LIVING ABOVE THE WATER OR ON DRY LAND? THE APPLICATION OF SOIL ANALYSIS METHODS TO INVESTIGATE A SUBMERGED BRONZE AGE TO EARLY IRON AGE LAKE DWELLING SITE IN EASTERN LITHUANIA

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Abstract

Lake dwellings are a well-known phenomenon in European prehistory. Two submerged sites in Lake Luokesai (Luokesai I and Luokesai II) are the only known lake dwellings from the Bronze Age and Early Iron Age in Lithuania. Soil analysis methods aimed to answer some crucial questions connected with Lake Luokesai's inhabitants during the period of the occupation of Luokesai I.

Key words: Lake Luokesai, Lithuania, lake dwellings, soil analysis, magnetic susceptibility, loss-on-ignition, particle size analysis, micromorphology.

Introduction

Two submerged sites in Lake Luokesai are the only known lake dwellings from the Bronze Age and Early Iron Age in Lithuania. While excavating terrestrial archaeological sites from the Bronze and Early Iron ages, archaeologists are rarely lucky enough to find preserved organic material. However, the remarkable state of preservation of organic material at the Lake Luokesai sites has opened up the possibility of reconstructing the prehistoric human diet, building types, working techniques, human interaction with the surrounding landscape, and many other aspects of past life in a wetland community in the northeast European forest zone.

In prehistoric lake villages of Switzerland, Austria, Italy and Germany, the extensive application of sub-bottom profiling to study inundated archaeological sites has been carried out, including GIS and micromorphological applications, together with the geochemical analysis of sediments. This research has led to the precise reconstruction of water level changes in Alpine lakes during various periods of lake dwelling occupation (Herz *et al.* 1998; Menotti 2002, 2003; Magn 2004; Wallace 1999). However, in Lithuania, due to the small scale of archaeological excavations and the lack of palaeoenvironmental investigations to date, many questions concerning former Lake Luokesai inhabitants and their environment still remain unanswered.

In 2004 and 2005, a set of core samples from the Luokesai I settlement site were taken, and various scientific soil analysis methods were applied to the samples. The soil analysis methods aimed to answer some crucial questions connected with Lake Luokesai's inhabitants, in particular:

- What was the water level during the period of lake dwelling occupation, and how much did it fluctuate?
- Did the ancient inhabitants of Lake Luokesai build their dwellings over the water or on temporarily exposed dry land?
- How can knowledge of varying water levels inform a discussion of possible building construction methods used by the dwellers, such as whether the dwellings were built on platforms supported by stilts or at ground level?
- What were the reasons for the occupation of Lake Luokesai, and why were the Luokesai dwellings abandoned?

Background information

Lake dwellings are a well-known phenomenon in European prehistory. Lake villages, or so-called pile/lake dwellings, are a type of settlement that has been used by humans in many parts of the world during different periods of history, with the most famous lake dwellings being those from European prehistory (Darvill 2003). These settlements were built above shallow water or on dry land, usually on the edges of lakes, rivers or islands. Their timber structures were subsequently inundated by rising water levels, and have been preserved in waterlogged conditions (Balaam *et al.* 1977). These

European lake dwelling sites are mainly distributed in three zones: 1 lakes around the Alps region; 2 in the lochs of Scotland and Ireland (where lake settlements are referred to as "crannogs"); 3 in the inland lake chain east and southeast of the Baltic Sea, distributed along the geological remains of what was the retreating front of the European glacial sheet from the last ice age (Motuzaitė Matuzevičiūtė 2002, 2005).

The first person to write about lake dwellings was Herodotus, who in the fifth century BC described the people of Lake Prasias as living in houses constructed on platforms supported on piles in the middle of the lake (Shöbel 2002). Yet, the archaeological investigation of lake dwellings was begun only in the late 19th century by F. Keller, who was the president of the Antiquity Society of Switzerland at the time. He was also the first person to propose that the piles sticking out of the bottom of Lake Zürich were the remnants of prehistoric lake dwellings (Ruoff 1987). The interest in the uniqueness of Keller's discovery travelled around Europe, and new lake dwelling locations were found not only in the Alps, but also in Scotland (Morrison 1985) and East Prussia (Heydeck 1909).

The search for lake villages in Lithuania started at the beginning of the 20th century (Jurkūnas 1914); however, it took almost 100 years for the first Lithuanian lake dwelling to be discovered. The first lake village (Luokesai I) is dated to the Late Bronze Age and the Early Iron Age, and was discovered in Lake Luokesai, eastern Lithuania, in the year 2000 by a few students from Vilnius University (see Plate III:2) (Baubonis *et al*. 2001, 2001b). In the year 2002, the ethnologist T. Šidiškis happened to read a legend, recorded in the 1930s, which talked about witches living in the hills around Lake Luokesai, and communicating with each other via a bridge stretching across the lake (Šidiškis 1997). While looking for this "witches" bridge, the author and his colleague, Elena Pranckėnaitė, found another lake dwelling site (Luokesai II) (Baubonis 2002; Menotti *et al*. 2005). The second site is situated on the opposite side of the lake from the previously discovered Luokesai I settlement (see Plate IV:1). These two sites are the only known lake dwelling sites in Lithuania from the Late Bronze and Early Iron Age, with most dates falling into cal 800–400 cal BC period (Menotti *et al*. 2005; Baubonis *et al*. 2004, 2005). Interestingly, the period when the lake dwellings were occupied in Lithuania coincides with the period when such settlements were abandoned in the Alps region (Menotti *et al*. 2005).

Since the year 2000, archaeological excavations have been carried out every summer at the Luokesai sites. The research has mostly focused on the Luokesai II settlement, due to its easier accessibility from the shore. This site contains almost no cultural layers, and most of the archaeological information available lies in wooden construction remains resting in calcareous lake marl at a depth of five to 20 centimetres below the lake bed. About 120 square metres have been excavated to date at the Luokesai II site (Baubonis *et al.* 2005). In contrast, the Luokesai I settlement is very abundant in archaeological artefacts, and possesses a 30 to 50-centimetre-thick cultural layer. The Luokesai I site has required very slow and precise archaeological research, and therefore only four square metres have been excavated at this settlement to date. The well-preserved stratigraphy of the Luokesai I site has allowed for palaeoenvironmental research to be conducted, and therefore the core samples analysed in this work were taken from this site. The specific geomorphological situation, as well as geographical and environmental details of the Lake Luokesai I settlement, will be discussed.

