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ПРОБЛЕМЫ ФЛЮВИАЛЬНОЙ ГЕОМОРФОЛОГИИ

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ПАЛЕОРЕКОНСТРУКЦИЯ ДОЛИНЫ НИЖНЕЙ ЛЕНЫ В ГОЛОЦЕНЕ И ПОЗДНЕМ НЕОПЛЕЙСТОЦЕНЕ: НОВЫЕ ДАННЫЕ, ПРОТИВОРЕЧИЯ И ПРОБЛЕМЫ

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Река Лена вместе со своими притоками входит в число крупнейших речных систем мира. В течение трех полевых сезонов в долине Нижней Лены от устья Алдана до “Ленской трубы” было исследовано 18 обнажений террас различного уровня, сложенных аллювиальными отложениями. Высоты террас определялись по топографическим картам, при помощи метода нивелирования и GPS-съемки. Обнажения были описаны в полевых условиях с отбором образцов для датирования радиоуглеродным методом и методом инфракрасной стимулированной люминесценции (IR-OSL). Суммарно было получено 26 радиоуглеродных и IR-OSL значений возрастов отложений. Нижняя пойма наиболее детально была обследована на участке от устья Алдана до устья Вилюя, где ее высота составляет от 5–6 до 8–9 м. Отложения высокой поймы были изучены на отрезке между устьями Алдана и Вилюя, в районе устья Дянышки, а также на участке между селами Сиктях и Кюсюр. Ее высота варьирует от 6–10 до 15–16 м. Отложения первой террасы (7–15 м) и второй террасы (20–23 м) наиболее подробно исследованы в районе устья Дянышки. На ряде участков (нижнее течение Дянышки, вблизи устьев Менкере и Натары) были датированы отложения более высоких террас. Изучение и датирование отложений, слагающих пойму и первую террасу в долине Нижней Лены, подтверждают, что их формирование было обусловлено колебаниями уровня моря в голоцене и в конце позднего плейстоцена, так же, как и в дельте Лены. Результаты датирования аллювиальных отложений в обнажениях 40–60-метровых террас методом инфракрасной стимулированной люминесценции противоречат ранее принятым в 3-й четверти XX столетия представлениям о возрасте соответствующих террас. Оледенения Верхоянского хребта не могли повлиять на конфигурацию долины Лены, так как горные ледники не достигали Лены с конца среднего плейстоцена.

Ключевые слова: долина Нижней Лены, пойма, терраса, голоцен, поздний неоплейстоцен, датирование отложений

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1. INTRODUCTION

The Lena River with its tributaries is one of the largest river systems in the world. The Lena River valley in the middle and lower reaches is completely located on the territory of the Yakutia (Russian Far East). The region has extremely difficult conditions for living and economic development due to the subarctic continental climate and the distribution of continuous permafrost. The Lena River is one of the most important transport arteries of Yakutia. Therefore, the study of the Lena River banks, its geological structure, morphology, history of its development is strategically important for the development of the region.

There is a relatively small number of published investigations dedicated to geomorphological structure and paleogeographic reconstruction of the Lower Lena Valley or to its separate parts, with the exception of the Lena River Delta. Most of them were published in the 3rd quarter of the 20th century, when ideas about the evolution of the Lena River Valley were based on the relative dating, spore and pollen analysis and paleofaunal reconstructions. Even then it was clear that the Lower Lena Valley has a vastly complex structure. Over time, it became clear that the existing ideas needed to be clarified on the base of new dating methods and new accumulated actual material.

From 1998 to the present, a Russian-German scientific expedition has been working in the Lena Delta. It has been organized by the Arctic and Antarctic Research Institute (St. Petersburg, Russia) and the Alfred Wegener Institute (Potsdam, Germany). Geomorphological and paleogeographic studies formed one of the central parts in the programs of this multidisciplinary expedition. Detailed results of geomor-

