeastern) section, about 80 km long, is distinguished by a weak development of accumulative surfaces of the second type – a complex of alluvial terraces and floodplains with lacustrine-boggy lowlands. They can be traced only by a strip of 3-5 km long between Lesnoi Kuitun and alluvial cones and trails of the right riverside of the Barguzin. Only in the Ust’-Garginskaya depression, this strip expands to 9-10 km.

According to our calculations, the first type makes up 24% of the area of the site, the second – 23%, and the third (Lesnoi Kuitun) – 53%.

The middle section, about 60 km long, includes the Verkhnii and Nizhnii Kuituns, the strips of foothill cones, trails at the foot of the Barguzinskii Range and the Barguzin River’s floodplains and terraces up to 15-16 km wide, as well as the lacustrine-boggy Khonkhinskaya lowland.

The lower section, about 60 km long, is characterized by the high priority placed on the second type of accumulative surfaces above the others. In the Ust’-Mindaiskaya Depression, the width of the Barguzin floodplain with remnants of terraces and lacustrine-boggy lowlands of the most recent subsidence zones is 25 km, and the foothill plumes of the foothills of the Barguzinskii and Ikatskii ranges are not wide (except for the delta of the Iia River). In the lower (southern) part of the depression, there is a sandy Suvinskii Kuitun and a number of small deflation areas belonging to the third type of surfaces. In general, the ratio of the types of surfaces in the depression discussed above is as follows: the first type – 1/5, the second and third – 2/5 each.

![Figure 1](image-url)  
*Figure 1.* 1 – Three-dimensional model of the research area’s relief in the southern part of the Suvinskii Kuitun with a hypsometric profile along the line A-B; 2 – overview map; 3 – aerial photograph of the research area.
The sandy massif Suvinskii Kuitun, located in the southeastern part of the Barguzinskaya Depression at the foot of the Ikatskii Range between the mouths of the Ina and Suvo rivers, is distinguished by the predominance of deflationary forms over accumulative ones. The most frequent deflation basins up to 10 m deep and 50-100 m wide with very steep side slopes and deflation corridors up to 2-4 m deep and 10-15 m wide, the sheer walls of which are actively corroded by sand are common here. The corridors are separated by linearly elongated deflation inselbergs. Yardangs are also developed here. This massif contains small oval basins and kar-like hollows open to the southwest (towards the prevailing winds), especially at the foot of the highest steep scarps separating the deflation basins and inselbergs. The formation of corridors and elongated hollows on these slopes of the inselbergs is associated with the initial focal deflation of the slope and further growth of the hollows to the northeast due to deflation. In the resulting corridors, the wind speed increases and the aeolian material loss is accelerated, hence, we observe an active destruction of the back wall, growing deeper into the massif. Therefore, the southwestern slopes of the massif often have a castellated and asymmetrical shape due to the more active growth of corridors and elongated hollows in comparison with the intervals between them, represented by sharp projections formed by the walls of the corridors.

In the sands of the Suvinskii Kuitun, the dominant position is occupied by silicon oxide; the content of oxides of aluminium, iron, manganese, titanium, calcium and potassium (in decreasing order) is lower. The mineralogical composition of the sands is represented by quartz, amphibole, plagioclase, biotite, epidote, chloride, and rarely garnet, magnetite, and apatite.

The morphological structure of the presented deposits is very diverse (Figure 2). Not all analysed samples differ significantly from each other according to the degree of rounding. In general, most of the fragments in their composition are non-rounded, characterized by the presence of sharp edges. The small number belong to subangular facies that do not have any traces of long-term wind processing, despite the fact that they form aeolian landforms. This is because most of the sands within this area are composed of deflated sediments of a low lake terrace and levees and are predominantly of lacustrine genesis [3].

There is a distinct movement of sands to the northeast both in the Barguzinskaya Depression in general and on the territory of the Suvinskii Kuitun, in particular, as defined morphologically and visually during strong winds within almost all sand massifs. Deflationary winds are mainly southwesterly, less often westerly. Winds of other directions play a less important role in aeolian relief formation due to their low frequency in the spring-early summer period.

The highway Ust-Barguzin – Maisk intersects in several places with narrow northeast ranges. The main transfer of material from the southwest to the northeast is observed everywhere, but near the Ina River cutoff, the prevailing small dunes up to 1-1.5 m, changed their shape due to strong northeast wind on 27 June 1983. Consequently, the gentle windward southwestern slopes became steep, like leeward slopes. Hence, owing to the change in the shape of the dunes, a cursory look at them may lead to a misconception about the prevailing sands transfer to the southwest, although this is a particular case and temporary phenomenon. The southwestern direction of sand movement is secondary, due to a separate rare relief-forming action of northeastern winds, which have a small frequency and strength, especially in the spring-summer period, when the most active sand movements take place. In 1984, these dunes again had a typical combination of steep northeastern and gentle southwestern slopes (Vyrkin, 1986).

In the northwestern part of the Suvinskii Kuitun in the deflation basin up to 3 m deep, we found a human skull, fire coals and artefacts (a bronze knife, an arrowhead, a plaque and a celt, pegs of clay vessels, split pebbles, cores and others) of the end of the Bronze Age (Tagar culture, as defined by V V Svinin). The age of the culture is about 2.7-2.2 thousand years. The formation of the ancient soil on which the artefacts have been found is associated with a period of more humid climate and the consolidation of sands. In the Selenga middle mountains, this period falls on the 13th-7th centuries BC [7].
A similar age is inherent in the ancient soil of the Suvinskii Kuitun. From the 7th - 2nd centuries BC (burial time) until now, this site has experienced a stage of sand accumulation, which was replaced by the formation of modern soil, and its ongoing destruction and the formation of a deflation basin. The artefacts of the Iron Age and later periods were also discovered in 1984 on the bare sands in the bottom of the deflation basin 2-2.5 m deep, located on the southwestern slope of the Verkhnii Kuitun, 5-6 km south of the village of Mogoito. Thus, the upper horizons of aeolian sands (up to 3-4 m) are predominantly young sediments formed in the last 2-3 thousand years [4]. In the Holocene, aridization of the climate in the south of Eastern Siberia was observed in the Subboreal and Subatlantic periods [8].

In the 1970s and 1980s, in the Barguzinskaya Depression many activities were undertaken to consolidate the sands by planting shrubs, but desired progress in deflation control has not been made. The deflation rate of bare sands is 5 times higher than that of semi-fixed sands, where partial phytomelioration was carried out. However, high deflation rates impede the rapid consolidation of sands in the first years after planting shrubs, since the root-taking of plantations on a highly mobile substrate in an arid climate is difficult. Unfortunately, the phytomelioration coverage in these years turned out to be insufficient for the complete fixation of mobile sands in the depression [9].
4. Conclusion
The main feature of the aeolian relief morphology of the Suvinskii Kuitun is the predominance of deflationary forms over accumulative ones. This is primarily due to the relatively small thicknesses of sandy deposits in comparison with the huge strata of sands in Lesnoi, Verkhnii and Nizhnii Kuituns. In the Suvinskii Kuitun, the sands move to the northeast and most of them are blown away to the foothills of the Ikatskii Range, where sandy and pulverized Quaternary aeolian thickness occupy an important place in the geological structure of the Ulan-Burg River valley. Within the sandy massif, the surface and the base of the lacustrine-proluvial and alluvial strata of the Barguzinskaya Depression are exposed.

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