View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Kazan Federal University Digital Repository

VOLCANIC ACTIVITY WITHIN THE JOM-BOLOK RIVER VALLEY (EAST SAYAN MTS., BAIKAL REGION) DURING THE LATE GLACIAL-HOLOCENE: THE FIRST CONTINUOUS TEPHROCHRONOLOGICAL RECORD FROM LAKE SEDIMENTS

Shchetnikov A.A.[1,2,3], Bezrukova E.V.[2,3,4], Filinov I.A.[1,2,3], Kerber E.V.[2], Belozerova O.Yu.[2], Krainov M.A.[2,3], Ivanov E.V.[2]

[1]Institute of the Earth's Crust SB RAS, Irkutsk, Russia
[2]Vinogradov Institute of Geochemistry SB RAS, Irkutsk, Russia
[3]Irkutsk Scientific Centre SB RAS, Irkutsk, Russia
[4]Institute of Archaeology and Ethnography SB RAS, Novosibirsk, Russia

Lava flows and volcanoes of the Jom-Bolok River valley represents the largest manifestation of Holocene eruptions in Central Asia. The overall volume of the erupted products has been estimated (Yarmolyuk et al., 2003) to be 16 km^3. Detailed data of the structures, compositions, sources and effusion principles of the valley lava flows are available (Yarmolyuk et al., 2003; Ivanov et al., 2011). However, their chronological order has not yet been reliably reconstructed. It is only known that the volcanic events were multiphase (Yarmolyuk et al., 2003) and began during the Pleistocene-Holocene transition and lasted until the last millennium (Arzhannikov et al., 2017).

In 2015, during field studies performed in the Jom-Bolok River valley, we carried out a detailed survey of the bottom relief of the water basin and compiled its bathymetric map. The drilling point was placed in the profundal zone of the basin. The coring point reached a water depth of 6,5 m. Bottom sampling was carried out by using inflatable boats with a UWITEC (Austria) gravity core sampler with an inner liner with a diameter of 63 mm. The cross-section of the bottom sediments was completely penetrated, up to the underlying glacial sediments.

The distribution of absolute age values along the core depth (Fig. 1) demonstrates the absence of inversions and an almost linear trend of increasing age along the core depth. The core lithology and age model suggest that the uninterrupted accumulation of sediments occurred over the last 14290 years, as well as the absence of cryoturbation in the bottom sediments, which occurs when the water basin freezes completely.

Samples from the tephra horizons contain microparticles of volcanic material, which are present as both pure glass without inclusions and as glass with fine-grained mineral inclusions of two types: 1 – xenomorphic glass with dust-like inclusions of fine-grained minerals, and 2 – vitreous masses with low degrees of crystallization, including micrograins of quartz, plagioclase, olivine, pyroxene and dust-like inclusions of ore material. X-ray spectral microanalysis results showed that crystalline mineral grains are represented by brown olivine, green pyroxene, and colourless plagioclase and quartz grains.

The maximum content of pyroclastic material was discovered in the lower part of the studied section, ranging from 150 to 138 cm (Fig. 1). Higher along the section, from 138 to 52 cm, the content of pyroclastic material drops to singular occurrences. In the interval ranging from 10-5 cm, the amounts of microtephra glass shards again increase considerably; in the upper 5 cm of the sediments, only rare microtephra shards can be found.

As a reference event, we chose the eruption that occurred ca. 6280 BP, which is related to the formation of the Khara-Nur lava-dammed lake in its modern shape (Bezrukova et al., 2016). At that time, considerable amounts of pyroclastic material entered the Kaskadnoe-1 lake sediments. Its peak content in the studied samples, which formed ca. 6280 BP, was chosen as a minimal benchmark signal, marking the occurrence of the volcanic eruption in the Jom-Bolok river valley. Lower microtephra contents were considered to be baseline values and were thus excluded from the statistical analysis. Undoubtedly, part of this pyroclastic material was brought into the lake after the ash falls due to the rainwash in the catchment basin, thus causing the overall volcanic material "contamination" of the lake sediments. Although this circumstance does not considerably affect the distinction of volcanic events, it can have a negative impact on the chronometric reconstruction of separate eruptions, as it appears to increase the duration of the "volcanic" signal in the sedimentary chronicles of the lake.

