Rusinowo. The Symbolic Culture of Foragers in the Late Palaeolithic
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2.1. Site stratigraphy and palaeogeography

Abstract: The aim of the geoarchaeological studies was to specify the geological context of the ornamented artefact and identify living conditions of forager groups of the Late Glacial period living in the upper reaches of the Mołstowa River. The study area covered the immediate vicinity of the original find-site.

Works undertaken had an interdisciplinary character. To reconstruct the palaeoenvironmental conditions, geological fieldwork was carried out (a borehole sunk to the depth of 11 m), followed by laboratory analyses of grain size, ostracod and mollusc, hydrogeology, geomorphology and radiocarbon dating of the obtained samples,

The interdisciplinary studies have added to our understanding of the palaeogeographical evolution in the study area. During the Allerød and the Younger Dryas, a large water body sheltered by surrounding high hills was found here, creating a local environmental niche with conditions favouring human settlement. Lacustrine sediments (lake chalk) accumulated in the shallow freshwater palaeolake in conditions of cold climate and the ornamented artefact passed into the lake at this stage. As a result of the melting of blocks of dead ice, the water levels in the palaeolake rose.

Accumulation of lacustrine deposits started in the Alleröd (ca 11800 BC) and continued until the middle Subboreal (ca 2100 BC) when the palaeolake grew over and peat started to accumulate. The peat deposit is spread across the entire area, overlying depressions filled with lacustrine deposits and the sandy hills separating them.

Keywords: Mołstowa River, ostracod analysis, grain size analysis, radiocarbon dating, geoarchaeology

The study area

The study area covered the immediate vicinity of the find-site, in the valley of the Mołstowa River, 2.5 km to the north of the village of Rusinowo, 12 km to the west of Świdwin – the administrative centre of the county, in the West Pomeranian Voivodeship (Fig. 1). The aim of the research was to identify the living conditions of forager groups living in the upper reaches of the Mołstowa River at the end of the Pleistocene. The Mołstowa is a river with a length of 48.9 km and a drainage basin of 371.5 km^2. It is a right-bank tributary of the Rega – the largest river which empties directly into the Baltic Sea, flowing from the Pomeranian threshold, a distinct macro-form (geological and morphological unit), legible in the topography of the European Lowland. The study area lies on the northern slope of this landform, 40 km to the north of the terminal moraine of the southernmost range of the Pomeranian Phase, within a young glacial landscape, 5 km from the headwaters of the Mołstowa. This river has its source in Lake Klępnicko and on the upland slopes north of the village of Naćmierz. At present the bottom of the valley found within the study area has an elevation of ca. 60.0 m a.s.l., higher than the valley bottom of the Rega River, which flows parallel to the Mołstowa – ca. 50.0 m a.s.l. (Cedro 2007).

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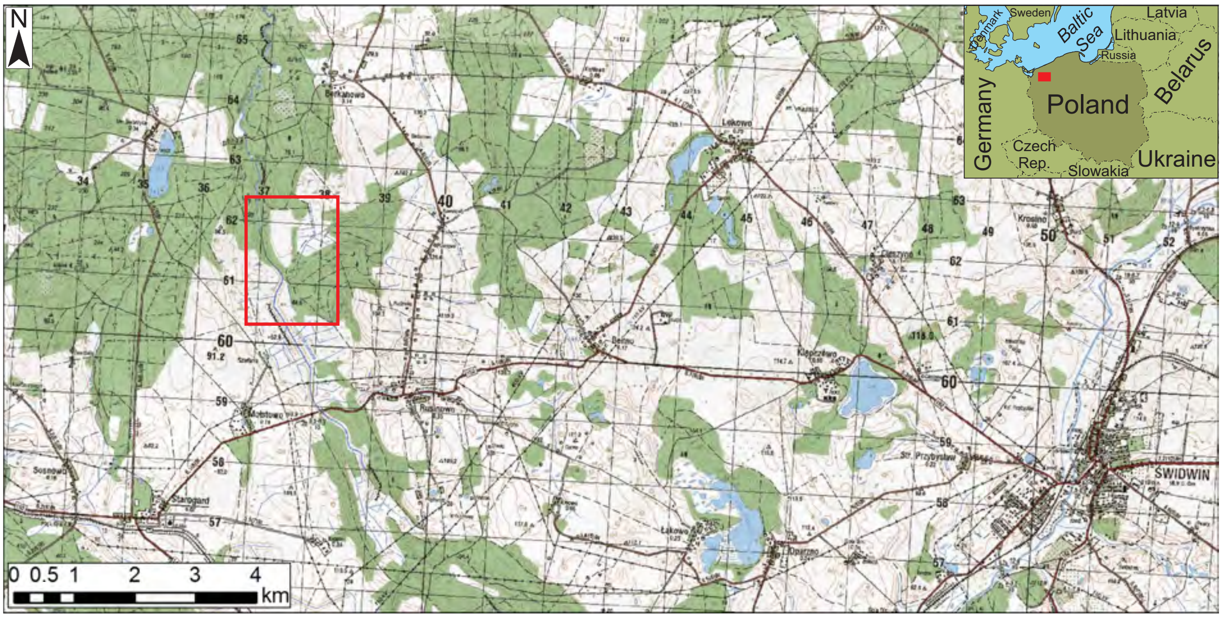

