STOP 2: Late-glacial and postglacial environmental changes, Lake Āraiši, Vidzeme Upland

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Palaeoecological records preserved in sedimentary deposits can provide a unique insight into the nature of past ecosystems. Moreover, the rapid fluctuations in climate and environmental conditions during the Late Glacial make this time period an important focus of study (Lowe et al. 1999). Relatively small, closed lakes are sensitive to these changes and integrate information about such variations in the lake basin and its catchment (Seppä et al. 2009). Although studies on the Late Glacial in the eastern Baltic area go back more than a century, focussing on ice-recession lines and chronology (Kalm 2012; Zelčs and Markots 2004; Zelčs et al. 2011), there is a lack of studies based on lake sediments. Thus, uncertainty remains with respect to the relative timing of environmental changes in relation to climatic fluctuation during the Late Glacial.

Lake Āraiši is located (57°15' N, 25°17' E) in central Latvia (Fig. 2.1), on the north-western edge of the Vidzeme Upland, 6 km S of the town of Cēsis, at an elevation of 120.2 m a.s.l. The lake covers 32.6 ha, with a flow-through hydrological regime. It has a mean and maximum depth of 4 and 12.3 m, respectively. The size of the lake's catchment area is ~10 km^2. The surrounding undulating landscape consists predominantly of open fields and meadows.

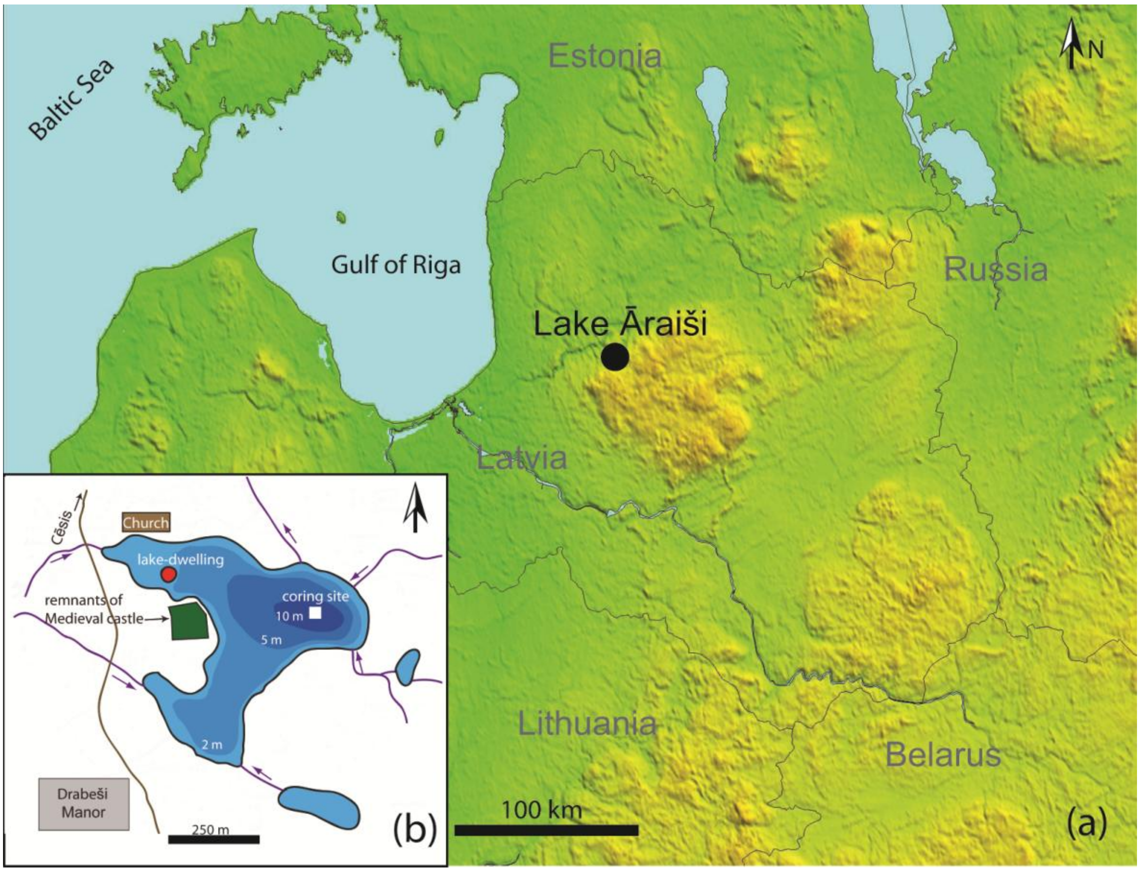

Fig. 2.1. The study area: (a) location of Lake Āraiši; (b) coring site and setting of the lake.

