ISSN 1028-334X, Doklady Earth Sciences, 2007, Vol. 412, No. 1, pp. 77–81. © Pleiades Publishing, Ltd., 2007.
Original Russian Text © S.B. Kuz'min, L.V. Dan'ko, V.A. Snytko, E.V. Bezrukova, L.A. Orlova, 2007, published in Doklady Akademii Nauk, 2007, Vol. 412, No. 1, pp. 107–111.

GEOGRAPHY

New Data on Environments of Cisbaikalia in the Late Holocene

S. B. Kuz'min[a], L. V. Dan'ko[a], Corresponding Member of the RAS V. A. Snytko[a], E. V. Bezrukova[b], and L. A. Orlova[c]

Received March 14, 2006

DOI: 10.1134/S1028334X07010175

New data on changes in late Holocene environments of Cisbaikalia have been obtained based on integrated studies of the mode of occurrence, genetic types, stratigraphy, and data on absolute geochronology and morphology, as well as palynological, chemical, and grain size compositions of paragenetically related loose sediments of key sections in the central part of the western coast of Lake Baikal. The sections are located in piedmont–saddle (the Bezymyannyi section) and floodplain–valley (the Kuchelga section) geomorphological conditions (Fig. 1).

Environments of the Subboreal and Subatlantic intervals of the Holocene were reconstructed based on the analysis of loose sediments of the Bezymyannyi section. The section is located in the water-logged, birch–willow, underbrush (dogrose and currant), and moss–sedge forest in the subaqueous (high floodplain) area between the Kuchelga River channel and the Bezymyannyi Creek at the foothill of the Primorskii Range. The forest is surrounded by petrophyte thin larch forest with stepped herbs and undergrowth (spiraea and cotoneaster), birch, and aspen. The section is located at the foothill–saddle surface (slope 1°–3°) characterized by the minimum influence of gravitational agents of morphogenesis. The basic results of the study of loose sediments in this section are presented below.

The total thickness of the section is 95 cm. Mineralized peat deposits occur down to the depth of 42 cm. A fragment of a buried cedar trunk was found at a depth of 22–32 cm. Five radiocarbon ages have been obtained for this part of the section (table).

[a] *Institute of Geography, Siberian Division, Russian Academy of Sciences, ul. Ulan-Batorskaya 1, Irkutsk, 664033 Russia; e-mail: kuzmin@irigs.irk.ru*

[b] *Institute of Archaeology and Ethnography, Siberian Division, Russian Academy of Sciences, pr. akademika Lavrent'eva 17, Novosibirsk, 664090 Russia*

[c] *United Institute of Geology, Geophysics, and Mineralogy, Siberian Division, Russian Academy of Sciences, pr. akademika Koptyuga 3, Novosibirsk, 630090 Russia*

Interval 78–95 cm. Sediments of this interval accumulated under hydrogeodynamic conditions with a stable regime of atmospheric precipitation, which afforded sand deposition and brought debris of medium roundness during snow melting, indicating a constancy of water flow. Such conditions seem to be typical for the end of the Atlantic interval of the Holocene. We failed to reconstruct paleovegetation due to the lack of pollen in this bed, probably because of the large size of sand grains in this bed (as compared to spore-and-pollen) and their consequent removal.

Bed 69–78 cm. The nature of sediments of this bed implies that the water flow had dried up and revived only in certain years to bring poorly rounded coarse debris, indicating reduced precipitation and higher geodynamic activity. This time interval should be defined as the beginning of the Subboreal interval of the Holocene.

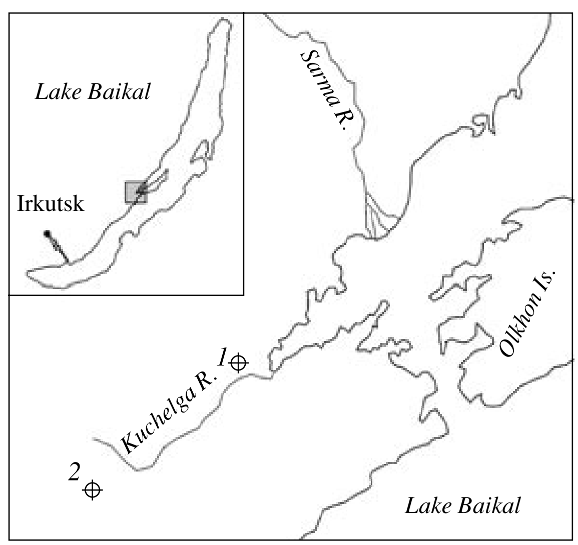

Fig. 1. Scheme of the investigation area. Sections of terrigenous loose sediments: (*1*) Kuchelga, (*2*) Bezymyannyi.