It has to be noted that, unfortunately, the radiocarbon dates in the settlement were obtained by dating timber randomly, without accurately detecting the depth of the wooden structures and their correlation with the absolute chronology (Motuzaitė Matuzevičiūtė 2007). Therefore, it is difficult to attach the analysed archaeobotanical remains with a particular dated layer. The radiocarbon dating of the peat/humus at one or two-centimetre intervals through the cores would have been very useful in order to connect archaeological material with the processes of peat formation. However, the detection of charcoal throughout the entire stratigraphy leads to the notion that humans occupied the Luokesai I site during the formation of the peaty layer.

The geographical context

Lake Luokesai is situated in the eastern part of Lithuania in the Molėtai district, 45 kilometres north of the capital Vilnius (see Plate III:2). The landscape morphology surrounding it consists of undulating hills, with highlands (160 to 170m above sea level) gouged by the last glacier, and it is now covered in forest, while the lowlands around the lake are mainly swamps. The lake also has two forest-covered islands (Menotti *et al*. 2005; Baubonis 2001a). On its eastern and southern sides, Lake Luokesai is connected with other lakes, which are joined by small creeks. A very characteristic feature of the lake is its set of distinct, widely extended morainic shoals, where the two lake dwelling sites were discovered (Baubonis 2002). The water of the lake is fairly clear, with visibility underwater extending up to five metres. Such good visibility is common in deep and cold rinic lakes, which typically lack plants and phytoplankton, and are deficient in oxygen.

The soil in the surroundings of Lake Luokesai consists mostly of argillic brown earth in the uplands, and peat in the lowlands. All soil types were formed under the calcareous sandy/gravely parent material bulldozed by the last glacier. The swampy territory around Lake Luokesai delineates the highest water level reached in Lake Luokesai during the Atlantic Period (6000–3000BC), which existed before the time when the first settlers established their lake villages (Motuzaitė Matuzevičiūtė 2004, 2005). The Luokesai I settlement was occupied during the transition period from the Subboreal Period (3000/3500–500BC) to the Subatlantic (500BC to present). The Subboreal Period in Lithuania is known to have been the driest of all the postglacial periods (Stančikaitė 2000; Seibutis 1998). During this period, the water level of Lake Luokesai was much lower, and the swamps around the lake were much drier than they are now. The lowland territory around the lake was probably exploited as pastoral or agricultural land (Motuzaitė Matuzevičiūtė 2007).

The environmental context of the settlement

The Luokesai I settlement is situated on a morainic shoal in the northern part of the lake (see Fig. 3) (Baubonis 2001). This shoal, a narrow ribbon in shape, stretches from the shore to one of the islands in the lake. The depth here is between 110 and 190 centimetres, with a steep drop-off down to a depth of ten to 15 metres along both sides of the shoal (Menotti *et al*. 2005). The settlement itself is situated about 45 to 55 metres from the shore, in the part where the shoal forms an outward bulge into the deeper portion of the lake (see Plate IV:2).

A top layer of light lake sediments up to 15 centimetres thick and abundant with freshwater molluscs covers the shoal. In parts of the area of the submerged settlement, the water circulation is more intense and the cultural layer is not covered by lacustrian sedimentation, meaning that the top part of the cultural layer may have been eroded away. In the area occupied by the lake dwellers various sizes of stone were found, some of which are up to 20 centimetres in diameter. The stones rest within or on the top of stratigraphy, indicating their postglacial appearance and possible anthropogenic origin (see “Discussion and conclusions” below).

Below the lake sediment layer, the lake stratigraphy changes into a dark peaty cultural layer (Baubonis 2002a). It starts at different depths, depending on the thickness of the overlying layer of lake sediment. Usually, the cultural layer starts at a depth of five centimetres, and is about 20 to 40 centimetres thick. It consists of acidic organic material incorporated into a basic (>7 pH) calcareous lake marl layer, which starts at a depth of about 30 to 50 centimetres. In such an anoxic environment, all kinds of organic materials have been very well preserved. Well-preserved wooden stilts from the settlement structures are vertically embedded up to 4.5 metres into the soft lake marl overlying the morainic shoal (Baubonis 2005; Menotti *et al.* 2005).

Applied research methods

The three core samples from the Lake Luokesai dwelling site were taken randomly, choosing places for sampling. Sample retrieval involved embedding seven-centimetre-diameter/50-centimetre-long drainage pipe tubes into the sediments. The samples were sent to Cambridge University and kept in the McBurney Laboratory’s cold room for a couple of months prior to processing.

The methods applied to the investigation of the Lake Luokesai dwelling cores are: magnetic susceptibility, loss-on-ignition, particle size analysis, and micromorphology.

Three core samples were analysed in total: LI(B), LI(2) and LI(H). The proceedings of the scientific analysis are as follows.

Magnetic susceptibility

Magnetic measurement is familiar to archaeologists as a method for prospecting, using a variety of instruments to record variations in the magnetic field of surface effects, buried features, and to interpret the palaeoenvironment (Allen *et al.* 1987). Magnetic susceptibility reflects the concentration of ferromagnetic minerals within the samples. Susceptible soils and sediments tend to have a larger proportion of ferromagnetic minerals in their matrix. There are three main factors that could influence low and high magnetic susceptibility values in the soil, which are: parent material, pedogenic processes, and human activity (Allen *et al*. 1987). The enhancement of the magnetic susceptibility signal may reflect sediment parent material. For example, igneous rocks, rich in ferromagnesian minerals, including olivine, biotite, maghaemite and iron carbonate, have a higher magnetic susceptibility signal, whereas sand, mostly composed of quartz and calcitic shells, feldspar and calcite have a low magnetic susceptibility signal (O’Connor *et al*. 2005). Magnetic susceptibility can vary with the sample type, amount and particle size (Thompson *et al*. 1986). Magnetic susceptibility values correlate well with human occupation; for example, areas used as fireplaces typically have enhanced magnetic susceptibility values. This occurs because soil surface sediments adjacent to hearths and bonfires are likely to undergo sufficient heating to convert the weakly magnetic hydroxides and oxides of iron that they normally contain to more strongly magnetic forms (Elwood *et al.* 1995).

Before splitting the cores into halves for invasive research, a magnetic susceptibility analysis was applied to the Luokesai I settlement cores coded LI(B) and LI(2). The Luokesai I settlement cores were passed through a scanning loop using the Bartington Magnetic Susceptibility Meter, with readings taken every two centimetres. The core samples LI(B) (see Graph 2) and LI(2) (see Graph 3) were measured with a magnetic field of weak amplitude.

