Transgressive Pleistocene Cycles and Their Place on the Milankovich Scale

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Abstract. The problem of cyclic organization of geological environment in the Pleistocene is specified based on materials on absolute chronology of marine and intracontinental sediments of North and Central Asia and North America. New data on absolute chronology of fluvial transgressive-regressive cycles of the Pleistocene in comparison with the known solar climate scale of M. Milankovich's are given. It is established that the two most ancient dates of the terrace sediments of the Lena River (234 and 182 thousand years ago) and the Vilyuy River (300 and 176 thousand years ago), as well as three groups of dates of younger Late Pleistocene and Holocene fluvial formations in the valley of the Lena River, Rocky Mountains and in the Primorsky Lowland of the Laptev Sea (36 - 42.8; 27-29 and 8-10 thousand years ago) correlate with the M. Milankovic's curve, describing the variability of the Earth's solar climate with the period of about 41000 years. The oldest dates - 300 and 234 thousand years ago, and the date series in the chronological range 27-29 thousand years ago (five dates) coincide with the cold extremums of the M. Milankovic scale. Dates of 182 and 176 thousand years ago, as well as series of the dates in the range 36-42 thousand years ago (four dates) and 8-10 thousand years ago (3 dates) tend to warm extremums of the same scale.

1. Introduction
It is now known that the sandy sediment are widespread in Central, Western and Northern Yakutia. Sand mass with a capacity of up to 50-100 m are registered in the coastal lowlands of the Laptev and East Siberian Seas, in the valley of the Middle and Lower Lena River and in the basins of the Vilyuy, Olenka and Khatanga. Existing conceptions about the origin of sands are controversial today [12]. However, the confinement of sands to the edges of river valleys and slopes of low watersheds and similarity of their granulometric and mineralogical composition can testify to a single factor that determined the facies of their sedimentation.

If we look at the planetary laws of sand sediments distribution, we can conclude that their accumulation is mainly confined to the deserts and coastal zone of the seas of the World Ocean. Fluvial, coastal and aeolian processes play a leading role in their formation [3].

In recent years, new absolute dates of sandy sediments in Central Yakutia, including terraces of the Lena River and its tributaries, have been obtained [12, 2]. In addition to the dates of the absolute age of fluvial sediments in Yakutia obtained earlier [4, 5, 10] and the dating of peat bogs and sediments of glacial moraines in Siberia and the Tien Shan and of lake and moraine sediments from the Rocky Mountains of North America [14, 15, 16], a broad analysis and comparison of the history of the
development of various natural complexes of the Pleistocene at different latitudes and continents of the northern hemisphere is also possible.

2. Discussion

In the valley of the Aldan River, the absolute age of sands on the 50-meter terrace of the Aldan River is 300.0±5.7 thousand years at a depth of 26 m, according to the thermoluminescent analysis data. This dating corresponds to the data of biostratigraphy: finds of the Middle Quaternary fauna of mammals in the same sediments [4]. The age of silts of the same 50m terrace of Aldan at a depth of 10m is 176.0±2 thousand years [4, 5]. For the Lena river valley the most ancient dating of fluvial sediments was obtained in the area of its middle course, where the base of Quaternary sediments (basin silts, on coal of the Paleogene) of the right bank of the river in the area of Edeitsy settlement (62°27’45.4” north latitude 129°10’04.5” east longitude) is dated to the age of 234,0±26 thousand years ago (RLQG 2268-025), and alluvial sands on the junction of the valley (62°27’32.3” north latitude 129°48’01” east longitude) have an age of 182.0±15.0 thousand years (RLQG 2269-025) [2].

Two dates showing the Late Pleistocene age were obtained from the Kysyl-Syrsky tukulan sediments. One of them, according to wood residues at the base of the section with an absolute marks of 71.8 m, showed the age of 13 C = 36.8±2 thousand years, the second, from the same horizon - buried peat, dates 14 C >42,7 thousand years [12].