Fig. 1. Rusinowo. Location of the study area

Research methods

Interdisciplinary studies of the palaeoenvironmental conditions during the Late Glacial period included analyses of the geology, the hydrogeology and the geomorphology of the area around the archaeological site. Input was drawn from the most recent analyses of geology (Piotrowski, Szczesiak 2010a, b) and hydrogeology (Oficjalska, Krawczyńska 2000). Use was made as well of data (eg, geological profiles, drillings and geochemical analysis results) published in a geological documentation of the Krosino–Mołstowo lake chalk deposit (Włodarczak 1993).

As part of the fieldwork a drill core was extracted from 11.0 m borehole Rusinowo-1 (R1) made with a Geoprobe drilling rig. Samples were taken from the core for the purpose of laboratory analyses.

Laboratory studies included ostracod, mollusc, grain size analyses as well as radiocarbon dating. Samples were extracted from the drill core for palynology analysis. The results of this research are presented in a separate report in this volume (cf. Chapter 2.2.).

Grain size analysis was made for 21 samples (fifteen taken from the lake chalk deposit, six from the sandy deposit underlying the lake chalk). On the basis of the macroscopic description of the core and the macroscopic description of samples of the lake chalk, fifteen samples were selected for analysis, made using the laser diffraction method. Prior to making the analysis, the sediment samples were treated with 30% H_2O_2 in order to remove organic matter. Moreover, after evaporation, the samples were treated with 10% HCl in order to remove carbonates. A sample weight of ca. 1 gram taken from the selected samples was placed in an Erlenmeyer flask and immersed in distilled water and sodium pyrophosphate. Next, the obtained suspension was subjected to dispersion for 7 minutes in an ultrasonic cleaner. Later still, it was placed in a dispersion unit of a laser sizer transferring the sample to the measuring unit. The analysis was made in a Laser Particle Sizer Fritsch ANALYSETTE 22. For samples containing a sufficient quantity of the studied material the measurement was repeated in order to confirm its accuracy.

Sandy deposits underlying the lake chalk deposit were analysed by sieving (6 sandy deposit samples). Samples with a mass of 100 g each were dried and sieved on a Fritsch Vibratory Sieve Shaker ANALYSETTE 3 PRO. The interval of the sieves used was 0.25 phi.

The main fractions of the investigated sediments were identified using the Wentworth classification system (1922). For every sample Folk and Ward parameters (1957) were calculated, the grain size curves and cumulation curves plotted over a probability scale. Cumulation curve types were determined using Sindowski's classification (1958).

Ostracod and malacology analyses were made for 67 samples. A sediment sample with a measured volume was treated for 24 hours with perhydrol to remove the organic substance. Next, the sediment was washed on a sieve with 0.1mm diameter mesh.

Tab. 1. Rusinowo. Radiocarbon dating results secured for drilled samples from borehole R1

Laboratory code	Depth (m)	Metres a.s.l.	Dated material	Radiocarbon date (BP)	Years BC
Poz-65935	2.00	56.50	peat	3705 ± 35	2200–1980
Poz-65936	10.50	48.00	peat	11 960 ± 70	12 060–11 640

Species determination was made under a binocular microscope. A total of 19 mollusc species and 18 freshwater ostracod species were identified.

Radiocarbon dates for two samples were determined using the Accelerator Mass Spectrometry (AMS) technique in the Poznań Radiocarbon Laboratory. To determine the age of the onset and the end of the lacustrine sedimentation samples were taken from peat underlying (10.5 m below the level of the terrain) and overlying (2.0 m below the level of the terrain) the lake chalk (Table 1).

Results

Topography

The analysis of modern and palaeotopography was made using data from several perpendicular and longitudinal geological cross-sections, and ca. 150 boreholes drilled into the mineral substrate underlying the deposits of lake chalk, gyttja and peat, made within a project of the geological documentation of the Krosino–Mołstowo lake chalk deposit (Włodarczak 1993).

