

**SEDIMENT FORMATION DURING THE HOLOCENE IN THE  
AIVIEKSTE OXBOW IN THE AREA OF THE ABORA I  
SETTLEMENT**

**NOGULUMU UZKRĀŠANĀS HOLOCĒNĀ AIVIEKSTES VECUPĒ ABORAS  
I APMETNES TERITORIJĀ**

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**Abstract**

Changes in sediment formation can tell us a lot about the palaeogeographical conditions in a given place. In order to contribute information about the conditions of sediment accumulation in the area of Lake Lubāns, studies have been carried out in different places. This study was done in the Aiviekste oxbow, located in the Stone Age settlement area of Abora I. A core U17 was taken and analyses such as Loss on Ignition (LOI), plant macro-remain analysis and sediment dating using AMS <sup>14</sup>C technique were carried out. The results show the process by which this part of the River Aiviekste became an oxbow, quickly becoming overgrown with vegetation. The dates obtained indicate that the process of sediment accumulation was for a time quite rapid, before slowing down. As far as the settlement is concerned, the only evidence of human activity are some fragments of amber in the oxbow. This suggests that the settlement didn't extend to this part of the oxbow.

**Keywords:** *LOI, macro-remains, oxbow, sediment formation*

**Introduction**

The Lubāns Plain is one of the regions of the East Latvian Lowlands and is located in the central part of it, and its hypsometrically lowest part is occupied by Lake Lubāns. This area is characterised by a complex geological structure, extensive wetlands and a hydrographic network. The area around the lake is also characterised by a large number of Stone Age settlements. Due to the complicated geological development of the Lubāns

Plain and Lake Lubāns, palaeogeographical conditions in various places in the area are diverse (Эберхардс, 1985).

Today, the Abora I settlement is located in the Lubāns wetland at an elevation of 92.5 m above sea level (Loze & Eberhards, 2012) and its on the right bank of the River Abora, near where it meets the River Abaine, which in turn flows into the River Aviekste. Archaeologist Ilze Biruta Loze discovered the settlement in 1963 during a survey near Lake Lubāns (Loze, 1964). In the following years many archaeological excavations took place at the site (Loze, 1979; Loze & Eberhards, 2012). As a result, an area of 1311 m<sup>2</sup> was excavated, but the estimated area of the whole settlement is ~5000 m<sup>2</sup>. Today the settlement is located in a meadow.