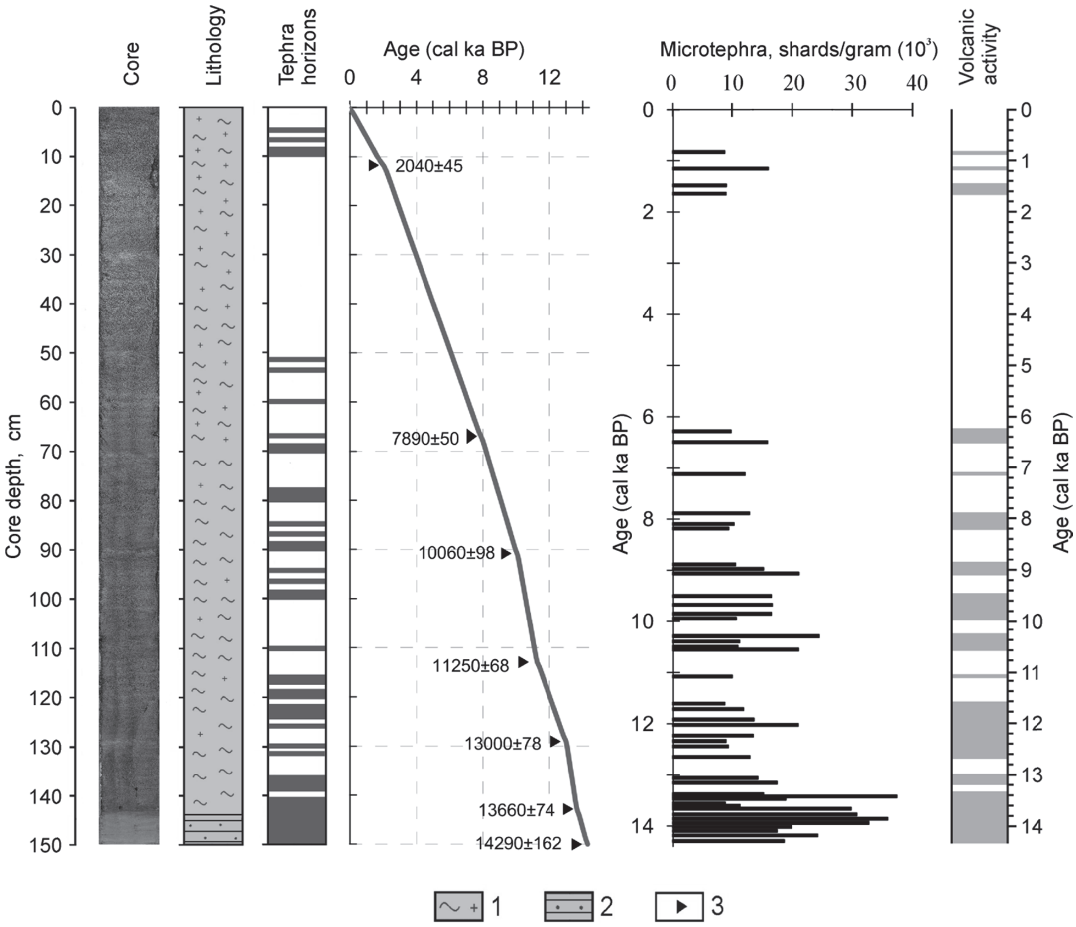

Fig. 1. Tephrostratigraphy of the Kaskadnoe-1 lake sediments and the timing of volcanic activity in the Jom-Bolok River valley. 1 – Biogenous-terrigenous silt with diatomic algae, 2 – silty blue clay of the periglacial lake sediments, 3 – sampling points for AMS C^{14} dating

The first phases of eruptions occurred in the presence of glaciers within the upper valley. Tephra was depositing on them and a part of volcanic matter could gradually arrive to the Cascade Lakes system with ice melt during the final stage of deglaciation. We are to ask ourselves: if that could result in considerable contamination of sediment record by microtephra from earlier eruptions? Maximum peaks of the tephra content in the base of studied section of the lake sediments, seemingly lead to such assumption. However, Lake Cascadnoye-1 has no direct fluvial feed. Watercourses that drain the valley upper parts do not fall into it, and this was one condition of importance to choice this object for tephrostratigraphic studies. If the volcanic matter from the ice tephra horizons fell finally into the Lake Cascadnoye-1 their volume could not be substantial. The rainwash is of greater importance here, but the volcanic glass particles are quickly destructed herewith.