Results of the radiocarbon analysis of sediments from the Bezymyannyi and Kuchelga sections

H, cm	^{14}C age as of the year 1950	Adjusted to the year 2000	Lab. index	v_s, mm/yr
Bezymyannyi section				
8–10	110 ± 5	160 ± 5	SOAN 5941	0.81
20–22	365 ± 30	415 ± 30	SOAN 5940	0.47
28–30	885 ± 30	935 ± 30	SOAN 5939	0.15
32–34	1040 ± 60	1090 ± 60	SOAN 5776	0.26
36–38	1360 ± 25	1410 ± 25	SOAN 5938	0.15
Kuchelga section				
1–2	130 ± 55	180 ± 55	SOAN 5425	0.15
8–9	315 ± 90	365 ± 90	SOAN 5426	0.38
14–15	915 ± 45	965 ± 45	SOAN 5427	0.10
20–21	1460 ± 90	1510 ± 90	SOAN 5428	0.11
33–34	2290 ± 90	2340 ± 90	SOAN 5429	0.16
41–42	4525 ± 50	4575 ± 90	SOAN 5430	0.04

Note: Calculation of age is based on the half-life period of ^{14}C equal to 5570 yr. (H) Sampling depth; (v_s) sedimentation rate.

Bed 59–69 cm. Sediments of this bed accumulated under different conditions. The amount of moisture increased, but it was irregular throughout the years that showed up in differentiation of sediments. Coarse material of medium roundness was delivered during snow melting and rainfall, whereas medium and fine grus accumulated during the remaining time.

Bed 42–59 cm. The grain size analysis of sediments from this bed (Fig. 2) indicates that floods became less significant (in terms of water volume and duration), and the water flow was stable between the floods. These sediments began accumulating at the end of the Subboreal interval of the Holocene.

In general, sediments within the depth interval of 42–69 cm accumulated during lower flood parameters (water volume and duration). Moreover, sediments within the depth interval of 42–95 cm fit the channel facies of alluvium.

Bed 36–42 cm. The composition of this bed (peat loam) indicates that the landscape–hydrological and sedimentation environment changed in the course of leveling of the water flow regime. Sediments began to accumulate in a floodplain at some distance from the primary water flow. Loose sediments could be washed out and the coarse-clastic material (poorly rounded lumps and debris) could be brought during extremely intense floods, as indicated by a wavy boundary with the underlying bed. Charcoal inclusions indicate the involvement of fire. The radiocarbon age of 1410 ± 25 ^{14}C yr B.P. (table) allows us to identify the bed with the first half of the Subatlantic interval of the Holocene.

Bed 30–36 cm. Accumulation of sediments of this bed was marked by two remarkable changes in the environment: (1) alignment of the climatic regime and uniform content of moisture throughout the year; (2) change in the hydrological regime and shift of sedimentation regime to the peripheral part of the valley. Both factors provided the accumulation of mainly sandy–loamy peat deposits. The subordinate debris and grus were delivered from adjacent slopes, as indicated by their angular shapes. The sediments were deposited in a stable floodplain facies. Simultaneously, the drift of sediments from slopes became activated. Sediments of this bed accumulated at the beginning of the second half of the Subatlantic interval of the Holocene (1090 ± 60 ^{14}C yr B.P.).