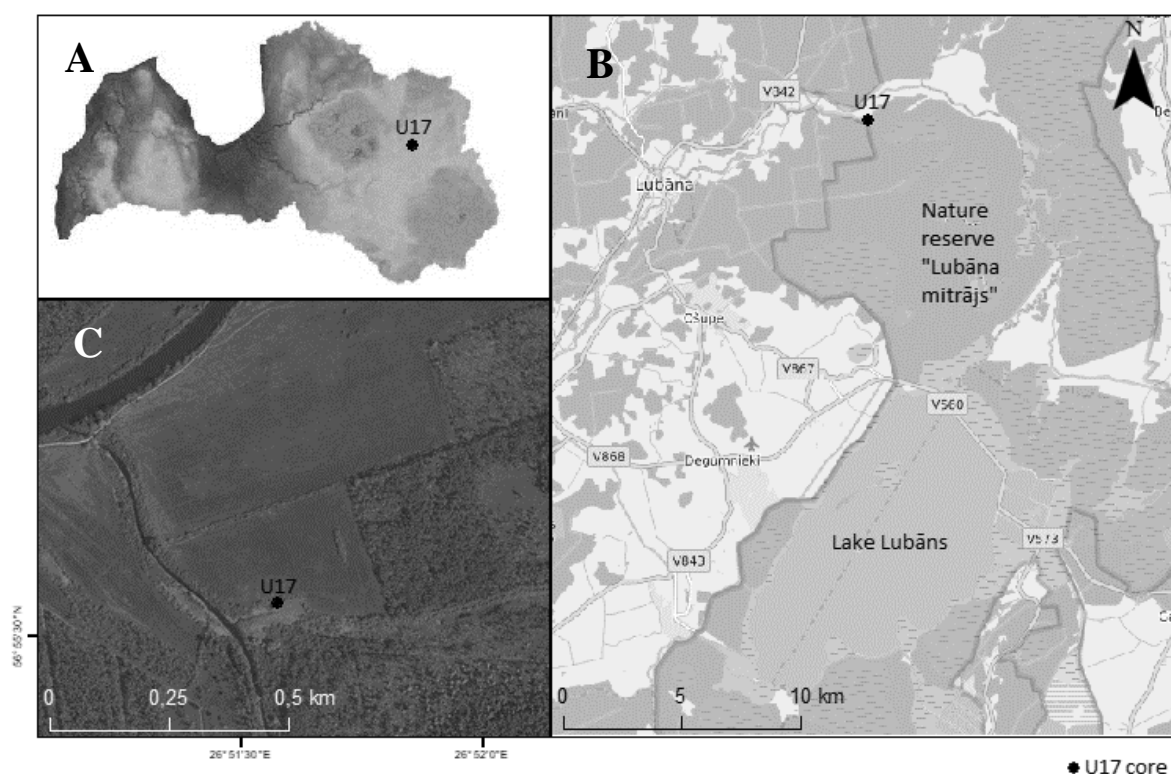


Figure 1. **Location of U17. A – Location of U17 on the map of Latvia. B – Topographic map of the U17 area. C – Location of U17 near the rivers Abora and Abaine** (authors' figure using a digital surface model of Latvia, OpenStreetMap and the 7th cycle orthophoto from the Latvian Geospatial Information Agency as base maps)

The place where the River Abora now flows was once the Aiviekste's riverbed. At some point this part of the riverbed got separated from the rest and over time became covered with vegetation, but more detailed information about this process is not known.

Some geological, paleontological and plant macrofossil research was carried out in the settlement area by G. Levkovskaya (1987), I. Loze and T. Yakubovskaya (1984) and Guntis Eberhards (Loze & Eberhards, 2012). It was shown that the geology in this single area is complex, due to the changes in the water level of Lake Lubāns.

The aim of this research is to investigate the palaeogeographical evidence in the sediment formation of the Aiviekste oxbow in the area of the Abora I settlement. During archaeological excavations in August 2023, sediment cores were taken. This research was carried out on one of these cores, U17 (Figure 1) (X674039,2 Y312728), using Loss on Ignition (LOI), macro-remain analysis and sediment dating with the AMS <sup>14</sup>C technique.

### **Data and methods**

In order to obtain information on the palaeogeographical conditions in the area of the Abora I settlement, the 1.5 m sediment core U17 was taken from the area of the Aiviekste oxbow at an elevation of 90.87 m above sea level. The sediment core was taken according to the established methods, using an *Eifelkamp* soft sediment corer with a 50-cm-long camera with a diameter of 5 cm. The sediment monolith was immediately placed in a special cartridge and sealed with polyethylene film to preserve the naturally occurring moisture. The monolith was then transported to the laboratory, where it was sectioned at 1 cm intervals for both LOI and macro-remain analysis, giving a total of 150 samples for each. The samples were stored in a cold room.

Loss on Ignition analysis is a widely used method for estimating organic, mineral and carbonate matter in sediments (Dean, 1974). By measuring the mass loss of samples when heated to temperatures of +550°C and +950°C, the percentage composition of the above materials can be determined (Heiri et al., 2001). These measurements provide an insight into the depositional environment of the sediments and the factors influencing their formation.

Plant macro-remains provide information about the palaeovegetation in the immediate vicinity of the sampling site and its changes over time (Birks, 2007). Samples for macro-remain analysis were processed in the laboratory using a 0.25-mm sieve to separate macro-remains from residue. Each sample was approximately 10 ml. The subsequent identification of plant and other kinds of remains was carried out using a ZEISS Stemi 508 stereoscopic microscope, using the available reference material such

as Cappers et al. (2006) and Rasiņš (1954). For AMS  $^{14}\text{C}$  dating, five plant macro-remain samples were taken at intervals of 48–52, 60–64, 84–85, 98–103 and 130–131 cm. The sediment accumulation rate model was made using the CLAM package in R (Blaauw, 2010).

### Results and discussion

During the fieldwork, the sedimentary monolith U17 was described in a field journal. As the core was taken in the Aiviekste oxbow, the majority of the monolith consists of brown and greyish-brown gyttja in the 0–1.28-m-long section. The gyttja consists of organic debris (detritus) that varies from coarse to fine throughout the section. In the lower part, from 1.28 to 1.43 m, there is sand, followed by aleurite and then sand again, indicating the river conditions. This indicates that the River Aviekste became an oxbow lake at about 127 cm (c. 4680 cal BP) and was covered by vegetation.