In the borehole Rusinowo-1 three main layers were distinguished in the geological profile of borehole R1, marked A, B and C. Of key importance for our considerations is the top of layer A, built by sandy sediments overlaid by a layer of peat having a thickness of 4 cm and a 14C date of 11 960 ± 70 BP (12 060–11 640 BC) resting under lake chalk (layer B) and sedge peat (layer C).

The present-day relief of the valley bottom is even, the effect of mineral-organic accumulation. The post-glacial terrain underlying the young mineral-organic deposits is more varied, and evidently includes a number of flat-bottomed depressions separated from one another by sandy elevations. It is possible to make out kettle holes left by melted out blocks of dead ice. The melting of these blocks caused changes to the local relief as sediment stratigraphy was disturbed by slipping when the substrate gave way (local landslides), the damming up of the river flowing through, fluctuation in the surface water table levels (increase and drop), formation of local lakes connected hydraulically with each other by underground waters. The map of the Pre-Holocene relief of these sedimentation basins (Fig. 2) presents eg, the original relief of the site of the discovery of the artefact. The map reveals the presence of topographic features as eg, a peninsula and incisions in the bottom of the reservoir with a depth of over 9.0 m below the level of the terrain of that age. The ornamented antler artefact was found to the west of the peninsula (Fig. 2), which at the end of the Pleistocene was surrounded by the waters of the palaeolake, with access only from the south. A sample cut off from the base of the artefact produced a radiocarbon date of 10 700 ± 60 BP (Poz-14541) (10 780–10 610 BC). The peninsula had a situation favourable for human settlement, both because it commanded the surrounding area and offered access to potable water from springs. Late Palaeolithic settlement on the peninsula was confirmed by a surface survey in 2016. A disadvantage to the settlement would have been unstable shores of the palaeolake subject to mass movement.

Geology and hydrogeology

At the stage when the area was fully buried under the ice-sheet the valley of the Mołstowa River functioned as a subglacial valley. In the section of the Mołstowa valley under analysis this is demonstrated by the following features: its deep incision into the surrounding upland, its uneven, alternately broader and constricted progress, and a very irregular uppermost stratum of Pleistocene sandy deposits underlying the organic sediment series.

In the light of the analysis of the geological map of the upland (Piotrowski, Szczesiak 2010a, b) the valley of the Mołstowa is bordered by glacial tills of the Weichselian, which emerged from under the ice-sheet, and by meltwater sands deposited the length of the valley after the retreat of the front of the glacier from the moraine of the maximum range of the Pomeranian phase, ie, after 15 200 uncal. BP. During the late Pleistocene, the uplands were a source area for carbonate deposits, and their elevated slopes formed a catchment for waters from precipitation. The waters of the first water-bearing level under the boulder clays found, and still do today, an outlet in the form of springs welling up at the foot of the slopes (Fig. 2), the source of surface waters of the