The present-day topography was largely formed during the Late Weichselian glaciation and deglaciation (Zelčs and Markots 2004; Zelčs et al. 2011). In the Lake Āraiši area the bedrock surface of Devonian siliciclastic sedimentary rock is overlain by 80 m of glacial deposits. Although the site is located in the continental-maritime transitional zone, the climate may be characterized as moderately continental. The mean annual precipitation is 700-800 mm, with mean temperatures in January and July of -6°C and +16.5°C, respectively.

Coring for laboratory analyses was undertaken using a 1-m-long Russian-type corer, a 12.4-m-long sediment sequence being recovered at the deepest point of the lake (12.3 m) from the ice-covered surface in March 2012 (See Fig. 2.1 (b) for location). Sediment cores were documented and packed in film-wrapped 1-m plastic PVC semi-tubes. Loss on ignition (LOI) analysis was performed at 2-cm continuous intervals. Samples were dried overnight at 105°C, combusted at 550°C for 4 hours to determine the organic matter (OM) content of the sediment and the ignition residue was estimated as the mineral matter (MM) content of the sediment. Magnetic susceptibility (MS) was measured with a Bartington MS2E meter (Nowaczyk 2001). In addition, pollen and non-pollen palynomorphs were identified. For the purpose of cryptotephra (distal tephra) investigation, sampling for rhyolitic glass shard extraction was carried out as described by Turney (1998) and Blockley et al. (2005). Rangefinder samples were taken at 5-cm intervals. After removal of OM, the samples were sieved, and particles between 25 and 80 μm were centrifuged in sodium polytungstate (SPT) to float rhyolitic shards from the background mineral matrix. Shards were identified optically under a polarizing light microscope.

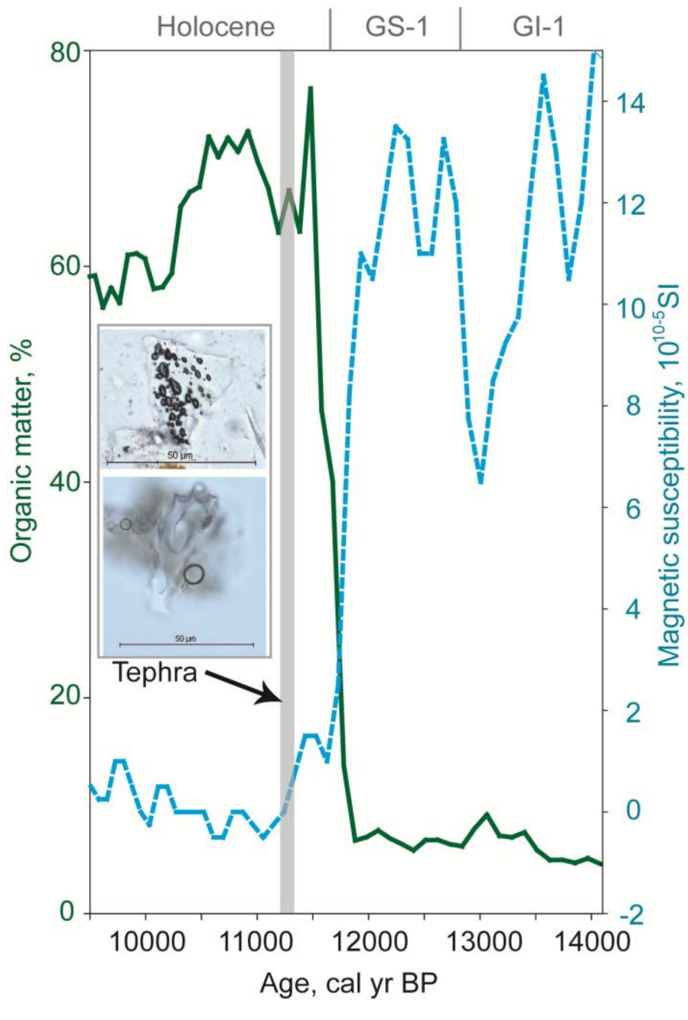

Fig. 2.2. Organic matter and magnetic susceptibility for Late Glacial sequence from Lake Āraiši. Grey vertical line indicates location of microtephra horizon; two pictures of microtephra are given at left.

The chronology for the whole sequence was based on 12 ^{14}C conventional and five ^{14}C AMS dates, and the chronology of the upper part on the distribution of spheroidal fly-ash particles (Rose et al. 1990; Heinsalu and Alliksaar 2009). Samples were dated at the Institute of Geology at the Tallinn University of Technology (Tln) in Estonia and Poznan Radiocarbon Laboratory (Poz) in Poland.

