

# Late pleistocene periglacial formations in landscapes of Zavolzhye-Urals region

**A G Ryabukha**

Institute of Steppe of the Ural Branch of the Russian Academy of Sciences, Orenburg, Russia

E-mail: annaryabukha@yandex.ru

**Abstract.** Google Earth satellite images analysis corroborated with materials of geological, geomorphological and landscape survey shows in Zavolzhye-Urals region wide distribution of relic relief forms that are shaped under Pleistocene periglacial conditions. Such forms are not always visible in field, but can be well read in satellite images. Following of them are well developed: continental dunes, relic thermokarst lakes, and the microform complexes determined by permafrost influence on the geological substratum: polygonal and hillock-pit complexes, nival relief complex including amphitheatres, niches, trays, etc.

## 1. Introduction

One of the Pleistocene characteristic features is the sudden global climate cooling resulted in continental ice shields and in the specific hyperzone spread for many hundreds kilometers from edges of ice shields [1]. Periglacial hyperzone was characterized by very severe climate with permafrost or very deep seasonal freezing, poor vegetation, and arctic fauna; specific relief forms shaped, and correlative sediments with specific textures accumulated within this zone [2]. The main maximum of climate cooling falls on the third stage of late Pleistocene from approximately 20 to 15-13 thousand years ago [1]. In this period the global permafrost belt occurred and suppressed the latitude zone order. Its southern edge was there about 50° North latitude (in the East European plain about 47° North latitude), while the zone of deep seasonal freezing penetrated modern subtropics to 30-32° North latitude. Cryogenic, deluvial and aeolian processes accompanied with correlative to them relief forms were the most developed in the periglacial hyperzone. During the transition from Pleistocene to Holocene, about 10 thousand years ago, permafrost degraded very quickly (in 1000-1500 years) and left split polygonal forms, wedge structures, cryoturbations, thermokarst pits that are all relic now [1].

## 2. Objects and methods

This study was aimed at finding local features and regulations of late Pleistocene periglacial forms in Zavolzhye-Urals region. The researched area is located at South-Eastern edge of the East European plain within the Bugulminsko-Belebeevskaya upland, Obschiy Syrt and Podurskoye plateau all characterized by subboreal continental East European steppe landscapes on alluvial little divided plains with loamy and sandy lithogenic base, and on denudation hilly and ridged plains with loamy, loess loamy and sandy lithogenic base.

This study based upon Google Earth satellite images analysis, materials of geological, geomorphological and landscape survey, and own field expeditions shows in Zavolzhye-Urals region



wide distribution of relic relief forms that are shaped under Pleistocene periglacial conditions, such as: continental dunes, thermokarst lakes, cryogenic morphosculptures, nival relief forms, etc.

### 3. Results and discussions

*Aeolian processes* were well developed within the periglacial zone, late Pleistocene relief forms are presented by old continental dunes, ravine-crest and hillock-pit sands. Areas of dune clusters in Zavolzhye-Urals region are overlapped to areas of middle- and upper Quaternary lake and river systems development, and are found as well in elevated watershed and near watershed zones of denudation plains where Quaternary sediments are presented by a cover layer of dealluvial and eluvial sands formed as results of Permian, Triassic and Cretaceous sandstones. Main areas of dune cluster development are right bank of lower Ilek river (Ilekskiy), Bolshaya Khobda and Malaya Khobda rivers interfluves from Aksay town longitude to the junction of these rivers (Khobdinskiy), basin of upper Utva river on both banks (Verkhneutvinskiy), right bank of upper Uil river (Verkhneuilskiya), basin of upper Kaldygaity and Buldyrty rivers (Buldyrty-Kaldygaitinskiy), and other areas [3].

The most wide spread shape of a continental dune in the region is parabolic, that is a narrow and long (up to several kilometers along crest) “rampart” curved into an arch or a horseshoe shape with asymmetric slopes: gentle long windward, and steep short leeward ones. The height of dunes fluctuates from several to 10-15 meters. Dune “horns” are orientated to the South, South-West or South-East, that indicates Southern, South-Eastern and South-Western winds in dune forming in Pleistocene [4].