Table 1. The AMS  $^{14}\text{C}$  dates from U17 samples

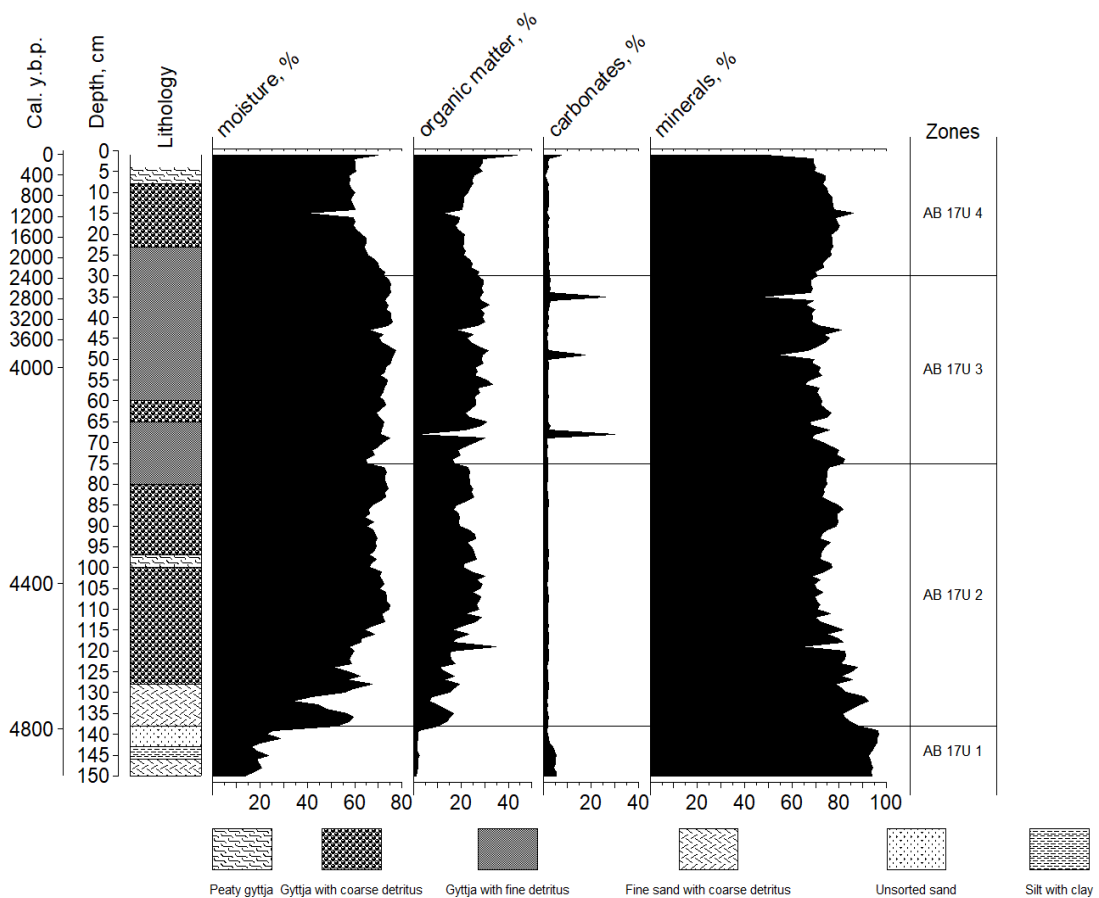
Sample depth, cm	Macro-fossils selected	Laboratoy code	$^{14}\text{C}$ years	Cal BP
48–52	<i>Poaceae</i> , <i>Cyperaceae</i> , <i>Pinus</i> , <i>Arctostaphylos uva-</i> <i>ursi</i> , wood fr.	Poz-174413	3655 ± 35 BP	4090–3880
60–64	<i>Carex</i> , <i>Eleocharis</i> <i>palustris</i> , <i>Persicaria</i> <i>lapathifolia</i> , <i>Betula</i> , <i>Chenopodium</i> , <i>Eleocharis</i> , wood branch	Poz-176664	3755 ± 35 BP	4240–3990
84–85	Wood branch	Poz-174239	3810 ± 35 BP	4390–4090
98–103	<i>Alisma</i> , <i>Schoenoplectus</i> <i>lacustris</i> , wood branch	Poz-176755	3925 ± 30 BP	4500–4250
130–131	Wood branch	Poz-174238	4170 ± 35 BP	4830–4580

AMS dating of the five samples was carried out at the Poznań Radiocarbon Laboratory (Poznańskie Laboratorium Radiowęglowe). The dates range from 3880 to 4830 cal BP (Table 1). All these dates refer to the period of the existence of the Abora

settlement, i.e. from 5320–4870 cal BP to 4086–3874 cal BP. This also means that the settlement existed before this part of the river became an oxbow lake.

The depth interval of the section 150–50 cm (4930–3980 cal BP) from the monolith is characterised by rapid sediment accumulation (the fastest being of fine detrital gyttja), which slows down significantly in the upper sections.