The results revealed that the Lake Āraiši depression was ice-free at least by 14,100 cal yr BP. In addition, macrofossil finds suggest the development of vegetation in the surroundings and the start of OM accumulation in Lake Āraiši from that time onwards (Fig. 2.2). These dates show good agreement with results of regional studies (Amon et al. 2014; Veski et al. 2012) and support the idea of relatively rapid ice retreat from the eastern Baltic. Moderately higher OM and lower MS values indicate changes in vicinity corresponding to the warmer period (Allerød) (Lowe et al. 2008) at the end of GI-1 (Fig. 2.2). Following cooling at GS-1 (Younger Dryas) there was increased inwash of MM into the lake, as also indicated by the elevated MS. Rapid accumulation of OM at the Pleistocene-Holocene boundary indicates major changes in the surroundings of Lake Āraiši. In a study on Lake Lielais Svētiņi (eastern Latvia) Veski et al. (2012) reported an accumulation of OM-rich gyttja and forest re-expansion at the start of the Holocene warming.

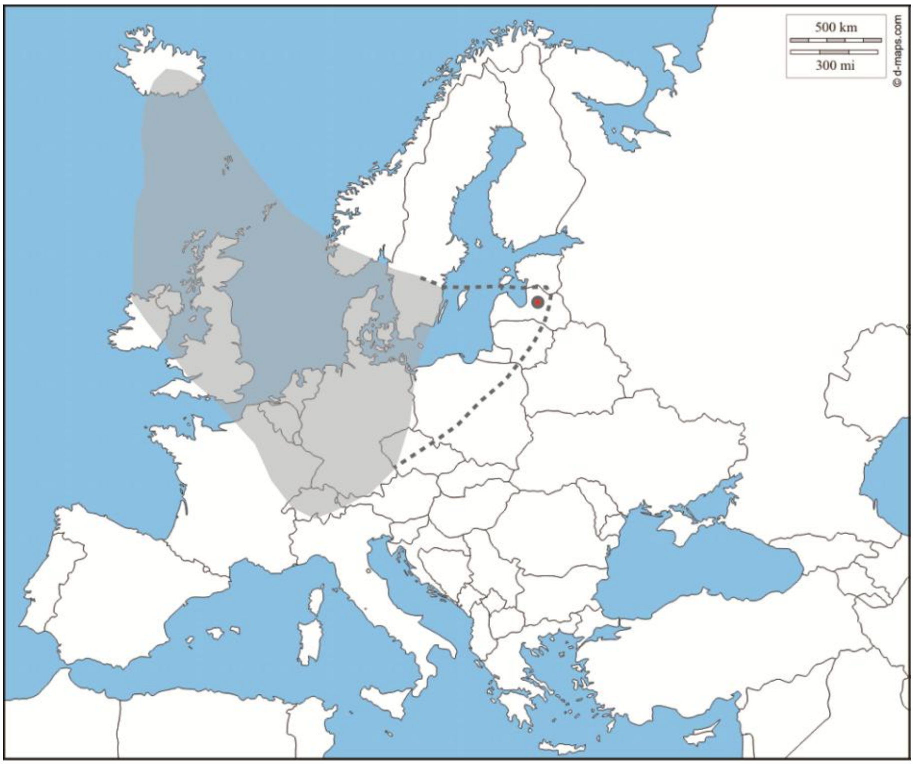

Fig. 2.3. Tephrostratigraphic time-slice map showing the currently known distribution of fallout deposits of the Hässeldalen and Askja tephras. Map redrawn after Lane et al. (2012). Grey shaded area – dispersal envelope of tephra layers; dotted line – possible dispersal of tephra; circle – location of Lake Āraiši.

Furthermore, the finds of microtephra shards (Fig. 2.3) at a depth of 23.40-23.45 m (11,050-11,300 cal yr BP) could be used as a time-marker horizon in future. However, a greater concentration of shards should be obtained and geochemical analyses performed. The Hässeldalen tephra (11,360-11,300 cal yr BP) is the possible source for this tephra. Lilja et al. (2013) point out that, due to several eruptive events and stratigraphical proximity, the 10-ka Askja could be another possible source. Even though there are two possible sources, this discovery offers great potential as a regional isochrone, which could be used to synchronize the chronology and sediment records of the central and northern European deglaciation.

The vicinity of Lake Āraiši was forested and sparsely populated, and the first cereal pollen grains showing human presence appear only at AD 400. During the Migration Period (AD 400-800) new tribal groups may have invaded, building the fortified lake-dwelling in A.D. 780 (Meadows and Zunde in press), associated with the most significant changes in landscape during the last 2000 years. The lake-dwelling was inhabited by Late Iron Age Latgallian tribes. During the early 13th century, the Latgallian territory was conquered by the Order of Swordbrothers (the later Livonian Branch of the Teutonic Order), and the lake-dwelling was destroyed. Nowadays the lake dwelling has been reconstructed and serves as an archaeological open-air museum.

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