Bed 0–30 cm. Sediments of this interval in the Bezymyannyi section accumulated during the last 900 yr

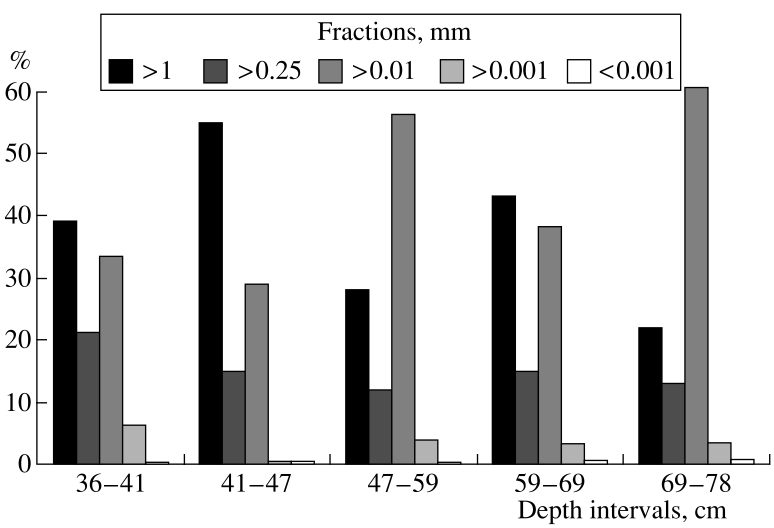

Fig. 2. Grain size composition of fine-dispersed fractions of loose sediments from the middle part of the Bezymyannyi section.

(see table for ^{14}C dates). The sedimentation rate constantly increased and reached the maximum in the past 100 yr (Fig. 3).

The reconstruction of paleovegetation in the Bezymyannyi section area is based on palynological analysis of ten samples of loose sediments described above. All the samples studied include abundant and diverse species spectra (Fig. 4).

The diagram is subdivided into three palynostratigraphic zones based on changes in the content of pollen of individual taxons in spectra. All spectra are characterized by the prevalence of wood plant pollen (45–92%) mainly represented by pollen of *Pinus sylvestris*, which indicates the predominance of light coniferous–taiga forests in the region during the whole sedimentation period of the section. Vegetation of this kind formed in the Lake Baikal basin after 5500 yr B.P.

Palynostratigraphic zone 3 comprises spectra of three lower samples obtained from the depth interval 26–38 cm. The age of sediments is 1360–885 ^{14}C yr B.P. In the Holocene climatic–stratigraphic scale, this interval is consistent with the Medieval warm period (1600–900 yr B.P.) [6]. The trend of natural climatic changes was not similar in different regions of the Northern Hemisphere. Judging from the palynological records of the Bezymyannyi section, the climate of the Baikal western coast was slightly warmer in winter and more humid relative to the present-day climate, as evidenced by a wider expansion of cedar taiga forests with fir. The area was dominated by overdamped willow–herb–sedge associations similar to those in overgrown floodplains. The slight expansion of xerophyte goosefoot–herb associations 880 yr B.P. might be caused by fires (presence of pollen of the family Onagraceae), which promoted the growth of goosefoot and Compositae in open spaces, or by a very short period of aridization.

The spore-and-pollen composition of palynostratigraphic zone 2 characterizes a short interval (880–350 yr B.P.) of climate cooling and humidity most likely due to a decrease in the effective evaporation. This environment fostered the expansion of valley spruce forests, the appearance of dwarf birch (*Betula nana*), and xerophyte wormwood–herb associations on steep slopes. This time interval characterizes a considerable part of the Little Ice Age [7]. The multiple reduction of floodplain willow–herb–sedge associations was most likely related to a decrease in the base level and, hence, local damping.

The spore-and-pollen composition of palynostratigraphic zone 1 (350–110 yr B.P.) indicates a considerable reduction in the area of taiga forests and expansion of pine–larch and larch forests with birch. Steppe associations are mainly represented by wormwood–herb associations with lycopods on rocky slopes. A sphagnum bog, mainly of atmospheric alimentation, with willow and underbrush of the Rosales family existed in the region. Such a wide development of pine–larch and larch–birch forests in the region, especially over the past 300 yr, during the expansion of steppes (mainly, xerophyte associations) in the central part of the western Baikal coast is a cumulative consequence of large fires in the region every 40–50 yr [2], economic activity, and secular climatic fluctuations.

