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First results of study of Lake Baunt bottom sediments (*northern Transbaikalia*)

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Abstract

In March 2014, the Lake Baunt bottom sediments were drilled in the deepest part of the lake basin (33 m). The penetrated interval is 13.7 m thick, with the age of the base being evaluated at 28–30 ka. Lithological study of the penetrated sediments demonstrates the upper part of the section dominated by diatom ooze, whose concentration decreases gradually downward the section, up to the replacement of the ooze by silty clay. The obtained data on variations in petromagnetic parameters, concentration of biogenic silica, and sediment compaction indicate considerable variations of sedimentary environments during the Late Pleistocene and Holocene. Being compared with the previously reconstructed landscape and climate dynamics for the sedimentary succession of Lake Kotokel for this time interval, the above parameters reveal that the Lake Baunt bottom sediments reliably fix the regional paleoclimate signal. For the first time for lakes of the Baikal region, Gothenburg and Mono Lake magnetic excursions are identified in the paleomagnetic record of the Lake Baunt section.

Keywords: Transbaikalia; lacustrine sediments; Pleistocene; Holocene; paleoclimate; paleomagnetism; excursions; lithology

Introduction

Nowadays, a special attention of many working groups is focused on study of sediments of lakes within the Lake Baikal region, both large (Baikal, Hövsgöl) (Bezrukova et al., 2004; Hövsgöl Drilling Project Group, 2007) and small (Dukhovoe, Arakhlei, Kotokel, etc.) (Bezrukova et al., 2011; Mackay et al., 2013; Reshetova et al., 2013) ones, because of the unique continuous sedimentary successions, accumulated during several thousand to several million years. Data derived from its detailed investigations improve our understanding on environmental variations of the Lake Baikal region through time.

Most of the previously studied lakes are localized on latitudes of central and southern basins of Lake Baikal. These objects include lakes Tsagan-Tyrm (Sklyarov et al., 2010), Namshi-Nur (Solotchina et al., 2011), Khall (Mackay et al., 2013), Ochki (Leonova et al., 2015), Kotokel (Bezrukova et al., 2010; Leonova et al., 2015; Tarasov et al., 2009), Chernoe and Dukhovoe (Tarasov et al., 2002), and Arakhlei (Reshetova et al., 2013). The great majority of these lakes are dated as <14 ka. It is only a core of the Lake Kotokel bottom sediments that provided a base for detailed continuous landscape, diatom and climate reconstructions for the last 48 kyr, unique for the Lake Baikal region (Bezrukova et al., 2010). However, none of the cores from these lakes has been paleomagnetically investigated. This method has been applied only for bottom sediments of Lakes Baikal and Hövsgöl (Bezrukova et al., 2004; Hövsgöl Drilling Project Group, 2007). In this paper, we report this method applied for the Lake Baunt sediments. A sedimentary reconstruction of Lake Baunt herein proposed provides a reliable and innovative data, since it documents 30 kyr of the Lake Baikal region geological history, and is based on petromagnetic data, for the first time derived for the small fresh lakes of the Lake Baikal region. Another key importance of this reconstruction is determined by the first documented environmental evolution of intracontinental territory of northern Transbaikalia, situated 200 km eastward Lake

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Baikal and northward the latitude 55° N, within the permafrost area.

Geomorphological characteristics of Lake Baunt

Lake Baunt occurs on the north of the Republic of Buryatia, 1060 m above the sea level (Fig. 1). The lake is 17 m in average depth (the maximum depth is 33 m), 19 km in maximum length (elongation SW–NE), 9 km in maximum width, and has an area of 111 km^2. It has two main tributaries (Verkhnyaya Tsipa and Tsipikan Rivers) and feeds the Nizhnyaya Tsipa River.