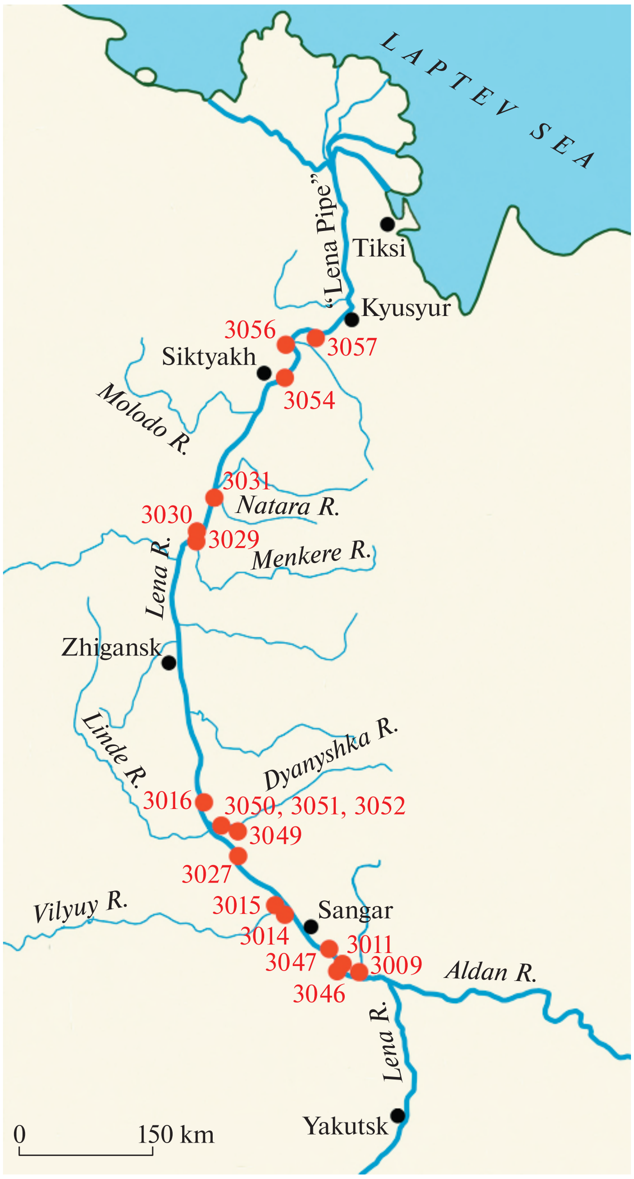

Fig. 1. Study area. Red dots and numbers are the studied outcrops and their IDs. Black dots are the settlements.

Рис. 1. Область исследования. Красными точками указаны изученные обнажения с их номерными обозначениями. Черные точки – населенные пункты.

phological studies of the Lena River Delta are presented in the article and in the monograph devoted to the origin and evolution of the delta (Bolshiyanov et al., 2013; Bolshiyanov et al., 2015). The marine factors of delta formation have been identified in sufficient detail. On the contrary, the role of riverine factors is not entirely clear. Therefore, in recent years, the idea of a comprehensive geomorphological study of the Lena River Valley has appeared. The main task of such a study became the paleogeomorphological reconstruction of the Lena River Valley from Yakutsk to the Delta as a single system during the Late Pleistocene-Holocene.

2. MATERIALS AND METHOD

To achieve the objective, three expeditions were organized in 2016, 2017 and 2019. During this period, 18 outcrops of alluvial deposits on terraces of different levels of the Lower Lena Valley were studied. The location of the outcrops is shown in fig. 1, and their coordinates are presented in tabl. 1. Terrace heights were determined using topographic maps, leveling and GPS survey. The outcrops were described in the field with sampling for radiocarbon dating and infrared stimulated luminescence (IR-OSL) method. These methods have been used to determine the depositional age of peat and fossil plant remains, as well as the depositional age of sands.

The easiest way to study the terraces is to explore them by moving along the river, but directly along the channels, the terraces can be traced locally and discontinuously. In vast valley, it is necessary to sail upstream along the tributaries of the Lena River to study terraces and deposits. In addition, satellite images and topographic maps should be deciphered, and the literature available on the problem should be analyzed.

Radiocarbon samples preparation and age determination were carried out in the Köppen laboratory of the Saint Petersburg State University (Russia). Lithium carbide was synthesized from a pre-cleaned sample by sintering with metallic lithium (Arslanov, 1987). Benzene was synthesized from lithium carbide via acetylene. The radiocarbon content in the benzene sample was determined on a liquid scintillation spectrometer "Quantululus-1220". The radiocarbon and calibrated age of the sample was calculated according to the results of measuring the activity of radiocarbon. The calibrated age values are based on the "OxCal 4.2" calibration program (Ramsey et al., 2010) and IntCal13 calibration curve (Reimer et al., 2013).

The IR-OSL age determination was carried out in the Research Laboratory for Quaternary Geochronology of the Tallinn University of Technology (Estonia). The samples were prepared for the luminescence analysis according to standard laboratory procedures (Molodkov, Bitinas, 2006).

A total of 26 radiocarbon and IR-OSL ages were obtained. The results are presented in tabl. 1.

3. RESULTS AND DISCUSSION

The floodplain in the Lower Lena Valley consists of low and high levels. The low floodplain has a predominantly fragmentary distribution. Generally, it occupies low river islands and areas near the mouths of the Lena tributaries. We have studied in more detail three outcrops of the low floodplain (3009, 3014 and 3015) in the section of the Lena River Valley between the mouths of the Aldan River and Vilyuy River, where it has a relative height from 5–6 to 8–9 m.

The outcrop 3009 is located at the mouth of the Belyanka River. It is a small right tributary of the

Lena River about 40 km downstream of the Aldan River. The outcrop is a vertical scarp with 4.3 m high. The lower part consists of a well-rounded, light gray and yellow gravel. The thickness of the layer is 0.8 m. The upper part of the outcrop consists of gray silty and sandy overbank deposits. The lower 0.5 m of this layer is rich in plant remains. The radiocarbon age of twigs near the contact with the active channel gravel is 470 ± 50 years BP (LU-8314).