Micromorphological investigation

Micromorphology is the study of undisturbed material in thin section. It allows features of soil/sediment horizons, their structures and boundaries, as well as the context and formation of archaeological deposits, to be examined under the microscope (Matthews 2005; Goldberg *et al.* 2003). Since the bulk of soil/sediment samples are observed *in situ* throughout the analysis of thin section slides, it provides archaeologists with a lot of unique and reliable data to answer key archaeological questions about environmental changes, occupation sequences, uses of space, archaeological preservation, and maybe other important aspects. Soil micromorphology techniques were used in detecting Lake Luokesai palaeoenvironmental changes before, during and after the lake dwelling occupation, and to recognise human impact and adaptation to the surrounding environment.

Two cores from samples LI(B) and LI(2) were used for micromorphological investigation (see Tables 4, 5). Three blocks were taken from each core embracing the boundaries of the changes in stratigraphy, with each block being five by eight centimetres in size. The blocks were impregnated with crystal-clear resin and prepared as thin section slides following Stoops (2003) and Bullock *et al*. (1985). As mentioned above, the analysed Lake Luokesai samples are very rich in organic material. In order to categorise, quantify and interpret an abundant amount of organic material in the Lake Luokesai dwelling profile, a system of description partly following the methods of Babel (1985) and Wallace (1999) was introduced. While analysing organic material in thin section slides, particular attention was paid to the presence of iron oxides and the rate of organic replacement, plant decomposition, and the amount of bioturbated material in the sediments. These features served as indicators for fluctuating wet-dry conditions (Wallace 1999). Condensed information for each unit representing the changes in the stratigraphical genesis of the core is provided in Tables 4 and 5.

Loss in weight on ignition

The loss in weight on ignition technique was used in order to measure the percentage of water, organics, calcium carbonate and silicate residue, as well as bulk density, in the Luokesai I sediment cores. One-cubic-centimetre samples were taken each centimetre along the stratigraphy of the cores LI(B), LI(2) and LI(H). A muffle furnace was employed, and the samples were treated for six hours at temperatures of 105°C, 500°C and 950°C. After each temperature treatment the samples were weighed. The weight loss when the samples were dried at 105°C represented the amount of pore-water held within the sample. The weight loss between the 105°C and 550°C temperature treatments represents the percentage of the total organic material in the sample. The weight loss of samples between the 550°C and 950°C temperature treatments represented the amount of carbon (CO_2) released from the sample and the amount of calcium carbonate ($CaCO_3$) present in the sample. Loss-on-ignition data is especially useful in conjunction with mineral magnetic values and particle size data in helping to understand other readings and possible correlations among data (Evans *et al.* 2005). The amount of water, organic material, carbon (charcoals), calcium carbonate and silicates in the Lake Luokesai core samples, determined by loss in weight on ignition, have provided very interesting and important results concerning the history of the lake's development. The results of these measurements are presented in Graphs 2, 3 and 4 as percentage matter plotted against depth.

Particle size analysis

Particle size analysis can provide valuable data about the sedentary sequence of the core, changes in sediment structure, density, and the impact of low/high energy flow (Orton 2000). For example, one of the ways to determine if flowing water conditions existed at the settlement is to look at the particle size of the clastic material. Sediments that are finer-grained silty clay indicate a deeper water level, whereas the sediments from the shallow side (littoral zone) are coarser (Wallace 1999). The investigations of Lake Luokesai I cores LI(B) and LI(H) provided some information about variations in sediment structure in stratigraphy (see Graphs 2, 4). Particle size analysis was applied to the two cores LI(B) and LI(H). For the particle size analysis one-cubic-centimetre samples were taken at every centimetre along the sample. A Malvern Mastersizer X laser particle sizer (in the Department of Geography, University of Cambridge) was used to measure the particle size distribution, ranging from 2mm to 0.1µm in size.

Molluscan analysis

Molluscan analysis was used to detect the ecology of the Luokesai I settlement shoal. This research was conducted together with the wet sieving of plant remains for macrobotanical investigation (Motuzaitė Matuzevičiūtė 2007). They were selected from the LI(B) core from depths of seven to 12 centimetres, 12 to 16 centimetres, 16 to 22 centimetres, and 22 to 28 centimetres, and analysed by the author (see Plate IV:4).

All the molluscs identified in the core samples constitute freshwater shell species. Most of the molluscs were found at the top and bottom layers of the core. The molluscs discovered in the upper core together with *chara* remains indicate lacustrine depositions that formed underwater. The molluscs at the bottom zone of the core (22 to 29.5cm) probably came from the lake marl, which starts at a depth of 29.5 centimetres, indicating a dramatic water level change in Lake Luokesai. Very few molluscs were found in the middle layers of the core, which might indicate periodical water level fluctuation and periodically wetter conditions. Reed roots perforating into the stratigraphy also might have brought molluscs from above into the middle layers (see Graph 1). The occurrence of snail species and their ecology coincides very much with data received from other analyses (see "Discussion and conclusions") (Ross 1984).

Discussion of overall results and conclusions

After conducting the various scientific analyses, valuable results were obtained concerning the palaeoenvironmental conditions and some stages of water level change before, during, and after the occupation of the Luokesai I settlement. In order to generalise the results obtained from three cores and to understand the processes of shoal formation, the development stages of the Lake Luokesai sediments within the settlement territory can be distributed into five different phases. Temporally, the phases start from the earliest (oldest) at the bottom of the core to the latest (youngest) at the top (see Graphs 2, 3, 4 and Tables 4, 5).

The first and the earliest stage of the development of Lake Luokesai starts from the bottom parts of the cores LI(B), LI(2) and LI(H). It is indicated by the layer of fine lake marl which formed due to the abundance of limestone and calcareous glacial drifts in the Lake Luokesai drainage basin (Dean 1981). The lake marl was detected in thin section slides and confirmed with loss-on-ignition and particle size data registering a very low magnetic susceptibility signal. It consists mostly of very fine silt particles and freshwater molluscan shells, but is bereft of *chara* which usually form in shallow sub-littoral zones where there is a lot of light (Wallace 1999). These features all show that the shoal consisting of lake marl formed in a deep, low energy environment, probably during the Atlantic Period (6000–3000BC) when the water level in Lake Luokesai reached a maximum (Motuzaitė 2004; Stančikaitė 2000).

