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NOTE

Paleolimnological studies on the East European Plain and nearby regions: the PaleoLake Database

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Abstract The PaleoLake Database contains available information on the lithostratigraphy, biostratigraphy and chronostratigraphy of bottom sediments from numerous lakes located on the East European Plain and nearby regions. The database includes results from more than 70 years of paleolimnological investigations, with information on deposits from 287 water bodies. The compiled data were published mainly in Russian and come from more than 145 monographs, journal articles, dissertations, abstracts, reports and other sources that were difficult to access by the broader science community.

Keywords Lakes · Bottom sediments · Paleolimnology · PaleoLake Database · East European plain

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Introduction

Paleolimnological studies are of interest to scientists who study climate dynamics (Steffen et al. 2015; Syrykh et al. 2017; Plikk et al. 2019), landscape evolution (Fritz et al. 2016; Nazarova et al. 2017; Wetterich et al. 2018) and interactions between past climate and human history (Rudaya et al. 2016; Zhilich et al. 2017). In Russia, the time since the 1950s was characterised by active development of paleolimnology (Subetto 2009; Subetto et al. 2017). In light of the ecological problems arising from modern climate warming (IPCC 2014), paleolimnological studies in Russia intensified during the last two decades (Frolova et al. 2013; Subetto et al. 2017). Numerous studies on the histories of the lakes and their surrounding landscapes were undertaken in different regions of the country (Hoff et al. 2015; Palagushkina et al. 2017; Kostrova et al. 2019; Druzhinina et al. 2020). Many of those paleolimnological investigations contain quantitative and qualitative paleoclimate/paleoenvironment reconstructions (Meyer et al. 2015; Biskaborn et al. 2019; Nazarova et al. 2015, 2020).

Databases are important tools for archiving, systematizing and analyzing paleogeographic information and are used routinely in modern science (Sundqvist et al. 2014; Engels et al. 2019; Kaufman et al. 2020). Databases that incorporate such paleogeographic information, such as the Northern Eurasian Paleoecological Database (Binney et al. 2008), the Neotoma Paleoecology Database (Williams et al. 2018) and PANGEA (Diepenbroek et al. 2002), contain a broad range of paleoecological data collected from sites across the globe.

Lakes on the East European Plain (EEP) and nearby regions (Fig. 1), however, are poorly represented in the European databases (Battarbee et al. 2011; Grimm et al. 2018). The EEP is a vast plain that extends eastward from about 25° E longitude. In the northwest, the East European Plain is bounded by the Scandinavian Crystalline Shield, whereas in the southwest it is bordered by the Sudetens and other mountains of central Europe. The EEP is bounded in the southeast by the Caucasus, and in the west, the Vistula River forms the boundary of the plain. The plain covers approximately 4,000,000 km^2 and averages about 170 m asl in elevation (Spiridonov 1971). Bottom sediments from numerous lakes on the EEP, which owe their origin to different processes and possess diverse hydrologic regimes, contain abundant information on Pleistocene-Holocene paleogeography in the region (Subetto 2009). Although a number of paleogeographic studies were carried out across the EEP and adjacent territories, most of the information from the investigations was published in Russian. At the end of the twentieth century, the monograph series "History of Lakes" was published, and included many paleolimnological studies in Russia (e.g. Istoriya … 1990, 1992, 1998). A synthesis of paleolimnological reconstructions of past lake level fluctuations was provided in several publications (Harrison et al. 1996; Tarasov et al. 1996). Paleogeographic databases have been created for very few regions of Russia (Subetto et al. 2017; Grekov et al. 2018). This paucity of information was a motivation for the current study, which systematized and summarized information on lakes of the EEP and adjacent areas, obtained by paleolimnological methods (Subetto and Syrykh 2014; Syrykh et al. 2014), thereby making such information accessible to the broader scientific community.

The PaleoLake Database

Structure

The PaleoLake Database (DB) comprises published information, those of others and our own, obtained during field expeditions and laboratory work carried out during the last several decades. In total, we analyzed more than 145 published sources that contain data on 287 lakes. Related links are provided in the database.

The PaleoLake DB includes morphometric variables for the studied lakes (area, mean and maximum depths), information on lake origin, data from studied sediment core(s) (e.g. core length, time span of the record), results of laboratory analyses (lithology, geochemistry, etc.), paleontological data (pollen, diatoms, macrofossils, etc.), sediment dating (methods, material analyzed, etc.) and references (Table 1).

Geographic coordinates of the investigated lakes were determined using topographic maps and digital images if inconsistencies in the original publications were encountered. Only confirmed and corrected coordinates were included in the PaleoLake DB. Compilation of the DB tables, however, contains additional information on the investigated lakes, which is in strict accordance with the original data.

The morphological variables for the lakes in the PaleoLake DB were taken directly from the original bibliographic sources, or from additional reference material if such information was not available in the original source. Total area data for 52 lakes were not available in the literature, and values for those water bodies were calculated from satellite images, using ArcGIS online (www.arcgis.com). If information on maximum depth of a lake was unavailable, we considered the water depth at the sampling location to be the greatest depth and included that value in PaleoLake DB.