The outcrops 3014 and 3015 are located at the mouth of the Vilyuy River: on the right bank and on the left bank. Both exposures are 9 m high. They are represented by horizontal bedding overbank sands containing plant remains. The radiocarbon age of buried wood from a height of 6.5 m on the outcrop 3014 is less than 200 years BP (LU-8660). The radiocarbon ages of small twigs from a height of 2.7 m and buried wood from a height of 3.0 m are 890 ± 70 years BP (LU-9020) and 340 ± 30 years BP (LU-8660) on the outcrop 3015.

Downstream from Zhigansk village, the height of the low floodplain increases to 9–12 m. We studied only two locations: Duoldanga-Aryta Island (the outcrop 3030) and Anna-Aryta Island (the outcrop 3054). Duoldanga-Aryta Island is a small river island located along the left bank of the Lena River approximately 150 km downstream from Zhigansk village. It has a height of 10 m. Radiocarbon dating of plant remains in the sediments of the island indicates that it continues to form in the present times. Anna-Aryta Island is one of the largest river islands located downstream from Siktyakh village to the "Lena Pipe". Central part of the island is a high floodplain with oxbow lakes, but its periphery should be attributed to the low floodplain not less than 7 m high. Radiocarbon age of plant remains collected from the edge of the outcrop is 230 ± ± 50 yr BP (LU-9402).

Compared to the low floodplain, the high floodplain is more widespread in the Lower Lena Valley. First of all, it occupies large massifs of river archipelagos, the islands in which are separated by numerous small branches of the Lena in areas along the left bank of the Lena River and locally along the right bank from the mouth of the Aldan River to the mouth of the Lungkha River, mainly along the left bank from the mouth of the Vilyuy River to the mouth of the Ulegir River, along the right bank from the mouth of the Oruchan River to the mouth of the Sobolokh-Mayan River and along the left bank from the mouth of the Khoruongka River to the Siktyakh village. The width of the high floodplain can reach about 30 km. In addition, we identified fragmentary narrow sections of a high floodplain along both banks of the Lena River between the villages of Siktyakh and Kyusyur. The height of the high floodplain from the mouth of the Aldan River to the "Lena pipe" increases from 6–10 to 15–16 m. Segmented-ridged and parallel-ridged floodplain relief is typical for the surface of high floodplain. In contrast to the low floodplain, the surface of the high floodplain is always covered by taiga and drift wood along the Lena main channel and its branches, which indicates the flooding of this surface in some years.

The high floodplain deposits have been studied in several key sections (fig. 2). The first section is located between the mouth of the Belyanka River and the Sangar village in a large river archipelago stretched along the right bank of the Lena River and separated from it by the Tab-Ary channel.

The outcrop 3011 is located on the Kurus Island, the left bank of the Tab-Ary channel. It has a height of 5 m above a sand river beach about 1 m high. The lower part of the outcrop (1–2.9 m above the river) is a talus. The middle part (2.9–4.3 m) is a horizontally layered silt strata with interlayers of sand and plant remains (small twigs and trunks). The upper part (4.3–6 m) is a horizontally layered oberbank sands and silts and cross-layered channel sands. A small trunk gave the radiocarbon age of 2460 ± 40 years BP (LU-8658) from a height of 3 m.

The outcrop 3046 is located on the left opposite bank of the Lena main channel. It had a height of 2.5 m at the time of observation at the end of the flooding processes. The edge of the outcrop has a height of approximately 6 m above the low-water level. The outcrop is composed by overbank deposits: horizontally layered sands, silt and plant remains. The plant remains gave the radiocarbon age of 2520 ± 70 years BP (LU-9396).

The Sya-Ary Island is located 20 km downstream from the mouth of the Tab-Ary channel near the right bank of the Lena (opposite the mouth of the Balamakan River). The outcrop 3047 was studied here. It has a similar height and similar structure to the outcrop 3046. The plant remains gave the radiocarbon age of 1530 ± 110 years BP (LU-9397).

In the section from the mouth of the Lyampushka River to the mouth of the Dyanyshka River, the Lena main channel expands sharply. The branching of river channels is the reason for the existence of a large river archipelago here. One of the largest islands here is the Ulakhan-Kistyakh. We attribute the level of its surface to a high floodplain. We studied the outcrop 3027 7 m high at the top of this island. It is composed of overbank deposits, less often channel deposits. There are horizontally bedded and cross-bedded fine-grained and medium-grained sands with interlayers and lenses of silt and a high content of plant remains in the scarp of the island. The plant remains gave the radiocarbon ages of 2810 ± 90 years BP (LU-2937) from a height of 2.1 m, 2620 ± 120 years (LU-8936) from a height of 2.6 m, and 1670 ± 90 years BP (LU-8935) from a height of 4.3 m.