Lake Baunt has a tectonic origin (Shchetnikov, 2007). The overall bottom morphology of Lake Baunt corresponds to a subaerial relief of its rift basin, and the isobath contours answer the coastline. However, it carries one important structural element—the maximum depth zone lays southeastward from the geometric center of the lake. It confronts with a morphological asymmetry of the basins within the Baikal Rift Zone, which usually has a half-graben morphology with a zone of maximum rate of tectonic settling (and consequently—the deepest part of the basin) being associated with the fault zone. In contrast, Lake Baunt has an opposite morphology, revealing the 'abyssal' zone to be displaced from the foot of the steep fault plane of inclined horst to the opposite gently-inclined slope of the domal uplift. At the same time, the lake itself is 'pushed' into the slopes of the horst, and actively ingresses into it, filling the corners where the basin enters the horst. The coastline here is morphologically 'immature', completely corresponding to the topography of the subaerial relief. At the same time, accumulative plains, bordering the lake on east, carry distinct morphological elements of lake aggradation—12 ancient beach ridges (up to 2.5 m in height, and up to 40 m in width).

All these aspects indicate active recent geodynamics of the Baunt basin, and tectonic activity among the blocks of its basement.

Methods

Location of the well. In November 2013, a bathymetric survey with Hummingbird Matrix 748 × 3D 6-beam echo sounder was performed for Lake Baunt. The map developed is shown on Fig. 1. Localization of the drilling site is determined by its maximal remoteness from the coast, that gives the most regular sedimentation rates. The place chosen exhibits the maximum depth at 33 m.

Drilling. The UWITEC gravity corer (Austria) with hammer action and inner PVC liner at 63 mm in diameter was applied. In March 2014, the drilling unit was rigged up on ice of Lake Baunt (55°11′15″ N, 113°01′45″ E). Three days of drilling have extracted a 13.7 m-long core in 8 liners. The core recovery is 95%.

This drilling experience suggests March to be the most suitable for this type of works on lakes, similar to the Baunt lake, because of the ice thickness being maximal (up to 2 m) and lack of the ice movements.

Biogenic silica concentration. SiO_{2bio} was measured through the core with a 5-cm step using a standard technique (Mortlock and Froelich, 1989), that involves sediment dissolving and following spectrophotometry analysis (UNICO 1200/1201) of the suspension with ammonium molybdate color reaction. The results obtained are shown on Fig. 2.

Physical properties of the bottom sediments. Sediment wetness, density, and volume density of dry sediment was measured through the core with 1-cm step, applying commonly used methods (Baikal Drilling Project Members, 1995; Bezrukova et al., 2004). 1365 samples comprising 1 cm^3 of the sediment were analyzed. All the samples were weighed on OHAUS Explorer scales, and then dried at 60 °C for three days. The dry samples were also weighed.

Radiocarbon dating. The core was dated in the Poznan Radiocarbon Laboratory (Poland): seven AMS^{14}C dates on sediment bulk organic fraction were obtained for the core depth intervals 200, 400, 600, 800, 950, 1110, and 1150 m, respectively. The radiocarbon ages obtained were converted into the calibrated ages, applying the INTCAL 13 calibration curve (Reimer et al., 2013). Calculations of the calibrated ages were performed with OxCal 4.2 (Ramsey, 2009).

Paleomagnetic and petromagnetic study. The oriented samples for paleomagnetic study were collected through the core with a 5-cm step (259 samples). Accordingly the age model further proposed, 99 of these samples belongs to the Holocene deposits, and 160 samples correspond to the Pleistocene interval, including 115 samples from MIS 2 interval and 45 samples—from MIS 3. 18 more samples were later collected from three intervals (6 samples per interval) with a 2-cm step to verify the excursions early obtained.

The paleomagnetic study was performed on AGICO JR-6 spinner magnetometer. The sample demagnetization was carried out in magnetic vacuum, produced by a self-made device. The sample magnetization was done in the Earth's magnetic field. Magnetic susceptibility was measured on a KLY-2 meter.

Natural remnant magnetization (NRM) was measured for all studied samples. To estimate the validity of the Lake Baunt bottom sediments for the paleomagnetic study, 25 samples were detailed stepwise demagnetized with an alternating magnetic field (2, 5, 10, 15, 20, 30, 40, 50, 60, 80, 100 mT). The rest of the samples were demagnetized with the alternating magnetic field (10, 20, 40 mT). Applying the same magnetic field values, the samples were remagnetized in the Earth's magnetic field (along the z-axis (parallel to the core) and vice versa). Considering these data, the anhysteretic remanent magnetization (ARM) was calculated for three values of the alternating magnetic field.

Results

The absolute radiocarbon ages obtained for all seven studied intervals are shown in Table 1. Further we give all the ages in calibrated values. Considering a linear interpolation