The Loss on Ignition and macro-remain U17 results are reflected in the plotted diagrams (Figure 2, Figure 3). According to the changes in sediment composition, four zones (AB 17U 1 – 4) have been identified in the LOI results (Figure 2). These show that sediment accumulation occurred under four different conditions.



**Figure 2. Loss on Ignition results for U17. The diagram reflects changes in the moisture content and composition of the sediments (authors' figure)**

The AB 17U 1 zone is characterised by a very high percentage of minerals (88.1% – 96.4%) while the proportion of other matter is much lower. This indicates stable underwater accumulation conditions with very little plant presence. Zone AB 17U 2 shows an increase in organic matter, indicating a rapid development of vegetation. This

also marks the beginning of this part of the river becoming a lake-like body of water which is starting to become overgrown. Fluctuations in the organic matter curve indicate periodic changes in sediment accumulation conditions, which may have been influenced by changes in water levels. There isn't much difference between zone AB 17U 2 and the next one, AB 17U 3, except that there are three carbonate peaks in the latter. Meanwhile, at the end of zone AB 17U 4, organic matter increases by up to 45%. This indicates that the area is being overgrown and that a paludification process is taking place, which coincides with the Lubāns Lake transgression about 3,400 years ago (Loze & Eberhards, 2012). The bed of the River Aiviekste was partially filled with sediments carried by the rivers Pededze and Bolupe. Therefore, at the upper end of Aiviekste, near the new bed, it was already partially blocked, but at the lower end, near Abaine, it was open, resulting in the formation of the old oxbow lake.

Based on the results of the macro-remain analysis, the U17 monolith was divided into three macroscopic zones (MA zones) (Figure 3). Throughout the monolith, the majority of remains are wood fragments and fish remains in the form of bone and scale fragments. Zone AB MA1, unlike the other zones, is characterised by the highest number of macro-remains found and the highest diversity of plant species. The majority of these are aquatic plants, especially water chestnut (*Trapa natans*) and pondweed (*Potamogeton*). Despite the presence of terrestrial plants, the abundance of aquatic, shallow water or coastal plants indicates the presence of aquatic conditions at the time these sediments were formed.

In the next zone, AB MA 2, aquatic plants decrease significantly, and while other plant groups do not change significantly in this zone, the presence of silver birch (*Betula pendula*) and other ruderal and shallow water/coastal plants indicates the process of lake overgrowth. This is also shown by the gradual decline in fish remains. In the upper zone, AB MA 3, there is a low total number of macro-remains. The low numbers of aquatic plants and fish remains indicate dry conditions, but these sediments have a high degree of decomposition, which is most likely the reason for the lack of macro-remains.



Macro-remains indicating human activity in U17 were very few in number. Some amber fragments were found at depths of 103 and 114 cm, as well as some bone fragments. However, it is possible that the presence of ruderals shows traces of human activity. In 2021, excavations were carried out in the central part of the Abora I settlement. There, in Object 2a, some ruderals were found, such as white goosefoot (*Chenopodium album*) and pale smartweed (*Persicaria lapathifolia*), together with charred *Trapa natans* fruit fragments and fragments of common reed stalks (*Phragmites australis*) (Ceriņa, 2023). As ruderals usually grow where the natural vegetation cover has been disturbed, it is possible that some human activity took place there. However, the paucity of human activity indicating macro-remains could be explained by the fact that U17 is located in the Aviekste oxbow area and the settlement was not located there, but a little further away.

### **Acknowledgement**

This research was funded by the Latvian Council of Science as part of the project “The Environment and Early Farming of the Abora Neolithic Settlement in Lake Lubāns Wetlands” (Izp-2022/1-0300).

### **Kopsavilkums**

Pētījuma mērķis ir noskaidrot paleoģeogrāfiskos apstākļus Aiviekstes vecupē Aboras apmetnes I teritorijā. Lai šo mērķi sasniegtu, vecupē veikts urbums U17, kura paraugi skatīti ar LOI un augu makroatlieku analīzēm. Pieci paraugi no visa 150 cm garā griezumā ir datēti. Visas analīzes, kā arī griezumā litoloģija liecina, ka laika gaitā Aiviekstes vecupe, pēc tam, kad kļuvusi par ezeram līdzīgu ūdenstilpi, sākusi strauji aizaugt ar veģetāciju. Datējumi norāda, ka nogulumu uzkrāšanās ir bijusi strauja. Pēc datējumiem ir zināms, ka apmetne pastāvējusi arī pirms vecupes izveidošanās, taču makroatlieku analīzē par cilvēku klātbūtni liecina tikai daži dzintara fragmenti.

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