The second stage of the genesis of Lake Luokesai is indicated by the drastic transition of the lake from a high to a low water level, and the subsequent exposure of the shoal to the surface. This exposure can be seen clearly in micromorphological slides from the polymorphic iron nodules indicating the lake marl's contact with oxygen in the atmosphere. This led to the first organic deposition and accumulation, mixed with some silicate sand residue. As can be seen from the loss-on-ignition and micromorphological data, the existence of charcoal and carbon in the first organic residue that formed on the lake marl shows that people inhabited the Luokesai shoal soon after the transition of the lake shoal to dry land had occurred. The extensive decomposition of organic material in this zone and the existence of soil mite excrement represent a relatively dry layer that was exposed as a surface for quite a long time, allowing organic material to decompose in an oxygen-rich environment. However, the absence of cracks and moderate impregnation organic material with iron oxide indicates that the conditions were still relatively moist, not allowing peaty organic materials to totally dry out.

The third layer has a very high percentage of silicate residues, that varies from gravel to silt sizes. The silicate residue had very few organic components and almost no $CaCO_3$. The high impregnation of organic material with amorphous iron oxide and its good preservation, and the discovery of some limnic organisms in this zone, such as molluscs, indicates water table fluctuation throughout the stratigraphy and wetter conditions than in the previous layer. Within the "flooding" horizon, deposits of anthropogenic origin were found, such as charcoal, plant remains and pottery fragments, showing that humans still occupied the site during the wetter periods of the development of the lake.

The fourth stage of lake formation is indicated by a rather equal distribution of organic and mineral material in the core. The abundance of amorphous and bioturbated organic material and its moderate impregnation with amorphous iron oxide indicate a more stable water table and drier conditions than in the core section below. As can be seen from the micromorphological and loss-on-ignition data, there is an abundance of charcoal within the sediments in this zone, suggesting human occupation. These humans lived probably in a relatively dry but still moist environment, with maybe seasonally fluctuating water levels.

The fifth stage is indicated by a big water level transgression. The change of organic and mineral deposition into calcareous lake marl or coarse minerals shows a rapid increase in the water level of the lake to perhaps greater water action. Micromorphological investigation and particle size analysis of the upper part of the core have shown relatively coarse particles. The coarse fractions in the upper part of the stratigraphy indicate that this layer was exposed to a high-energy zone, and sediment was deposited by waves in the shallow litoral area (Digerfeldt 1986). Such investigations have also led to the conclusion that the lake dwellings were abandoned due to the rise in the water level and the inundation of the island.

Magnetic susceptibility readings

The story of water level changes presented above raises some important questions regarding human activities on the site.

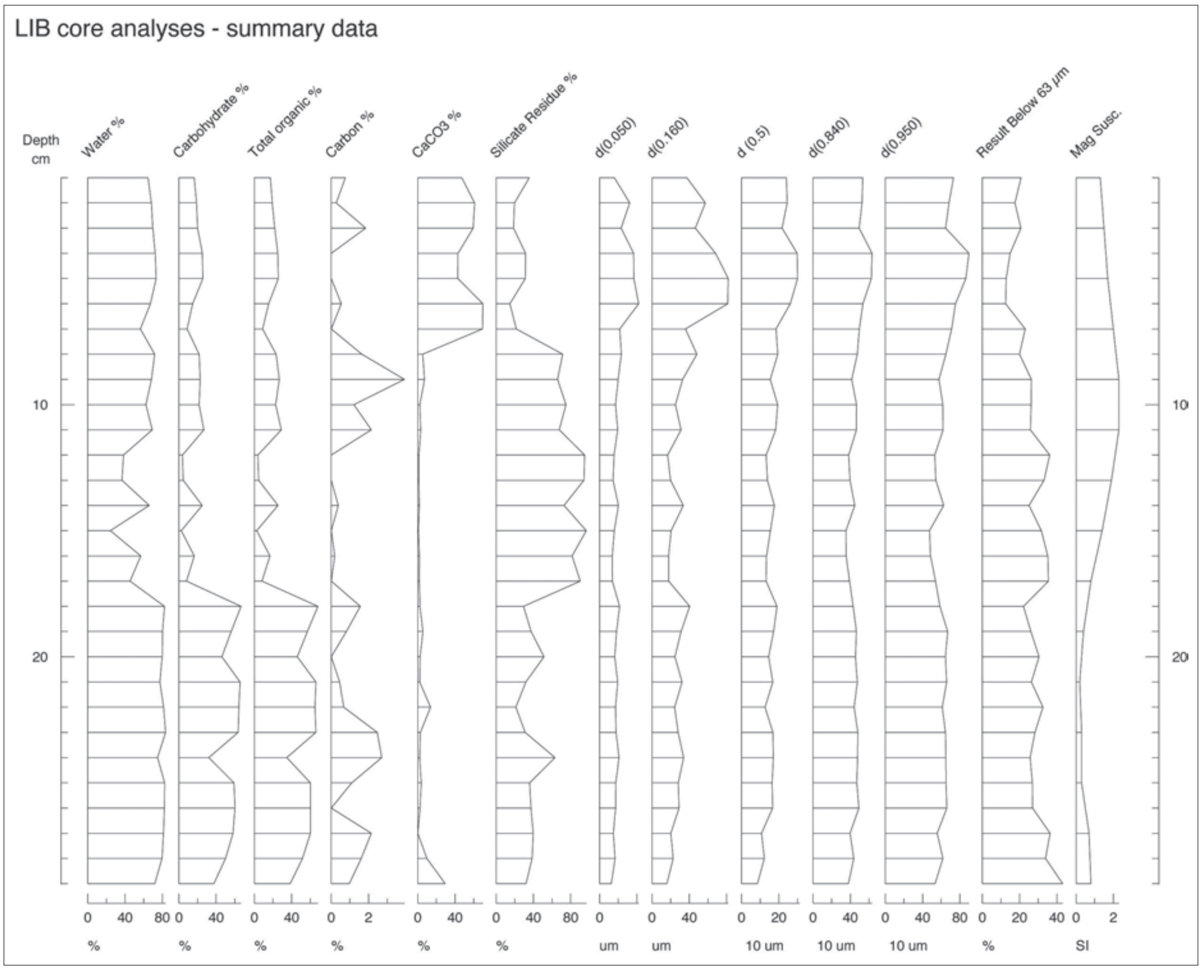
Firstly, what gave the high magnetic susceptibility signal to the Lake Luokesai cores, and does it represent any aspects of human activity on the site? As has been discussed above, the high signal can be affected by parent material that contains ferromagnetic elements as well as pedogenic and oxidation processes, and human activities introducing fire in the settlement during which the heating of minerals converts iron oxide from weakly ferromagnetic iron oxides to strongly magnetic forms (Allen 1987; Courty *et al.* 1982). When compared to micromorphological and loss-on-ignition data, the highest magnetic susceptibility signals in the cores occur at the layers with 45% organic material, 55% mineral matter (mostly silicates) and charcoal (see Graphs 2, 3). From this data, it can be concluded that humans who were burning organic material together with minerals caused the enhancement of the magnetic susceptibility signal in the Luokesai core samples. It might be suggested that this particular mineral matter came from a fireplace and could be used to form a fire-resistant base on which the hearth could safely rest. Sometimes just a layer of sand was placed on a wooden platform, and the fireplace built directly on top of this. Such fireplaces were found at Lac de Chalain and other Neolithic wetland settlements in the Alpine region (Wallace 2003; Dieckman *et al.* 1997; Schlichtherle 1997).