In the section between the villages of Siktyakh and Kyusyur, we found that the upper part of the high floodplain is composed of layering organic and miner-

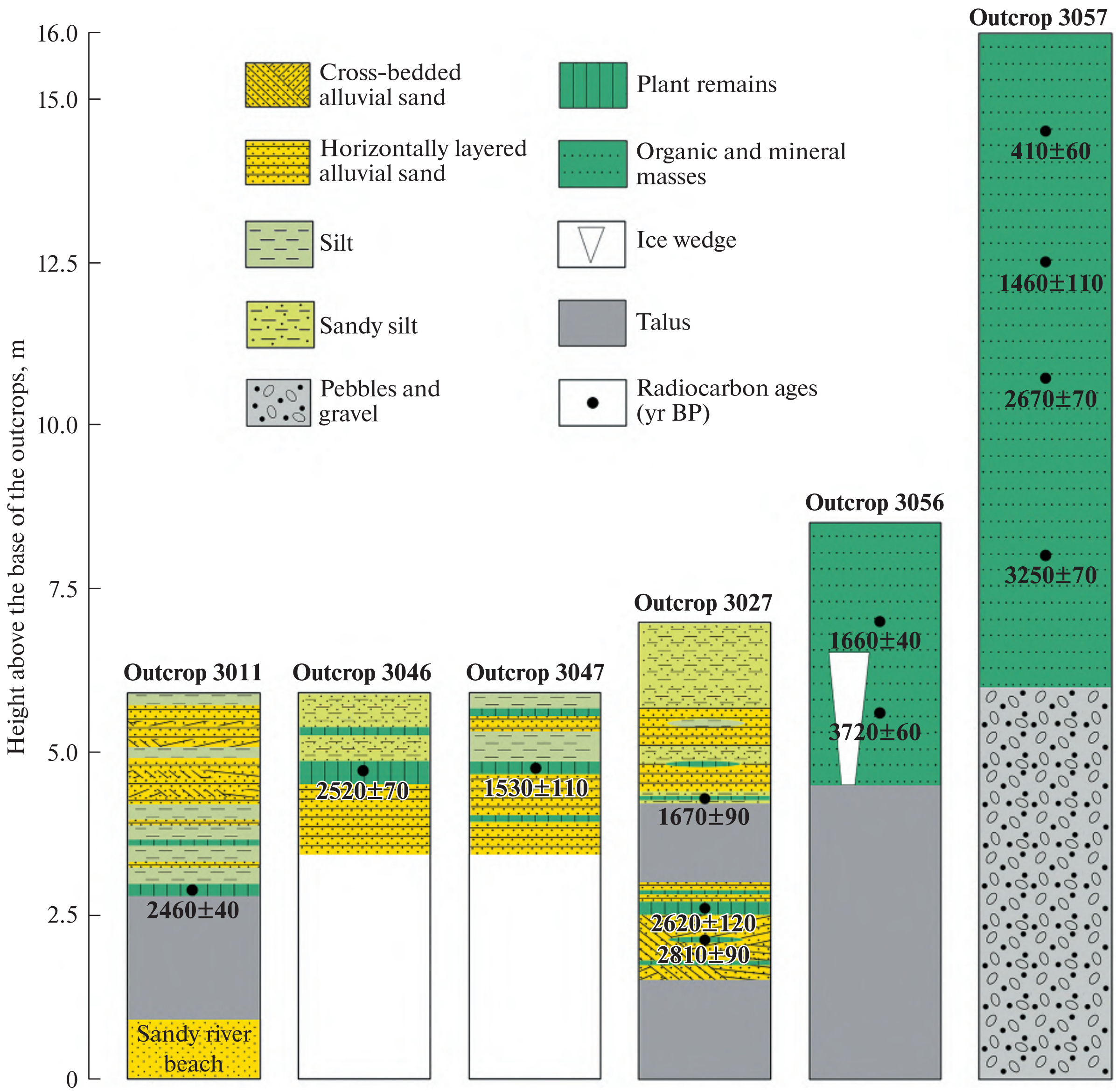

Fig. 2. Lithological logs of the high floodplain outcrops and radiocarbon ages of organic remains.
Рис. 2. Литологическое строение обнажений высокой поймы и радиоуглеродный возраст органических остатков.

al masses (strata of horizontally layered sands, silt and plant remains). Such kind of deposits is typical for the Lena River Delta complex (Bolshiyanov et al., 2013; Bolshiyanov et al., 2015). We studied two outcrops. The outcrop 3056 is located on the left bank of the Lena River near the Sutukilakh Island, 230 km upstream from the top of the Lena Delta. It has a height of 8–9 m. Layering organic and mineral deposits are 4 m thick and are penetrated by ice wedges. Radiocarbon ages of plant remains from a height of 5.6 m is 3720 ± ± 60 years (LU-9405) and from a height of 7.0 m is 1660 ± 40 years BP (LU-9404).

The outcrop 3057 was studied approximately 60 km downstream on the right bank of the Lena River. It has a height of 16 m. The bottom of the outcrop is the lower part of a high floodplain. The upper part, 10 m thick, is composed by organic and mineral masses. The radiocarbon ages of plant remains are 3250 ± 70 years BP (LU-9409) from a height of 2 m above the bench, 2670 ± 70 years BP (LU-9408) from a height of 4.8 m, 1460 ± 110 years BP (LU-9407) from a height of 6.5 m and 410 ± 60 years BP (LU-9406) from a height of 8.5 m.