The highest concentrations of microtephra particles are located in the layer of silty clays formed between 14300-13770 BP; high amounts of microtephra are typical for the lower layers of these biogenous-terrigenous silts (13770-13300 BP). Obviously, the most widescale volcanic events occurred ca. 14300-13300 BP, when eruptions occurred almost continuously and the explosive activity reached its maximum development.

The age of 13300 BP represents the start of the weakening intensity of explosive activity, which is marked by the lesser inflow of microtephra shards into the lake sediments. However, these eruptions still continue, with few interruptions, until 6280 BP. In total, from 14300 to 6280 BP, 10 groups of microtephra enrichment peaks can be distinguished in the sediments of Lake Kaskadnoe-1. The detailed age model allows us to calculate the average interval between the eruptions during this time; these calculations yield an average interval length of 500-600 years.

The Lake Kaskadnoe-1 sediments, which accumulated between 6280 and 1600 BP, contain only rare microtephra shards, which can probably be related to a period of relative quiescence in the volcanic activity of the Jom-Bolok region. New microtephra enrichment peaks are fixated in the upper part of the exposed section of the Lake Kaskadnoe-1 sediments, suggesting that volcanic activity was reinitiated in the Late Holocene. These peaks reach maximal values in the sediments formed ca. 1150 BP. According to these acquired dates, therefore, the last volcanic events occurred approximately 800 years ago. At that point, it seems, a modern stage of volcanic quiescence began in the Jom-Bolok River valley.

The correlation of eruption dates, sediment density and wetness variations in Lake Kaskadnoe-1 between 14300 and 6280 BP show that there is no considerable dependency between the changes in the physical properties of the sediments and the eruptions that occurred in the Jom-Bolok region. After 6500 BP, the MS values increased several times with increasing sediment density, but this occurred during the long period of stillness in the regional volcanic activity.

The last volcanic activity peak, which is recorded in the Lake Kaskandoe-1 sediments ca. 1600-800 BP, could probably have been the reason for the short-term decrease in the bioproductivity of the lake system.

Thus we acquired the first and, to date, most complete record of volcanic activity in the Jom-Bolok River valley. This record represents the longest of the currently known, reliably dated sequences of Holocene eruptions in North Asia and unites the results of previous studies of microtephra shards, the physical and chemical properties of bottom sediments, and their AMS ^{14}C ages. The lithological structure of the exposed section of the bottom sediments of Lake Kaskadnoe-1 and their reliable age model allow us to state that, at least during the late ice age period, which began 14300 years ago, the upper reaches of the Jom-Bolok River valley (at an altitude of 2080 m above sea level) were clear of glaciers and that the formation of glacial lakes occurred there.

The analyses conducted here allow us to identify distinct phases of the intensification of explosive activity in the Jom-Bolok River valley. However, due to the peculiarities of the local, Hawaiian-type eruptions, these effusive phases could have been longer or more numerous.

The study was performed by RSF (grant No. 16-17-10079, tephrochronology), RFBR (Grant 16-05-00586) and the Integration program No. 0341-2016-001.

REFERENCES

1. Arzhannikov S.G. Age of the Jom-Bolok lava fields according to dendrochronological and radiocarbon data // Russian geology and geophysics. – 2017. – Vol. 1. – P. 27–47.

2. Yarmolyuk V.V. The structure, composition, sources and mechanism of Jombolok valley lava flows (Holocene, South-Baikal volcanic area) // Vulkanologiya i Seismologiya. – 2003. – Vol. 5. – P. 41–59 (in Russian).

3. Bezrukova E.V. First Data on the Environment and Climate Change within the Jom-Bolok Volcanic Field (Eastern Sayan Mountains) in the Middle-Late Holocene // Doklady Earth Science. – 2016. – Vol. 468. – P. 527–531.