The possible origin of mineral sand

It is interesting to pay attention to the possible origin of the ten to 20-centimetre-thick silicate sand layers that are found in the middle parts of the cores (see Tables 1, 2, 3, 4, 5). An explanation might be that the mineral sand is of anthropogenic origin, and was transported to the site by people (Bocquet *et al.* 1987). From the particle size distribution analysis, non-homogeneity of particles can be seen in the varying size classes, from very gravel to very coarse to silt-size mineral sand. It should be expected that if mineral sand was inwashed from the shore, the particle size of the minerals would be similar. As was described in the section about the geographical setting of the Luokesai I settlements, the site is situated on the unusual ribbon-shaped shoal that stretches from the shore to the island. The site is about 55 metres from the shoreline. This long distance, as well as the deep water which surrounds the settlement on three sides, makes it pretty unlikely that the sand and gravel-size minerals found in Luokesai were inwashed into the settlement. It is also important to note that in the areas with an increase in silicate residue, there is only a very small amount of $CaCO_3$. If the sand was inwashed, we would assume that it would also come with calcium carbonate material from the lake, which is absent in these layers (see Graphs 1, 2, 3). As mentioned earlier, there are also a lot of big stones on the site, which were most likely brought by people because they were integrated into a cultural layer that obviously formed after the glacial activity. The arguments listed above tend to indicate that people brought the mineral sand, and such a layer was artificially created to strengthen the peaty layer of the occupied island.

Fine charcoal and ash layer

It is interesting to look at the layer of very fine burnt organic material and ash found in the core LI(B) at a 22 to 22.5-centimetre depth, which indicates fire episodes at the site (see Plate IV:3 and Tables 1, 4). It is also important to note that, from its consistency, this layer is very similar to the rich organic layer lying just below it. This layer's discrete location in the profile, the density and the absence of big charcoals shows that this layer was not inwashed from the other layer above, nor did it fall from the fireplace at the settlement. The most likely explanation is that this fine organic and burned charcoal layer indicates the *in situ* burning of a peaty organic material that previously constituted the



Graph 1. Summary of all applied data of the core LI(B).

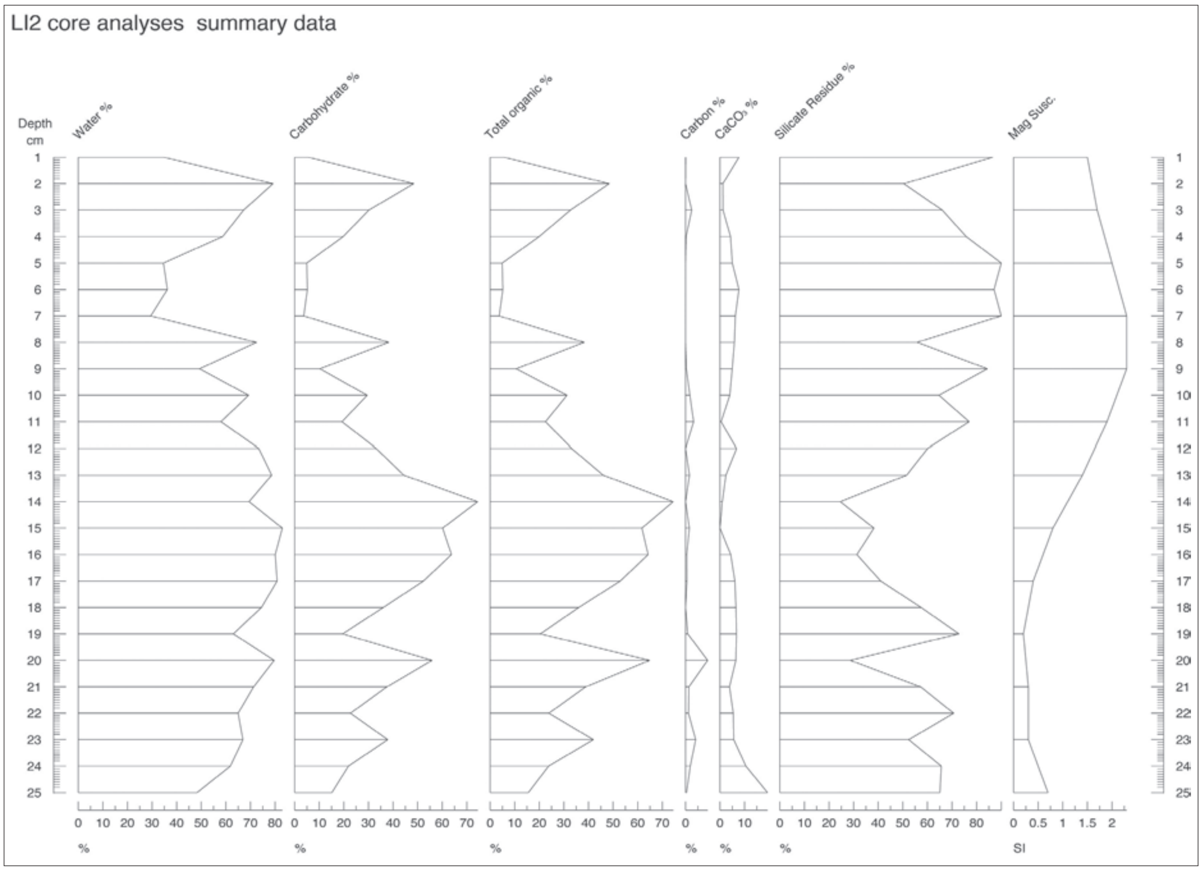
dry land surface. This layer provides three very important facts about the site. Firstly, it confirms the interpretation that the submerged shoal really constituted the exposed surface. Secondly, it also shows that the conditions on the site were dry enough to allow a fire to burn the accumulated organic material. Thirdly, the burning layer's existence at a depth of 22 to 22.5 centimetres confirms its occupation by humans very soon after the water level on the site had decreased.