The results of radiocarbon dating the organic and mineral masses composing the 1st terrace of the Lena River Delta (Bolshiyanov et al., 2013; Bolshiyanov et al., 2015) indicate that they accumulated in the same period when the deposits of the high floodplain were formed in the Lower Lena valley. During the Holocene, the Laptev Sea level repeatedly fluctuated up to

Table 1. Radiocarbon and IR-OSL dating results. The list is sorted in the order of location of the outcrops downstream of the Lena River
Таблица 1. Результаты радиоуглеродного и IR-OSL датирования по обнажениям, приведенным в списке сверху вниз по течению Лены

Outcrop ID	Location	Coordinates	Lab No.	Sample type	^{14}C ages	^{14}C ages calibrated	IR-OSL ages
3009	Mouth of the Belyanka River	N 63°31′03.8″ E 128°49′36.3″	LU-8314	Twigs	470 ± 50	510 ± 50	–
3011	Kurus Island	N 63°39′37.6″ E 128°25′19.4″	LU-8658	Trunk	2460 ± 40	2550 ± 100	–
3046	Left bank of the Lena River, opposite the Tab-Ary channel	N 63°29′37.9″ E 128°18′22.1″	LU-9396	Plant remains	2520 ± 70	2580 ± 100	–
3047	Sya-Ary Island	N 63°53′03.3″ E 127°43′35.1″	LU-9397	Plant remains	1530 ± 110	1450 ± 110	–
3014	Mouth of the Vilyuy River, right bank	N 64°21′26.6″ E 126°25′48.5″	LU-8660	Wood	<200	<200	–
3015	Mouth of the Vilyuy River, left bank	N 64°22′30.6″ E 126°24′08.4″	LU-9020	Twigs	890 ± 70	820 ± 70	–
			LU-8661	Wood	340 ± 30	390 ± 50	–
3027	Ulakhan-Kistyakh Island	N 64°47′31.1″ E 125°23′03.7″	LU-8937	Plant remains	2810 ± 90	2950 ± 110	–
			LU-8936	Plant remains	2620 ± 120	2690 ± 160	–
			LU-8935	Plant remains	1670 ± 90	1580 ± 110	–
3049	Lower reaches of the Dyanyshka River	N 65°00′45.2″ E 125°05′57.7″	RLQG 2643–060	Sand	–	–	64500 ± 4500
3050	Lower reaches of the Dyanyshka River	N 65°02′02.0″ E 125°03′22.9″	RLQG 2644–060	Sand	–	–	6000 ± 400
3051	Lower reaches of the Dyanyshka River	N 65°02′16.3″ E 125°02′42.0″	LU-9399	Twigs	12030 ± 110	13900 ± 140	–

Table 1. Окончание

Outcrop ID	Location	Coordinates	Lab No.	Sample type	^{14}C ages	^{14}C ages calibrated	IR-OSL ages
3052	Lower reaches of the Dyanyshka River	N 65°02′12.8″ E 125°01′55.4″	LU-9400	Peat	9710 ± 60	11090 ± 120	–
			LU-9401	Peat	5740 ± 50	6540 ± 60	–
3016	Right bank of the Lena River, 10 km downstream from the mouth of the Dyanyshka River	N 65°05′20.6″ E 124°47′42.8″	RLQG 2466–067	Sand	–	–	6900 ± 600
3029	~3 km downstream from of the mouth of the Menkere River	N 68°01′58.0″ E 123°19′38.6″	RLQG 2544–118	Sand	–	–	23600 ± 1900
3030	Duoldanga-Aryta Island	N 68°06′04.1″ E 123°19′43.4″	LU-8938	Plant remains	Recent	Recent	–
3031	Mouth of the Natara River	N 68°24′06.8″ E 123°55′27.9″	RLQG 2552–118	Sandy silt	–	–	68800 ± 5600
3054	Anna-Aryta Island	N 69°58′04.1″ E 125°35′48.3″	LU-9402	Plant remains	230 ± 50	230 ± 120	–
3056	Left bank of the Lena River, between the villages of Siktyakh and Kyusyur	N 70°16′40.8″ E 125°58′09.8″	LU-9405	Plant remains	3720 ± 60	4070 ± 90	–
			LU-9404	Plant remains	1660 ± 40	1560 ± 60	–
3057	Right bank of the Lena River, between the villages of Siktyakh and Kyusyur	N 70°29′47.6″ E 126°42′39.3″	LU-9409	Plant remains	3250 ± 70	3480 ± 80	–
			LU-9408	Plant remains	2670 ± 70	2800 ± 80	–
			LU-9407	Plant remains	1460 ± 110	1380 ± 110	–
			LU-9406	Plant remains	410 ± 60	430 ± 70	–