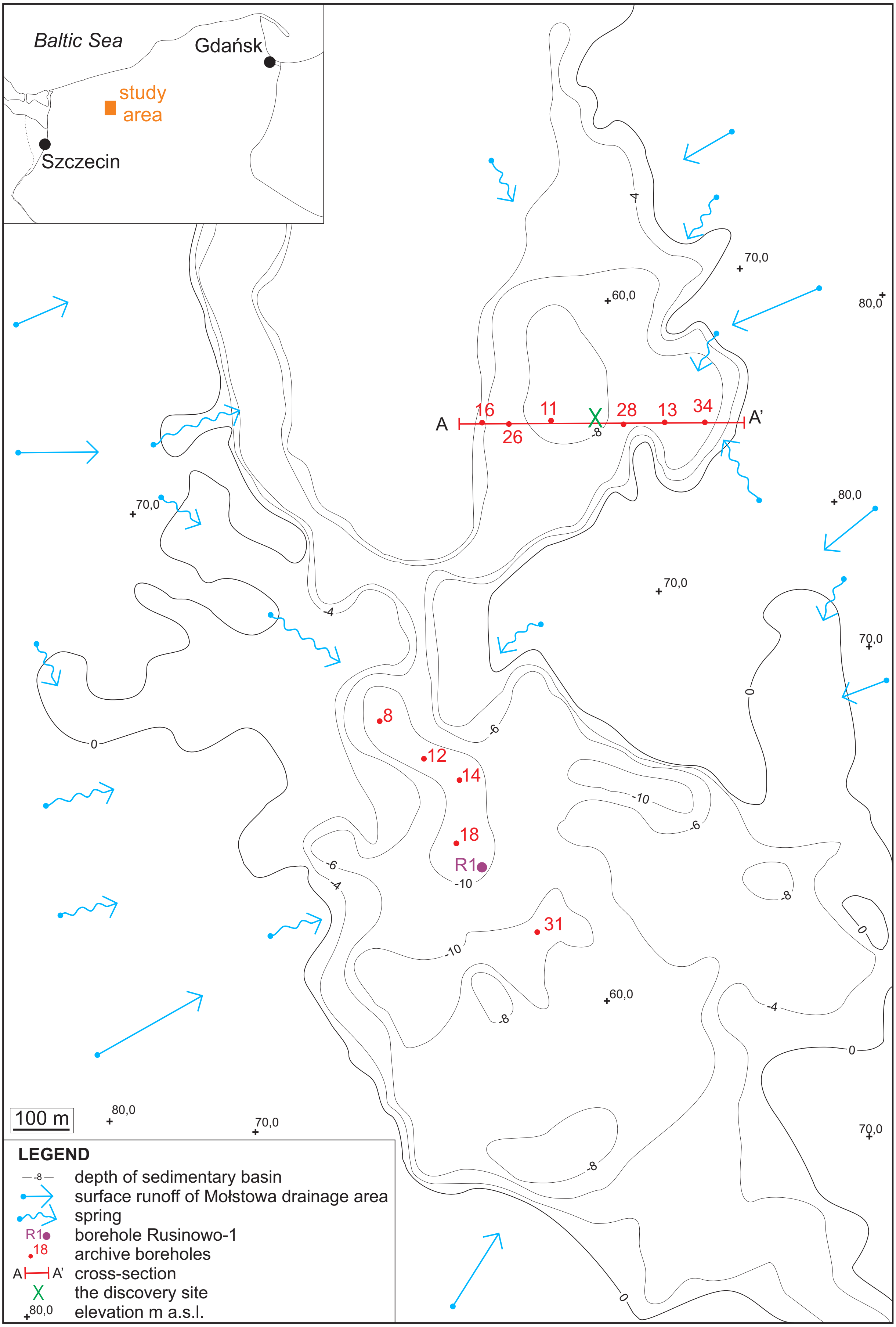

Fig. 2. Rusinowo. The sedimentation basin in the valley of the Mołstowa River investigated in the study

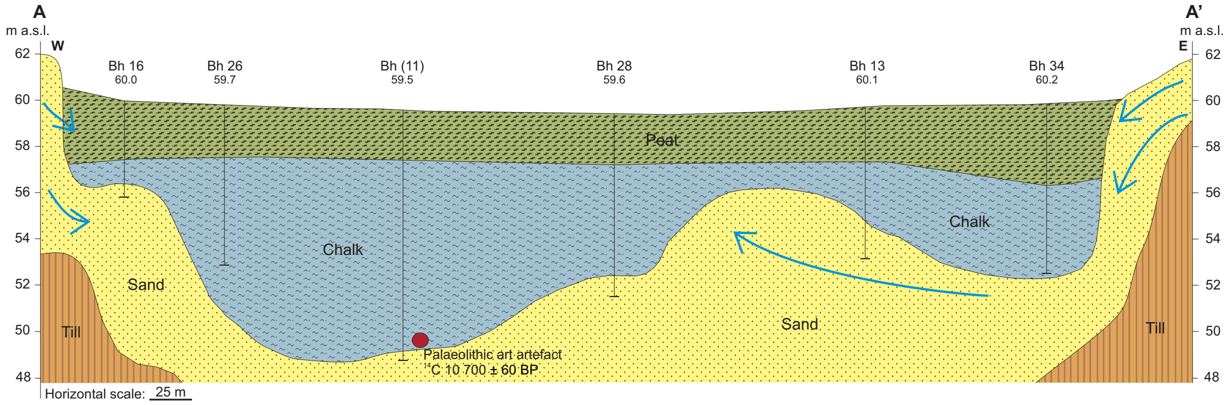

Fig. 3. Rusinowo. Synthetic view of the geological structure of subsurface deposits near the study site. Blue arrows show the direction of the water flow. The location of the geological cross-section is shown in Fig. 2