Probable building construction type

After the reconstruction of the past environment, it is possible to make some suggestions about the building type that was used on the exposed Lake Luokesai shoal.

Firstly, it is important to note that charcoal appears in the first layers of peat formation above the lake marl, showing that people occupied the site very soon after it became an exposed surface. As this thin peat could not hold the constructions built directly on it, it is almost certain that dwellings were not built at ground level but were elevated above the ground.

As is discussed above, the conditions on the Luokesai shoal even during the driest periods of lake formation were still damp. This is indicated by the absence of fine cracks in the sediment groundmass that would have appeared if the conditions on the site were very dry. The suggested water level changes and the distribution of charcoal throughout the stratigraphy have shown that people were living on the site in both wetter and drier environments, and that the buildings had to be constructed in a way to protect people from the recurring wet conditions. During the archaeological excavations and the reconnaissance of the lake dwelling area, it was discovered that the vertical pilings of the buildings are embedded up to 4.5 metres into lake marl (Menotti *et al*. 2005). Horizontal beams and planks with poles were discovered lying on the bottom of the lake, some of which were jointed with each other (Baubonis *et al.* 2002). It might be suggested that instead of building dwellings on the island on piles, as was previously suggested (Baubonis, 2001a), the buildings at Luokesai I still had some kind of structure elevating the buildings, but that these were much closer to ground level. The slightly elevated construction of buildings, on the so-called grade basement, on partly reclaimed islands,



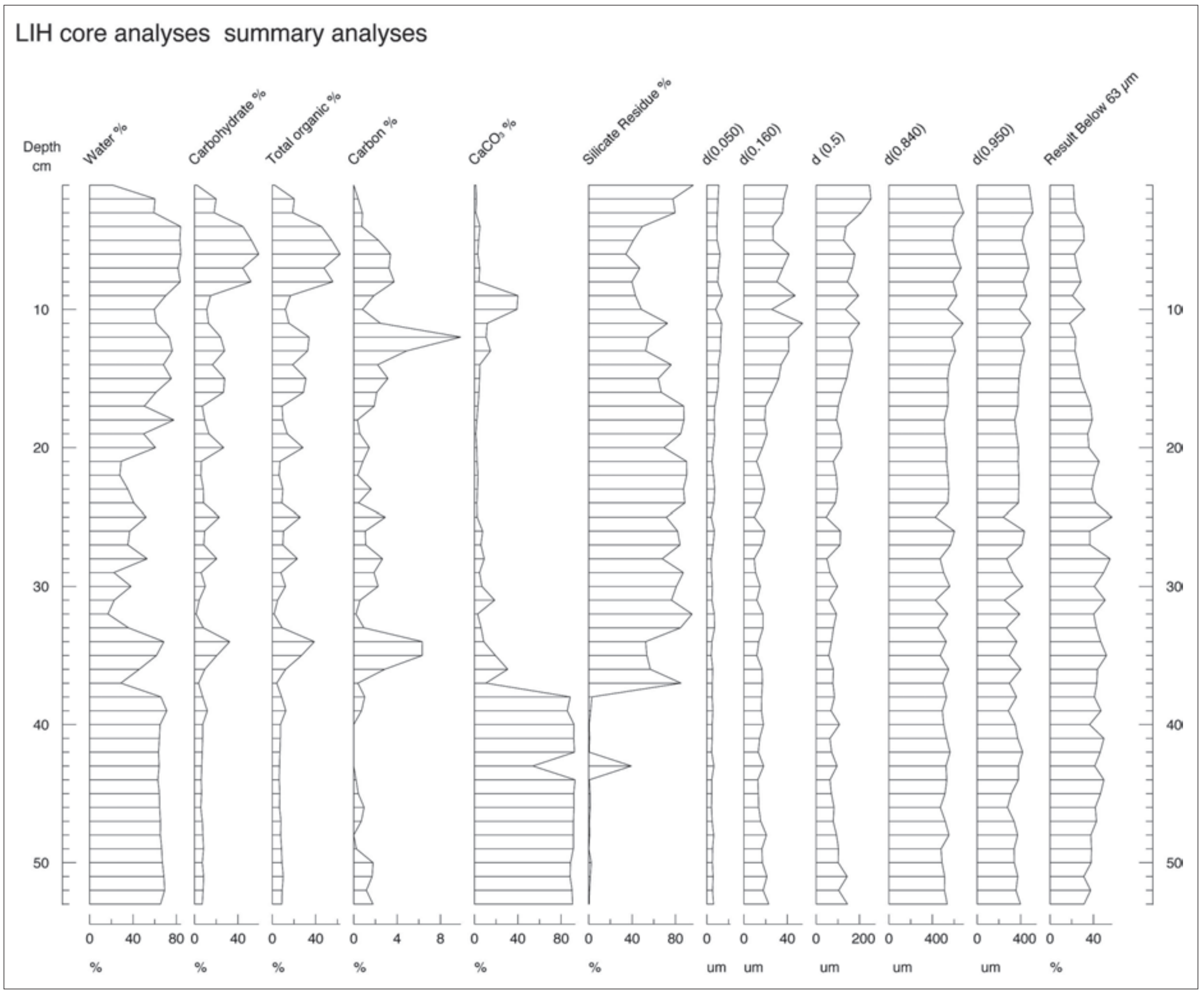
Graph 2. Summary of all applied data of the core LI(2).

was very widespread during the Early Iron Age, for instance among Prehistoric lake dwellings in north-east Poland, in the Mozurian lake district. “These lake dwellings were usually erected in shallow water bays. The construction of the lake dwellings involved placing alternate layers of wood piles and beams to create a kind of grillwork extending above the water’s surface. This construction was reinforced with vertical piles driven into the lake bottom inside and outside the grill, and the surface of the island was topped with stones” (Gackowski 1993). One example of such a dwelling in Poland is the Pieczarki settlement, which is dated to the beginning of the Early Iron Age (450–250BC) (Polcyn 2000). It can be suggested that the Luokesai I settlement structures were similar to the ones found in the adjacent regions of the Mozurian lakes in present-day Poland.

Possible reasons for occupying lake dwellings

There are many possible reasons why people chose to live by a lake. The first and main reason that drove people to live in an environment surrounded by water was safety. This can also be seen clearly by the need for the double palisade wall protecting the part of the settlement facing the lakeshore (Baubonis 2001a). A common type of settlement during this period in Lithuania was the fortified hill-fort, showing the demand for people to protect themselves (Grigalavičienė 1992). The other reason to live in an environment surrounded by water could have been the fire hazard resulting from living in an area surrounded by forest where slash-and-burn agriculture took place (Motuzaitė 2005).