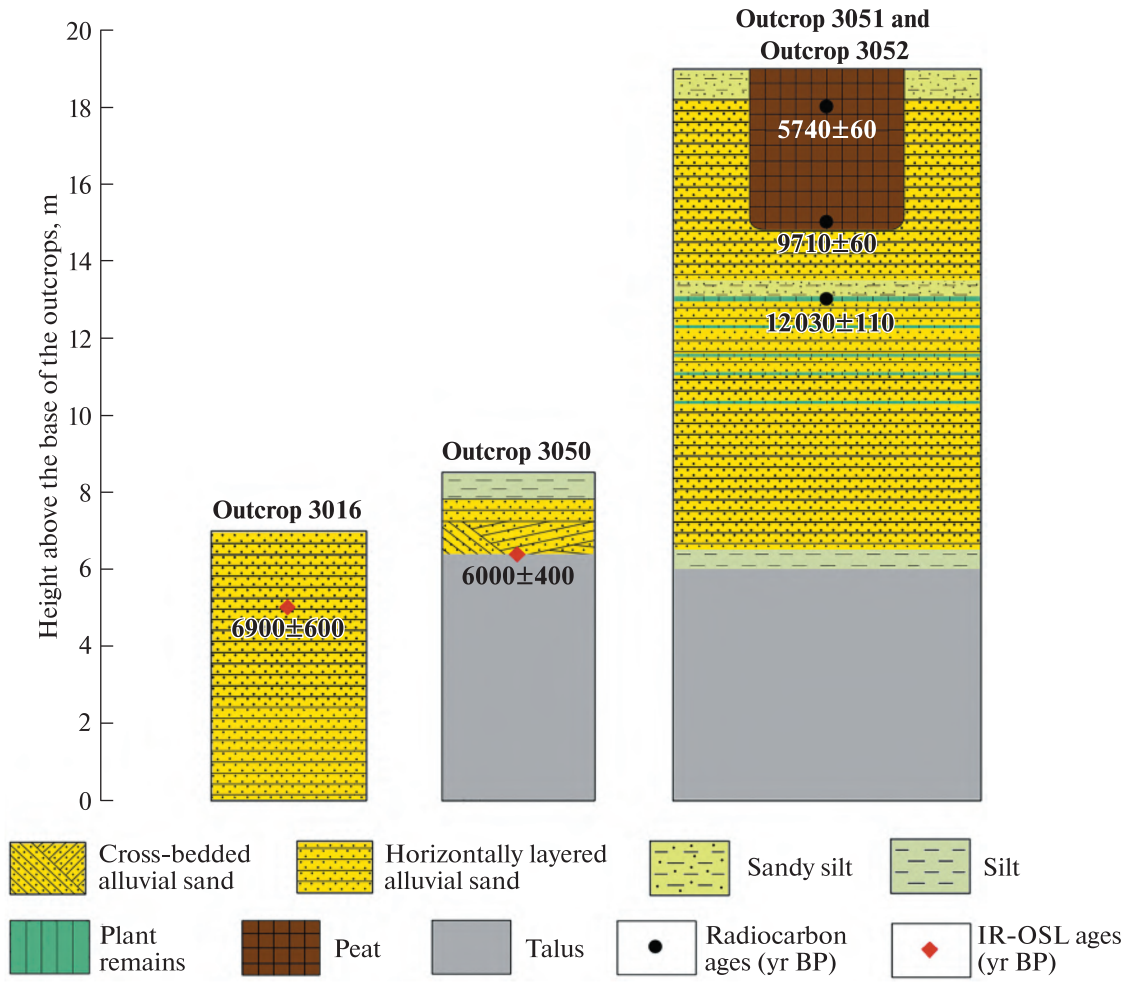

Fig. 3. Lithological logs of the 1st and 2nd terrace outcrops. Radiocarbon ages of organic remains and IR-OSL ages of alluvial sand deposits.

Рис. 3. Литологическое строение обнажений первой и второй террас. Радиоуглеродный возраст органических остатков и IR-OSL-возраст аллювиальных песков.

a height of 7–8 m above the present level (Bolshiyanov et al., 2013; Bolshiyanov et al., 2015). This is the reason for the accumulation of thick strata of specific ingressive organic and mineral deposits in the Lena River Delta.

Identification of terraces in the Lower Lena valley is a more difficult problem, because they are often separated from the river by large floodplain areas and are difficult to explore. M.N. Alekseev identified 7 terraces above the floodplain with a height of 15–16, 25–32, 40–45, 50–60, 65–80, 90–100 and 130–140 m (Alekseev et al., 1962). In his opinion, the first two are of Late Pleistocene age. In addition, in the Sobolokh-Mayan river basin, he noted fragments of a 200-meter terrace eroded by water flows and glaciers.

Two lowermost terrace levels are found everywhere throughout the Lower Lena River Valley, but we studied them in the most detail in the area of the mouth of the Dyanyshka River (fig. 3).