*Cryogenic processes* related to frost-shattered cracking because of temperature fluctuation in upper horizon of permafrost were one of dominating in the periglacial zone. Lowland interfluves and high floodplain terraces of river valleys both formed by middle- and lightloamy sediments (loess loam) are always covered by the network of paleocryogenic polygonal relief of various preservation, which is well indicated in satellite images as a picture on ploughed fields (the system of light cells surrounded by relatively dark lines is well visible). This relief is presented by tetragonal, often of a round shape, microuplands of relative height 0,2-0,3 meters, and by dividing them network of flat ravinelike depressions (traces of old splits). The linear dimension of a block is averagely 30-50 meters, but sometimes larger ones is found, up to 100-120 meters or more. In whole, this block relief forms on a map a continuous polygonal network in the form of tile grid. Since it is not apparent in the relief, it is not always can be detected in field. Centers of blocks are sometimes especially brightened, this occurs when a thin humus layer is taken away by ploughing up. In many times depressions between blocks are occupied by an erosion network. In gentle slopes of an upland a polygonal network is transformed into lengthwise stripe relief [5], that is the series of barely visible furrow occurred on ploughed plots as dark stripes 20-30 meters wide parallel each other and orientated along the slope. A.A. Velichko named such cryogenic relief forms as “fan striated” [1].

Flat watersheds and floodplain terraces are often characterized within the region by steppe depressions and flat lake hollows, which are in most of paleocryogenic thermokarst origination. It is not deep saucer-like depressions of regular round shape with flat bottom and gentle slopes. The diameter of depressions fluctuates from 20-50 meters to 300-400 meters or more, the depth – from 0,5 to 4 meters. Some of them, judging by satellite images, are linked to polygonal microrelief and nodes of polygonal network splits. Larger flat bottom depressions occupied by a shallow lake, are relic thermokarst (alas) lakes formed most likely as result of land subsidence of plots rich in ice (core and segregation ones) [1, 6]. The concept of cryogenic genesis of depression relief is substantiated in works by A.A. Velichko, S.P. Kachurin, A.I. Popov, V.V. Berdnikov, N.B. Novoselskaya, V.A. Nikolayev, I.I. Milodykh, A.O. Makeev, et al. There is many hypotheses of the depression relief origination (tectonic, karst, suffusion, erosion et al.). In literature the most often seen hypothesis is the suffusion-subsidence origination of the depressions, however by professor Nikolayev V.A. opinion the little thickness of loess loam cover and the aquiclude proximity to the surface contradict the suffusion-subsidence hypothesis of the depressions origination [6].

The shaping of *nival relief forms*, such as amphitheatres, depressions, niches, trays and ravines on steep and high right bank slopes of Bugulminsko-Belebeevskaya upland and Obschiy Syrt, is related

to periglacial conditions of late Pleistocene. Nival forms are oval or round with relatively flat bottom and steep slopes. They are often of “hanging” character with bottom always opened to the erosion basis [7]. The shaping of nival forms is related to the relief forming role by snowfields evoking destruction downshift of rocks around and under relatively static snow spots. The largest forms are characteristic for areas of loamy-marl rocks development, and are observed on right slopes of Samara, Dyoma, Sok and their tributary river valleys. The diameter of nival forms fluctuates from a few tens of meters (niches) to few hundred meters (amphitheatres). Usually, a nival complex is presented by a set of various nival relief forms, and transforms the original slope shape in several kilometers [7]. Basing upon the age of amphitheater cover material, Butanov G.P. made the conclusion that most of nival forms in the East of the Russian plain are shaped in the late Pleistocene [2]. Terentieva L.P. believes that their shaping is related to the Kalininskoye glaciations [7].

#### 4. Conclusions

The periglacial relief forming is in Zavolzhye-Urals region the poorly studied process while it is significant for practice, that is the strong reason for further detail research into it.

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#### References

- [1] Velychko A A 1973 The natural process in Pleistocene (Moscow: Nauka) p 256 (in Russian)
- [2] Butakov G P 1986 The Pleistocene periglacial in Russian plain (Kazan: Kazan University press) p 144 (in Russian)
- [3] Ryabukha A G 2016 Features of continental dunes in Zauralia-Pricaspian region *Acta Geographica Silesiana* **21** 63-75
- [4] Drenova A N 2000 Dune forming as the indicator of natural processes in periglacial zone of East European plain: with the example of Oka and Klyazma rivers interfluves (Moscow: Moscow University press) p 148 (in Russian)
- [5] Popov A I 1962 The loamy cover and polygonal relief of Bolshezemelskaya tundra *Problems of geographical permafrostology and periglacial morphology* pp 109-130 (in Russian)
- [6] Nikolayev V A 1999 Asian steppe landscapes (Moscow: Moscow University press) p 288 (in Russian)
- [7] Terentieva L P and Valliulina G Sh 2012 Nival relief forms in Prikamia within Udmurtia and Tatarstan *Bulletin of Udmurt University* vol 2 pp 109-30 (in Russian)