During the Prehistoric period, eastern Lithuania was thickly covered by forest, and open spaces suitable for pasture and agriculture were rare. Therefore, by living on the exposed shoal, the Lake Luokesai dwellers saved space, leaving the adjacent open territories around the lake to be advantageously exploited for agriculture and cattle grazing. An important discovery, connected with human diet and activities, was the recovery of the remains of emmer wheat (*Triticum dicoccum*) (cereal grains, glume bases) as well as domesticated cereal pollen grain, in the analysed LI(B) core samples (Motuzaitė Matuzevičiūtė 2007). This discovery strongly supports the interpretation that the lake dwellers were farmers, who had their fields very close to Lake Luokesai, and that possibly some cereal processing activities might have taken place at the site (reference as above).



Graph 3. Summary of all applied data of the core LI(H).

Future research

Any future research of the Lake Luokesai I settlement should include research into understanding more about the formation of the Lake Luokesai shoals, and the life of the wetland population.

In the future, more archaeological excavations should be conducted (at the moment only four square metres have been excavated). The continuity of archaeological excavations would lead us to understand more about the building strategies, dwelling size and number, as well as the construction type of the settlement. The conjunction of archaeological excavations with micromorphological analysis would help to understand the use of space on the site, such as recognising the areas within and outside buildings, and to reconstruct a plan of the village. By knowing the distribution of the buildings, micromorphological analysis would help us to answer questions concerning cattle rearing, human hygiene, what activities took place inside and outside the houses, and many other questions.

Some investigation on the adjacent terrestrial land, by test-pit digging and charcoal dating from test-pits, soil fertility research, and searching for past agricultural fields, would provide information about human activities around the lake, and the size of the area possibly exploited by the former population.

All these further research possibilities would lead not only to the construction of a broader picture about the lives of this Prehistoric wetland community, but would also open up possibilities to reconstruct the lake village as a museum site, and in this way help to introduce modern society to the lives of these former lake villagers.

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Table 1. Lake Luokesai I(B) core samples

Depth (cm) from lake bed/water interface	Description
0-0.2	Dark organic sediments covering the top part of the core
0.2 – 7/8	Lake marl abundant with freshwater shells. In a 3.5cm zone there is a 0.5cm thick layer of leaf and herb litter
7/8-14	Very dark brown to black, possibly peat layer with charcoal and some medium to fine size quartz sand
14-21	Brown-greyish peat with some coarse to very fine sand granules
21-22	Layer of very dark peat
22-22.5	Layer of ash and charcoal
22.5-27	Brown peat layer with reed stem remains
27-28	Dark brown peat with decomposed and compressed reed/carr remains
29+	Layer of lake marl with pieces of charcoal, some shells and reed stems

Table 2. Lake Luokesai I(2) core sample

Depth (cm) from lake bed/ water interface	Description
0-1	Gravel (>2mm) and coarse sand
1-1.5/2	Dark brown to black layer with remains of wood/bark and hazel nuts
1.5/2-8/9	Greyish-brown silty sand layer with peat, some patches of darker peaty layer, charcoal and a few stones (>3-5mm)
8/9-9/10	Dark brown to black layer of wood remains
9/10-20	Greyish brown peaty layer with some charcoal, pieces of burned wood, fine silt and medium to fine sand
20-24.5	Dark brown peat with frequent charcoal, wood remains, reed stems and roots
24.5-25+	White lake marl with shells and reeds

Table 3. Lake Luokesai LI(H) core samples (From H. Lewis in Menotti et al. 2005)

	LI (H)
Depth (cm) from lake bed/water interface	**Description**
0-1.5	Coarse sand and rounded gravel
1.6-9	Peat with woody fragments
9.1-10	Greyish yellow sandy clay
10.1-19	Very dark brown peat with reddish brown patches (<2cm in size)
19.1-20	Reddish brown lens
21-24	Very dark brown to black possible peat with charcoal
25-27	Very dark grey gritty peaty layer
28-32	Layer of burnt wood and possible peat
32-52+	Yellowish brown lake marl, molluscs (<0.3cm)

Table 4a. Abbreviations

Plant tissue with cells	PC
Plant tissue without cells	PNC
Plant tissue <60μm	P<60
Amorphous matter	AM
Bioturbated organic material	BOM
Minimal iron replacement	FeMin
Moderate iron replacement	FeMod
High iron replacement	FeH
Organic material	Org
Minerals	Min
Silicate residue	Sil.
Cross polarised light	XPL
Coarse and fine sand size (fine starts >$60_{\mu m}$)	C/f

Table 4. Luokesai I settlement LI(B) core layers (see Table 4a)

Depth (cm)	**Unit/slide**	**Organic material**	**Mineral components**	**c/f $_{60\mu m}$ ratio % organic: org mineral: min**	**Porosity**	**Iron replacement/ oxidation**	**Main fabric and interpretations**	**Illustration**
0-8/7	1/LI(B)1	20%: Shells, PNC, and PNC: 80% AM: 20%	65%: Micrite$_{(CaCO3)}$70% Sil. Coarse and medium size sand 30%	Org.: 80:20 Min. 30:70	15%: Compound packing voids and vughs	FeMin	Lake marl layer formed underwater (no charcoal)	XPLx100
8/7-9.5	2/LI(B)1	60%: PC-15% PNC-15% P<60-25% AM-30% BOM-15%	30%: Medium and fine sand sil.: 50%, silt size sil.: 30% Micrite: 20%	Org. 30:70 Min. 50:50	10%: Complex packing voids	FeMod	Highly compacted dry organic layer exposed to the air (with charcoal)	XPLx100
9.5-17	3/LI(B)1-2	20%: PC-30% PNC-30% P<60-10% AM-15% BOM-15%	65%: Medium and fine sand sil.: 70%, silt size sil.: 20% Micrite:10%	Org. 60:40. Min. 70:30	15%: Vughs and channels	FeH	Semi wet surface with periodically fluctuating water table, abundant with charcoal (a few freshwater molluscs were found)	XPLx40
15.5-17	4/LI(B)2	10%: PC-10% PNC-10% P<60-40% AM-30% BOM-10%	80%: Sil. sand: coarse-60% medium-20% fine-10% silt size-10%	Org. 20:80 Min. 90:10	10%: Single grain bridge structure	-	Mineral infillings in between organic layers	XPLx100
17-21	5/LI(B)2-3	50%: PC-15% PNC-10% P<60-15% AM-50% BOM-10%	25%: Minerals coarse to fine sand size sil. 80% Silt size sil. 20%	Org. 25:75 Min. 80:20	25%: Vughs and channels	FeMod	Moderately compacted semi-dry peaty/ humus layer (with charcoal)	XPLx100
22-22.5	6/LI(B)3	65%: PC-10% PNC-40% P<60-40% AM-5% BOM-5%	15%: Mineral: Coarse to fine sil. 30% Silt size sil. 20% $CaCO_3$- 50%-	Org. 50:50 Min. 30:70	20%: Complex packing voids	FeMin	Ash and charcoal layer indicating fire episode in the settlement	XPLx100
22.5-27	7/LI(B)3	60%: PC-10% PNC-10% P<60-15% AM-50% BOM-15%	30%: Minerals: Sil. sand of coarse and fine sand: 70% Sil. Silt size: 10% Silt size $CaCO_3$-20%	Org. 20:80 Min. 70:30	10%: Complex packing	FeMod	Highly decomposed semi-dry peaty layer (with charcoal)	XPLx100
27-29+	8/LI(B)3	25%: PC-30% PNC-40% P<60-30%	70% Micrite $_{(CaCO3)}$ - 70% Sil. medium to fine sand size – 30%	Org: 70:30 Min. 30:70	5%: Vesicles	FeMin	Lake marl formed underwater (some charcoal mixed from above)	XPLx100