The number of samples examined in each sediment core varied considerably, from three to almost 200. Thirty short sediment cores ($\leq$ 30 cm) were analysed to study recent anthropogenic impacts on the lake

Fig. 1 Locations of lakes included in the PaleoLake Database

Table 1 Main geographical characteristics of the studied lakes

Variable	Max	Min	Mean	Median	SD	Mod
Latitude (°N)	69.63	43.58	61.55	62.25	6.70	69.18
Longitude (°E)	65.75	21.25	32.96	32.51	6.87	33.40
Altitude (m asl)	2425	−21	121	92	218	45
Surface area (ha)	1,787,000	0.05	66,431	140	228,731	5.6
Max depth (m)	230	0.5	9.5	4	20.9	4
Age (cal yr)	117,600	150	8955	9500	8229	11,000

Max maximum, *Min* minimum, *SD* standard deviation, *Mod* the most frequently occurring value

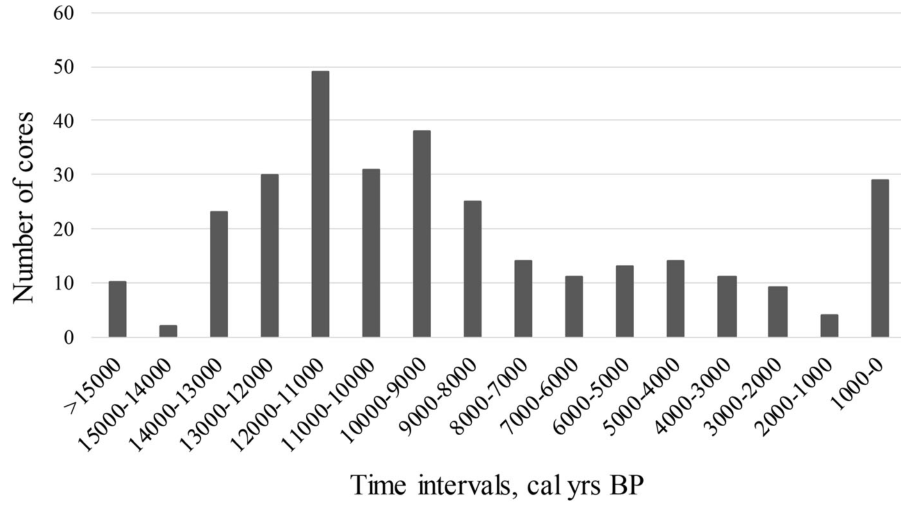

Fig. 2 The number of sediment cores that span specific time intervals. The *x* axis shows time intervals in 1000-year increments. The *y* axis shows the number of sediment cores for which the oldest samples fall in those time intervals

ecosystems. Long sediment cores were used to infer paleoclimate, paleoenvironment, or the long-term history of the studied lakes and the surrounding landscapes.

Complete sediment cores were investigated from 191 lakes. In other cases, only single sediment sections, corresponding to specific time intervals of interest (e.g. the Pleistocene-Holocene transition), were studied.

Sediment cores from 186 lakes were dated by standard radiocarbon analysis. An additional 18 lakes were dated using the accelerator mass spectrometry (AMS) radiocarbon method. The ^{210}Pb dating method was used to develop age-depth relations for 30 short sediment cores. Varve counting was used to estimate age in five sediment cores. Tephrochronology, based on fingerprinting of tephras of catastrophic eruptions, was utilized to date two sediment cores. The oldest sediments, from Lake Ladoga, were dated by Optically-Stimulated Luminescence (OSL). A test version of the PaleoLake Database is available at clck.ru/N5ksZ.

Spatial data coverage

Lakes included in the PaleoLake DB are shown in Fig. 1. The number of sites in different parts of the study area differs considerably and mainly reflects the availability of lakes suitable for paleolimnological study, and their appropriateness for specific research goals. More data are available from the northwestern part of European Russia. Between ca. 110,000 and 11,000 years ago, that area was affected by Pleistocene glaciation (Velichko and Faustova 1986; Mangerud et al. 2004). Today, the NW part of Russia lies within the forest zone, which has a moderate, mostly temperate maritime climate (Klimenko and Solomina 2010). Characteristics of the Quaternary history of this region, including its geology and climate conditions, led to formation of a large number of lakes suitable for paleolimnological studies. Data from other parts of the EEP and neighboring areas are scarce, mainly because of the lack of appropriate sites or paucity of paleolimnological studies.

Temporal coverage

The most frequently studied time interval in lakes from the EEP and adjacent territories is the late Pleistocene–early Holocene transition, from ca. 12,000 to 9000 years ago (Fig. 2). That period marks a time of substantial climate change and the beginning of organic sedimentation in the lakes (Subetto 2009), and was investigated in 83 lakes. The oldest paleolimnological record dates to about 117,600 cal yr BP, and comes from Lake Ladoga (Andreev et al. 2019).

Conclusions

The PaleoLake Database provides access to information generated over the last 70 years from paleolimnological investigations in the East European Plain and nearby territories. It summarizes information from 287 investigated lakes that appears in more than 145 publications. The database reflects the spatial distribution of lakes in the region and their suitability for research objectives. The synthesis of paleolimnological studies included in the PaleoLake DB will help with planning and optimizing future "paleo" investigations. New information will be included in the database as it becomes available.

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