The first terrace has a scarp with 7–9 m high. It stretches along the Lena River from the mouth of the Dyanyshka River for about 25 km with a maximum width of about 7 km. The total height of the first terrace increases to 15 m at a distance from the Lena River. This terrace is composed by overbank horizontally layered, less often channel cross-layered, gray and yellow, fine-grained and medium-grained sands. Among sands there are also layers of silty sand, rarely thin layers of silt. Plant remains are very rare. This terrace was studied in two exposures. The outcrop 3016 is located on the right bank of the Lena River, 10 km from the mouth of the Dyanyshka River. Its height is 7 m. The IR-OSL age of sands from a depth of 2 m from the edge of the terrace scarp is 6.9 ± 0.6 ka (RLQG 2466–067). The outcrop 3050 is located on the right bank of the Dyanyshka River, 25 km from its mouth (about 6 km from the Lena River in a straight line). Its height is 8–9 m. The IR-OSL age of sands from a depth of 2.1 m from the edge of the terrace scarp is 6.0 ± 0.4 ka

(RLQG 2644–060). By analogy with the deposits of the high floodplain, the alluvium of the upper part of the first terrace is synchronized with the deposits accumulated in the Lena delta 6000–7000 BP, when the sea level was higher than present time.

Nearby at the Dyanyshka River there is the outcrop 3051 of the 2nd terrace of the Lena River. The exposure is a sandy-silty strata with separate layers of plant remains. Relative height of the terrace is 18–20 m (20–23 m above the Lena River). The results of radiocarbon dating indicated that it was formed in the end of the Late Pleistocene: the radiocarbon age of the twigs sampled at a depth of 6 m below the edge of the terrace is 12030 ± 110 BP (LU-9399). A peat bog was found 600 m downstream on the surface of this terrace. It occupies the upper part of the outcrop 3052, it has a thickness of 4.2 m, and it extends along the bank of the Dyanyshka River for 30 m (fig. 3). The results of radiocarbon dating indicated that the main part of its sequence was formed in the period from 9710 ± 60 BP (LU-9400, the sample from the peat bog bottom) to 5740 ± 50 BP (LU-9041, the sample from a depth of 1 m from the peat bog top). In general, this time interval corresponds to the time of the 1st terrace formation in the Lena River. It should be noted that according to other sources, the peat bog is a bit older – it began to form 12590 ± 300 BP (Siegert et al., 2007).

At the mouth of the Natara River, the outcrop 3031 of a strath terrace 45–50 m high was studied. Its upper part is composed of sandy silt overbank sediments. The IR-OSL age of a sample from a height of 35 m is 68.8 ± 5.6 ka (RLQG 2552–118). But according to M.N. Alekseev, these deposits should have been formed in the second half of the Middle Pleistocene, and the terrace is the 3rd highest in the Lower Lena valley (Alekseev et al., 1962). In addition, we obtained a similar result when dating the outcrop 3049 of the strath terrace 42 m high. It is located 30 km upstream from the mouth of the Dyanyshka River. The IR-OSL age of sand, sampled from a depth of 2 m from the surface, is 64.5 ± 4.5 ka (RLQG 2643–060).

In the lower reaches of the Molodo River (the left tributary of the Lena River), a group of Russian and German researchers drilled and studied the bottom sediments of the Kyutyunda Lake. The underlying alluvium near the contact with lake sediments has been dated to 38–32 thousand years (Biskaborn et al., 2016). The lake is located on the surface of a 40-meter terrace (50 m above the Lena River). This terrace has the same elevation as the terraces at the mouth of the Natara River and the lower reaches of the Dyanyshka River, but its alluvium has been formed much later. It is possible that all these terraces have been formed in the same long time interval, but additional dates are needed to verify this conclusion.

Approximately 3 km downstream from the mouth of the Menkere River on the right bank of the Lena River the outcrop 3029 is located. It is a part of the 4th 60-meter strath terrace, and its alluvium should be of Middle Pleistocene age (Alekseev et al., 1962). We assume that these deposits do not belong to the Lena River, but to its ancient tributary. Investigated well-sorted fine-grained and medium-grained sands with silt interlayers at a height of 33–34 m near the contact with bedrock have the IR-OSL age of 23.6 ± 1.9 ka (RLQG 2544–118). It means that these deposits began to form at the end of the Late Pleistocene.

Middle Pleistocene alluvial deposits of the 80-meter 5th terrace are traced to the northwest towards the lower reaches of the Olenek River in the area of the Siktyakh village and they are associated with the Ajakit-Kelimyar segment of the Lena paleovalley (Zhuravlev, 1960; Alekseev et al., 1962). The existence of a river paleovalley in this area is indirectly indicated by information obtained during the study of the El'gene-Kyuele Lake (Biskaborn et al., 2013). This lake is located presumably within its boundaries, and around the lake there is a specific composition of the ice complex sediments. There are no dates from alluvial deposits in this area.

The oldest known dated deposits formed by the Lena River in its lower reaches were studied in one of the outcrops of the Dyanyshka River valley. The IR-OSL age of the alluvium sample is 325 ka (Zech et al., 2011). The outcrop is confined by an uneven moraine surface (Alekseev et al., 1962) with absolute height of 100–160 m (55–115 m above the Lena River). The known coordinates of the outcrop (Zech et al., 2011), earlier information about the distribution of the Lena terraces in the Dyanyshka River valley, glacial and fluvioglacial deposits (Alekseev et al., 1962), suggest that the right side of the Lena River valley should be located further east than expected.