Table 5. Luokesai I settlement LI(2) core layers (see Table 4a for abbreviations)

Depth (cm)	Unit/slide	Organic material	Mineral components	c/f $_{60\mu m}$ ratio % organic: org mineral: min	Porosity	Iron replacement/ oxidation	Main fabric and interpretations	Illustration
0-3	1/LI(2)1	50%: PC-15% PNC-15% P<60-25% AM-35% BOM-10%	30%: Sil. Coarse and medium size sand-70% Micrite$_{(CaCO3)}$-30%	Org. 30:70 Min: 70:30	20%: Complex vughs and channels	FeMod to FeH	Very disturbed, damp peaty surface with charcoal and molluscs	XPLx40
3-7	2/LI(2)1	10%: PC-15% PNC-15% P<60-25% AM-35% BOM-10%	70%: Medium and fine sand sil.-70%, silt size sil.- 20% Micrite- 10%	Org. 95:5 Min. 70:30	20%: Single grain structure	-	Mixed mineral sand layer (probably anthropogenic origin)	XPLx40
7-14	3/ LI(B)1-2	25%: PC-20% PNC-10% P<60-30% AM-30% BOM-10%	60%: Medium and fine sand sil.- 40%, silt size sil.- 50% Micrite-10%	Org. 30:70- Min. 40:60	15%: Complex vughs	FeH	Damp mineral mixed with organic and charcoal layer	XPLx40
14-20	4/LI(2)2-3	65%: PC-20% PNC-20% P<60-35% AM-20% BOM-5%	20%: Sil. sand coarse/ medium- 15% Silt size- 60% Micrite-5%	Org. 40:60- Min. 45:65	15%: Complex packing voids	FeH	Wet surface with fluctuating water table (with charcoal)	XPLx40
20-21	5/LI(2)3	20%: PC-40% PNC-20% P<60-20% AM-15% BOM-5%	60%: Sil. sand: coarse-20% medium-30% fine-20% silt size-20% micrite-10%	Org. 60:40- Min. 70:30	20%: Vughs, single grain and complex packing voids	FeMod to high	Charcoal and fine organics disturbed peaty layer	XPLx40
21-24	6/LI(2)3	60%: PC-15% PNC-10% P<60-15% AM-50% BOM-10%	25%: coarse to fine sand size sil.- 60% Silt size sil. - 20% Micrite $_{CaCO3}$-20%	Org. 35:65 Min. 60:40	15%: Vughs and single grain structure	FeMod	Well decomposed semi-dry peaty/ humus layer with charcoal	XPLx100
24-25+	7/LI(2)3	15%: PC-35% PNC-35% P<60-30%	75%: Coarse to fine sil. 30% Silt size sil. -20% Micrite$_{CaCO3}$- 50%	Org. 70:30 Min. 30:70	10%: Single grain bridge and vesicles structure	FeH on the top of the layer	Lake marl with freshwater molluscs formed underwater	XPLx100

GYVENIMAS VIRŠ VANDENS AR SAUSUMOJE? PEDOLOGINIŲ METODŲ TAIKYMAS RYTŲ LIETUVOS BRONZOS–ANKSTYVOJO GELEŽIES AMŽIŲ POVANDENINĖS LUOKESŲ GYVENVIETĖS TYRIMUOSE

Giedrė Motuzaitė-Matuzevičiūtė

Santrauka

2005–2006 metais trys kernai buvo paimti iš bronzos amžiaus pabaigos – geležies amžiaus pradžios Luokesų I ežerinės gyvenvietės, kuri šiuo metu yra 1,5–2 m gylyje. Šiuose gyvenvietės stratigrafiją rodančiuose kernuose buvo nustatytas magnetinis imlumas, kaitinimo nuostoliai, dalelių dydis ir mikromorfologija. Šių tyrimų pagrindinis tikslas buvo atsakyti į klausimus: koks buvo vandens lygis Luokesų I gyvenvietės egzistavimo metu? Ar ši gyvenvietė buvo pastatyta virš vandens? Kokią įtaką Luokesų I gyvenvietės pastatų tipo nustatymui gali daryti žinios apie tuometinį vandens lygį.

Atlikti tyrimai parodė, kad Luokesų I gyvenvietė buvo statyta ant nedidelės salelės, susidariusios nusekus ežerui. Tai, kad gyvenvietės teritorijoje buvo sausuma, parodė mikromorfologiniuose šlifuose aptikti dirvožemio faunos (sliekų, dirvožemio erkių) veiklos pėdsakai ir ryški organikos oksidacija, aiškiai matoma per visą Luokesų I gyvenvietės stratigrafinį pjūvį, bei organikos *in situ* degimo žymės. Šie požymiai nuosėdose galėjo susidaryti tik sausumoje, deguonies aplinkoje. Periodiškai saloje buvo gan drėgna, todėl Luokesų gyventojai ją tvirtino smėliu, atsineštais rieduliais ir medinėmis konstrukcijomis. Pastatai gyvenvietėje galėjo stovėti ant grotelinės konstrukcijos pagrindo, šiek tiek pakelto virš žemės paviršiaus.