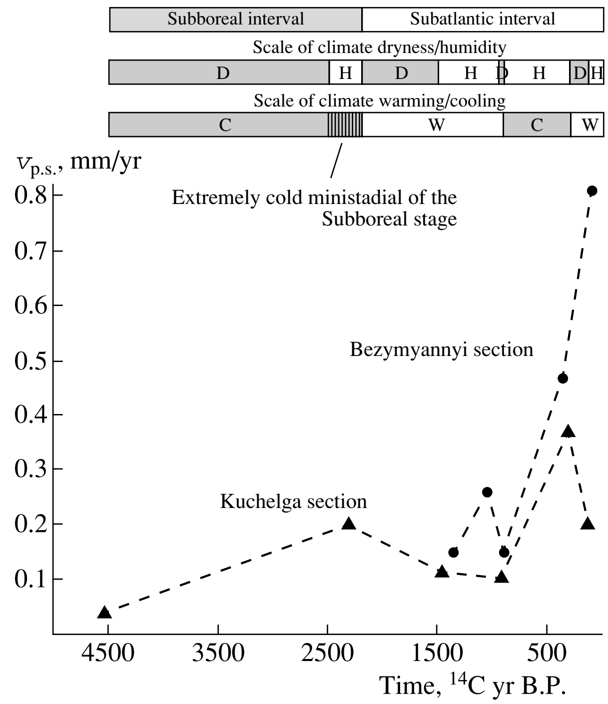

Fig. 3. The peat sedimentation rate ($v_{p.s.}$) and the correlation scale of heat and moisture contents in landscapes in the late Holocene of Cisbaikalia (based on the Bezymyannyi and Kuchelga sections). (H) humid; (D) dry; (C) cold; (W) warm.

In terms of the sedimentation rate, the Bezymyannyi section is comparable to the Kuchelga section (Fig. 3), for which we obtained six radiocarbon dates (table). Accumulation of peat deposits in the Kuchelga section region began much earlier (~4600 yr B.P.), but the process was inactive at the beginning (0.04 mm/yr). It is only after 2300 yr B.P. that the rate increased to 0.2 mm/yr, which may be regarded as a regional value comparable with present-day rates. In [1], we reconstructed evolutionary and dynamic changes in vegetation based on the palynological record of the Kuchelga section. Therefore, we will not dwell here on this subject.

The radiocarbon dating and palynostratigraphy of the peat sequence from the Bezymyannyi and Kuchelga sections provide insight into features of sedimentation during variations in thermal and hydrologic conditions of landscapes in Holocene Subboreal and Subatlantic environments in Cisbaikalia.

Regional peculiarities of the environments were such that variations in the environment were mainly governed by dryness of the climate [3]. This parameter regulated decrease in the peat formation rate. As a