Surprisingly, the dates 13 C of Kysyl-Syr sand sediments correlate with the age of lake sediments from a completely different region of the planet - the Rocky Mountains (North America). These sediments, in turn, correlate with the last stage of the Bull Lake glaciation. Thus, for peat lying 4 m below the surface of the lake layers at American Falls, Idaho, the age of more than >42 thousand years (W - 292) has been established [16]. The lake layers are overlapped by sediments of streams flowing out of Lake Bonville in late Bulley time. These sediments contain terrace gravels with shells of mollusks, which age is 29.7±1 thousand years (W - 731).

Close in age terrace sediments were found in Yakutia. These are sandy strata forming the Bestyakhskaya terrace of the Lena River with a height of 45 m. The age of sands on this terrace from the section in the area of the Nizhny Bestyakh settlement at 7.7 m above the modern Lena River watercourse was 27.6±2.2 thousand years ago (RLQG 2266-025) [2]. Very close dating on sands of the same terrace was previously obtained by M.S. Ivanov. In the area of the rear seam of this terrace - at a depth of 49 m - the age of sands of its channel alluvium, determined by radiocarbon method on wood residues, was 27.9±0.4 thousand years [3]. The sand interlayers of detritus in the Kysyl-Syr tukulane sequences at 83 m - 14 C, 28.4±0.6 thousand years [12], as well as sediments of the famous Nikolaev terrace of Lake Issyk-Kul in the Tian Shan and in one of the terraces of the Chui Depression of the Altai [9].

Two most ancient dates of terrace deposits of Lena River (234 and 182 thousand years) and Vilyui (300 and 176 thousand years), as well as three series of younger Late Pleistocene and Holocene dates (36 - 42.8; 27-29 and 8-10 thousand years) correlate with M. Milankovich's curve describing the variability of the Earth's solar climate with the period of about 41000 years. And the most ancient dates of 300 and 234 thousand years of oil equivalent, and date series in the chronological range of 27-29 thousand years of oil equivalent (five dates) coincide with cold extremes of the Milankovic scale. Other date groupings: 182 and 176 thousand years ago, 36-42 thousand years ago (four dates) and 8-10 thousand years ago (three dates) tend to warm extremes of the same rhythm.

Available dates allow to say that about 300 - 234 thousand years ago in the middle course of the Lena river on a wave of cold peaks of insolation and growth of the general humidifying sands of the Aldan 50-meter terrace and sands covered basin silts to the north of the Kangalassky ridge near the village of Edeitsy were washed up. The age of these sediments was the lowest geochronological boundary of our studies. The warm peak of the insolation curve, which appeared about 182 thousand years ago also brought the watering of the Lena River basin and was reflected in the fluvial sands inclined to the mound of a 200-meter terrace near the village. Edejci. Another warm peak, manifested in the late Neleistocene correlates with the beginning of the Kysyl-Syr tukulan inlet (36.8 - >42
thousand years ago) and the accumulation of peat in the Bulley time in the Rocky Mountains of North America (>42 thousand years ago).

The cold insolation peak, which followed the warm one, is compared with the inundation of sands of the Bestyakhskoy terrace of the Lena river (27.6±2.2 thousand years ago), terraces of the Lena river, the Issyk-Kul lake and Chui depression and the deposition of terrace gravels with shellfish in the Rocky Mountains (29.7±1 thousand years ago), as well as the accumulation of plant detritus on the surface of the Kysyl-Syr tukulan (28.4±0.6 thousand years ago).

The latter - the warmest and closest to the present day peak of the Milankovic curve - correlates with the inundation of two large terraces of the Lena River and its tributaries, the Sergeliakhskaya (about 10,000 years ago) and the Yakutskaya (8190 years ago). It also correlates with the period of attenuation of aeolian manifestations on the Kysyl-Syr tukulan due to the strengthening of vegetation on its surface (8140 years ago) and accumulation of moraine loams at the mouth of the Karachan brook in the valley of the Chon-Aksu river on the southern slope of the Kungei-Ala-Too ridge (9130 years ago) in the Tien Shan [7].