There is an opinion that the Pleistocene glaciations were one of the most important reasons for the formation of the Lena terraces and the restructuring of the Lena River valley. The center of glaciation was located in the Verkhoyansk Ridge. Glaciers descended from the mountains along the tributaries of the Lena River could reach its main channel, deflect it, and maybe stop the outflow of a stream. The question of the number, age and boundaries of the distribution of glaciers is debatable. According to V.V. Kolpakov, the Lower Lena valley is a complex of several isolated paleovalleys of different ages (Ajakit-Kelimyar, Motorchuna-Ajakit, Sobopol-Siktyach, Linde-Khoruongka segments) (Kolpakov, 1966). Its formation and disappearance was due to the fact, that glaciers shifted the Lena River to the west. He distinguishes 4 stages of glaciation. Three of them occurred in the Late Pleistocene. During the warm epochs that followed them, the 2nd and 1st terraces were formed.

N.V. Kind distinguished 6 stages of glaciation in the region, the last of which had an age of 16–15 thousand years (Kind, 1975). Recent studies indicate the existence of 5 stages of glaciation. They are based on remote sensing and IR-OSL dating of intermoraine deposits in the valleys of the Dyanyshka and Tumara rivers. The age of the most ancient stage is 135–141 ka, and the youngest is over 50 ka (Stauch, Lehmkuhl, 2010). These studies proved that the glaciers had not reach the modern channel of the Lena River since the end of the Middle Pleistocene. However, all known segments of the paleovalleys of the Lena River, the youngest of which is the Sobopol-Siktyach segment, formed by the end of the Middle Pleistocene (Alekseev, Drouchits, 2004).

4. CONCLUSION

The deposits composing the low floodplain have been formed over the past thousand years. The age of the high floodplain deposits is at least 3700 years. The first terrace in the central part of the Lena River Delta has the same age. The first terrace in the area of the mouth of the Dyanyshka River was formed in the first half of the Holocene, and the second terrace was formed by the end of the Late Pleistocene – the beginning of the Holocene.

During the Holocene, the Laptev Sea level repeatedly fluctuated up to a height of 7–8 m above the present level. This is the reason for the accumulation of the high floodplain deposits and thick strata of specific ingressive organic and mineral deposits in the Lena River Delta. Alluvium of the first terrace accumulated 6000–7000 BP for the same reason. The sea level during this period was higher than today. Therefore, the change in the basis of erosion is the main factor of the Lower Lena valley evolution in the Holocene. The relationship between the formation of the first terrace and the glaciation stages in the western foreland of the Verkhoyansk Ridge is not obvious, as noted earlier.

Higher terraces are usually located at a distance from the Lena main channel. Some outcrops of high terraces contain Late Pleistocene deposits. However, according to earlier ideas, they had a Middle Pleistocene age, and the stages of their accumulation were synchronized with the epochs of glaciations. Despite the existing contradictions, glaciations in the region played a key in the formation of highest and older terraces, but additional studies are required to identify their age and relationship with the accumulation of alluvium in the Lower Lena valley.

HOLOCENE AND LATE NEOPLEISTOCENE PALEORECONSTRUCTIONS FOR THE LOWER LENA RIVER VALLEY: NEW DATA, CONTRADICTIONS AND PROBLEMS

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The Lena River with its tributaries is one of the largest river systems in the world. During three field seasons, 18 outcrops of alluvial deposits on terraces of different levels of the Lower Lena Valley from the mouth of the Aldan River to the “Lena Pipe” were studied. Terrace heights were determined using topographic maps, leveling and GPS survey. The outcrops were described in the field with sampling for radiocarbon dating and infrared stimulated luminescence (IR-OSL) method. A total of 26 radiocarbon and IR-OSL ages were obtained. The low floodplain was studied most in detail on the section from the mouth of the Aldan River to the mouth Vilyuy River, where it has a height of 5–6 to 8–9 m. The deposits of the high floodplain in the section between the mouths of the Aldan River and Viluyu River, in the area of the mouth of the Dyanyshka River and in the section between the villages of Siktyakh and Kyusyur were studied. It has a height of 6–10 to 15–16 m. The deposits of the 1st terrace (7–15 m) and 2nd terrace (20–23 m) most in detail in the area of the mouth of the Dyanyshka River were studied. In some areas (the lower reaches of Dyanyshka River, near the mouth of the Menkere River and the mouth of the Natara River), deposits of higher terraces were dated. Investigation and dating of the floodplain and first terraces in the valley of the Lower Lena River confirms that their formation was caused by sea level fluctuations in Holocene and at the end of Late Pleistocene as well as in the Lena River Delta. The results of IR-OSL dating alluvial deposits of 40–60 me terraces contradict the ideas about their age, formed in the 3rd quarter of the 20th century. Glaciations of Verkhoyansk Ridge could not influence to configuration of the Lena River valley as mountain glaciers had not rich the Lena River since the end of Middle Pleistocene.

Keywords: Lower Lena Valley, floodplain, terrace, Holocene, Late Neopleistocene, dating of deposits

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