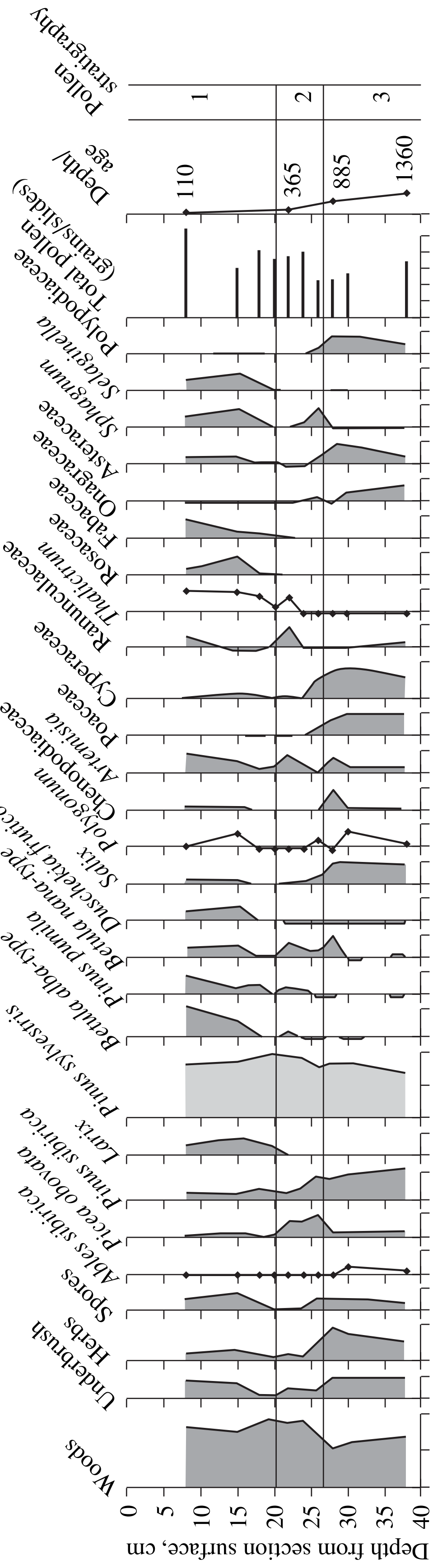

Fig. 4. Spore-and-pollen diagram of the Bezymyannyi section.

result, peaks of peat formation fall on the transition from dry to humid climatic periods rather than from cold to warm periods (Fig. 3).

Sedimentation in the Subboreal interval was also affected by geodynamic activity, which resulted in the rise of the territory and decrease in the water level of Lake Baikal. This is confirmed by the detection of beach ramparts and other offshore landforms beneath the water [4]. The uplift was followed by drainage of the high floodplain, which hosted the studied peat deposits.

The beginning of the Subatlantic interval was accompanied by the stabilization of geodynamic processes and formation of the low floodplain of present-day river valleys. On the Baikal coast, present-day beach ramparts overlap sediments of the first terrace of Lake Baikal, indicating a gradual rise of the lake water level over the past 2000 yr [5].

Sudden activation of peat formation on the high floodplain and low terraces (the Kuchelga section) began 2200 yr B.P. The peat accumulation rate increased progressively and reached the maximal value (0.38 mm/yr) in the late Holocene at the end of the Little Ice Age ~300 yr B.P. Active peat formation in upper courses of rivers (the Bezymyannyi section) began slightly earlier than 1400 yr B.P., but the sedimentation rate reached 0.50 mm/yr at the end of the Little Ice Age and 0.80 mm/yr after 100 yr B.P.

Thus, detailed reconstructions and their correlation with the geochronological scale based on the radiocarbon dating yielded a model of the evolution of environment in Cisbaikalia over the past 2300 years. The results of integrated studies of the paragenetic series of loose sediments from the Bezymyannyi and Kuchelga sections demonstrate that the late Holocene environment of Cisbaikalia underwent principle variations at the beginning of the Subatlantic interval (2900 ± 90 ^{14}C yr B.P.), in the second half of the Medieval Optimum (1410 ± 25–1040 ± 60 ^{14}C yr B.P.), and in the Little Ice Age (885 ± 30–365 ± 30 ^{14}C yr B.P.). The period of the last 500–100 yr is characterized by intensification of the trend of substitution of light coniferous–small-leaved forests for taiga fir–cedar and spruce forests. This is a consequence of human impact superimposed on climatic variations in vegetation. Under severe continental conditions, peaks of the peat formation rate mark not only the transition from a cold climate to a warm one, but also from a dry climate to a humid one. Processes of peat formation were also affected significantly by geodynamic processes that govern changes in the erosion base.

REFERENCES

1. E. V. Bezrukova, L. V. Dan'ko, V. A. Snytko, et al., Dokl. Earth Sci. **401**, 303 (2005) [Dokl. Akad. Nauk **401**, 100 (2005)].
2. V. I. Voronin and R. G. Shubkin, Pozharn. Bezopasnost, No. 4, 110 (2005).
3. L. V. Dan'ko, Geograf. Prirodn. Resursy, No. 4, 48 (2005).
4. A. A. Rogozin, Geograf. Prirodn. Resursy, No. 1. 69 (1992).
5. A. M. Sizikov, in *Modeling and Programming of Geophysical Processes* (Nauka, Novosibirsk, 1987), pp. 36–39 [in Russian].
6. I. Kalugin, V. Selegei, E. Goldberg, and G. Seret, Quatern. Int. **136**, 5 (2005).
7. R. Moritz, C. Bitz, and E. Steig, Science **297**, 1497 (2002).