A number of dating of river terraces and organogenic interlayers in the thicknesses of tukulane Kysyl-Syrsky sand showed Holocene age. Thus, in the area of Chekurovka settlement on the left slope of Lena valley D. Yu. Bolshiyano found accumulations of sloping sands (up to 53m above the water edge) deposited as a result of waterlogging from the sea. Judging by radiocarbon dating of organic remains contained in the sands, the time of their accumulation will be 2050±30 years old, 1710±60 years. At formation of these sands the growth of the water level in delta Lena on estimation of Bolshianov made to 10-15 m above modern [2].

Attention is drawn to the fact that the waterlogging of the delta of the Lena delta at 10-15 m, identified by D. Yu Bolshiyano, chronologically coincided with the phase of moisture and cooling of the climate appeared in the activation of mountain glaciers around 2000 years ago. This stage of mountain glaciation is known as the historical or "Egesen" stage in alpine terminology [13, 6]. At one time we discovered and dated a number of moraines of this stage in the glacial valleys of the Northern and Central Tien Shan using the lichenometric method [7, 8].

Three more dates of organic layers and buried soils from the Kysyl-Syrsky section at absolute marks from 85.8 to 108 m showed the age of 14C 4060±95 years; 4450±90 years; and 4470±95 years. They quite well correlate with the moraine sediments of the Down stage, which are dated by us in the mountain and glacial valley Syutbulak on the southern slope of the Kungei Ala-Too ridge (Northern Tien Shan) on the soil 14C 4100±270 years (Pomortsev, 1980).

One date of 14C (scattered organics) from the Kysyl-Syr tukulan 14C 5840±100 years was close to the age of the Gshnitz (5700 - 6000 years ago) glacial stage. Another (scattered organics) - 8140±135 - was close to the age of the Byul stage (7700 - 8000 years ago). Very close to Byul age of 14C, 8190±100 years ago was obtained by D.Yu. Bolshiyano on alluvium of the first (Yakutsk) - 7-8 meter terrace of the Lena River floodplain near the mouth of the right tributary - the Buotama River.

The age of the more ancient glacier stage - Ammersee (9800-1000000 years ago) found its analogue in alluvium, lying at the base of the second (Segeliah) - 17-meter terrace of the Lena River floodplain near the city of Yakutsk. At a depth of 10 m the deposits of this terrace are 14C, 10020±230 years ago [1]. In the valleys of the Northern Tien Shan the age close to the dating of this stage was shown by charcoal from the Karachan brook outlet cone sediments, covered with moraine loams at an abs. mark of 2700 m in the Chon-Aksu tract (southern slope of the Kungei-Ala-Too ridge) - 9130±640 years (Pomortsev, 1980).

The most ancient Holocene sediments were installed according to the sample of wood selected from the depth of 3.5 m from the 20-meter terrace of Aldan 14C with the age of 11800±200 years [5], which is comparable with the completion of the glacial cool and wet phase of the Holocene - about 12.0 thousand year. The youngest sediments comparable to those of the Small Ice Age - the Fernau stage - were uncovered in sediments of the modern Vilui River floodplain. They showed the age of 14C 230±60 years - (wood residues at an absolute mark of 81.5 m). A number of 14C dates, which are in the "corridor" of Fernau stage dates, were obtained by A.A. Urban and A.A. Galanin for organic
layers in the sands of the upper - actively translated - zone of Kysyl-Syr tukulan. In the mountain and glacial areas of the Tien Shan, moraines of this stage are widespread enough, they frame the ends of modern glaciers. Their dating by lichenometry and $^{14}$C method showed a large number of glacier movements, which manifested themselves in the range of the last millennium, culminating in the XVI-XIX centuries [8].

3. Conclusion
Thus, we can conclude that the history of Pleistocene and Holocene of Yakutia closely resonates with the history of the largest mountain and glacial systems in Eurasia and North America - the Tien Shan and the Rocky Mountains. Comparison of the dates of reservoir transgression, accumulation of lake sediments, formation of river and sea terraces, and glacier thrust has shown a high level of consistency between most of the established Pleistocene and Holocene events. We consider the main milestones of the Late Pleistocene to be chronological milestones a little earlier than 40-42 thousand years and 25-29 thousand years ago. It seems that these milestones are associated with major changes in the climatic system of the planet, which led to the emergence and development of wet and cool climatic phases, contributing to the strengthening of both glacial and fluid activity.

The first period is associated with sand deposition and nucleation of Kysyl-Syrsky tukulan in the valley of the Vilyuya River. It also accounts for the accumulation of peat bogs in the Rocky Mountains, and glacial shifts of the bull leek glaciation stage. The second period has shown in formation of terraced shingle with shells of mollusks overlapping lake layers of late Bull Age in Rocky Mountains, and also silts in Southern Alberta (Canada) laying under a moraine of last glaciation and on more ancient moraine which age is considered as early Viscosity. This chronological boundary also includes the time of formation of the Bestyakh terrace of the Lena River with a height of 45 m, formed by fluvial sands, as well as the accumulation of detritus layers in sediments of the Kysyl-Syr tukulan, the inland of the Nikolaev terrace of Lake Issyk-Kul and the coastal ledge in Chusk in the depths of the Altai.

In the Holocene, against the background of the last glacier decay, natural processes were subordinated to the widely known 1850-year-old rhythm of A.V. Schnitnikov. The most important milestones of this period include time intervals close to 8 and 10 thousand years ago - the time of formation of the first and second terraces of the Lena River floodplain, well developed in the area of Yakutsk. At the same time there was an accumulation of scattered organic horizons in the Kysyl-Syr tukulane sands and activation of mountain glaciation of the Tien Shan, Southern Verkhoyanya and other mountainous countries. Another date - about 2 thousand years ago - combines glacial movements on the Tien Shan and 10-15-meter rise of the Lena level, as evidenced by the accumulation in the lower reaches of the Lena River (Lena Pipe region) thicknesses of sloping sands with a capacity of 53 m, as well as the accumulation of organic layers in sediments of the Kysyl-Syr tukulan. A clear chronological connection has also been revealed between the periods of soil formation and organic accumulation in the Kysyl-Syr outcrop and the stadium glacier movements that manifested themselves in the Tien Shan about 4 and 6 thousandyears ago. The youngest - the last stage of glaciation, the Fernau stage - was reflected not only in the foothills of mountain glaciers, where it delineates the languages of modern glaciers, but also in the sandy strata of the Kysyl-Syr tukulan and in sediments of the modern Vilyuy floodplain.

If we turn to the main problem of the Pleistocene, there is no doubt about the flooding of lowlands and plains of Northern, Central and Western Yakutia, as well as the lack of traces of cover glaciers on them. This is confirmed by all geological, geomorphological and palaeogeographical materials, generalized by us in the process of research, and, above all, the spatial, elevation and chronological position of river terraces, moraines of mountain glaciers and dune-sand complexes - tukulans of Yakutia.

In general, the natural and climatic conditions of the Pleistocene and Holocene were determined by the stroke of insolation recorded on the M. Milankovich scale in the form of waves of 40700-year rhythm. In the course of this rhythm both heat supply and moisture content of continental and oceanic
spaces were changing. These two factors set the tone for the dynamics of the entire spectrum of natural processes from river runoff, lake and mountain glacier pulsations to large-scale ocean transgressions and regressions that changed the hydrography of the continents and created conditions for the development of floods. At the same time, the activity of fluvial processes took place on both warm and cold "waves" of the Pleistocene, beaten by the Milankovich rhythm. In the Holocene, the history of which has been studied in more detail, a certain role in the dynamics of fluid and glacial processes, along with the 40700-year rhythm, was played by the 1850-year rhythm of A.V. Schnitnikov [13].

4. References
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