River and several lakes (Oficjalska, Krawczyńska 2000). The springs and smaller streams feeding the main stream created favourable conditions for human settlement and for migration (river transport). The late Pleistocene and the Holocene was a period of the accumulation over the surface of the variously elevated, Pleistocene sandy formations of organic carbonate deposits in the form of carbonate gyttja, locally, clayey-sandy gyttja and especially – lake chalk; while these deposits form no compact cover across the entire broader parts of the valley and have a very uneven distribution, they are sufficiently abundant and widespread to confirm the existence of a palaeolake which occupied the entire width of the upper reaches of the Mołstowa River. The layer of carbonate deposits has an alkaline reaction of pH 7.2 to 7.9, on average of pH 7.7. The originally heavily diluted sediment gradually underwent compression and became compacted under the weight of the overburden – at which stage the artefact passed into the deposit. At present the natural moisture content of the deposit is on average at 55.0% (ranging from 45.0% to 68.0%). The oxygen-poor, alkaline and bacteria-free environment favoured the survival of the osseous tissue of the antler artefact. The carbonate layer of the lake chalk accumulated over approximately 8000 years and has at present a thickness of 8.5 m. Taking account of the average rate of sedimentation of 1 mm/year it may be estimated that the artefact had passed (dropped by accident or deliberately discarded) into the carbonate deposit then 1.0 m thick, and sank immediately, thanks to its jelly-like consistency. The datum of the top of the stratum at that time was at 47.0 m a.s.l. Resting over the carbonate deposits (lake chalk), and where they are not present, immediately over sands, is a compact layer of peat which fills the whole valley bottom. Jointly, the thickness of the organic formation series (jointly – gyttja, chalk and peat) is quite varied and ranges from less than 1.0 m to 12.6 m. A synthetic view of the geological structure of subsurface valley deposits in the vicinity of the study area may be seen in cross-section A-A' (Fig. 3).

Grain size

Based on changes in the proportion of individual fractions, variation in grain size statistics, analysis of grain size curves and of cumulation curves, two lithofacies were separated within the investigated drill core, marked as L1 and L2, with between them, a layer of peat.

Lithofacies L1 occurs at the depth of between 11.0 m and 10.52 m. Its main fraction is fine sand, ranging in content from 25.84% (sample from the depth of 10.55–10.60 m) to 52.3% (sample from the depth of 10.85–10.90 m). On occasion, the silt fraction may be present, ranging from 2.16% (depth 10.85–10.90 m) to 22.89% (depth 10.52–10.55), and the gravel fraction (from 0.22%, at the depth of 10.60–10.70 m, to 7.94%, at the depth of 10.70–10.75 m) (Figs. 4 and 5). This sediment is characterized by moderate to poor sorting (σI 0.89–1.74). The sediments in lithofacies L1 are characterized by a substantial range of skewness $-Sk_I = -0.37 - 0.29$). The range calculated for kurtosis is similarly large. In the analysed lithofacies this parameter ranges from $K_G = 0.89$ (platykurtic distribution) to $K_G = 1.64$ (very leptokurtic distribution).

Analysis of the spatial variability of the Folk and Ward parameters within the lithofacies L1 demonstrates a correlation of individual parameters with depth (Fig. 5). The decrease in depth is paralleled by an increase in the value of the mean grain size (Mz), and by a minor improvement in sorting (a minor drop in the standard deviation σ_I). Despite marked fluctuations, there is also an observable increase of

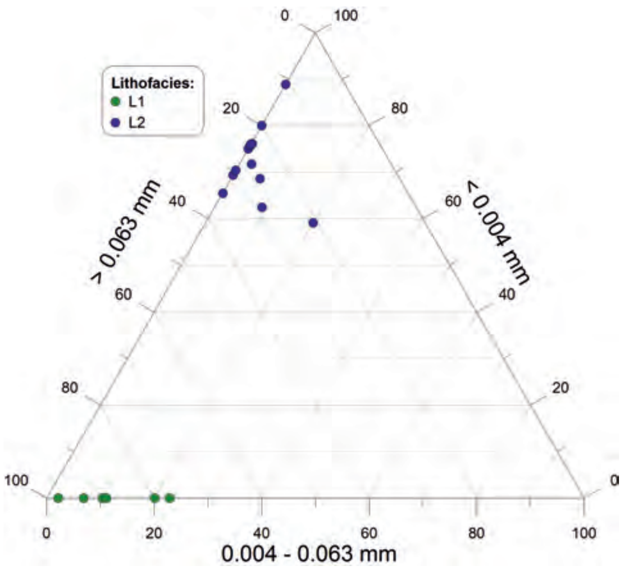

Fig. 4. Rusinowo. Triangle diagram of grain-size analysis results

the skewness (Sk_I) and a decrease in the value of the kurtosis (K_G) parallel with decreasing depth.

Cumulation curves (Fig. 6A) obtained for the investigated deposit were moderately sloping (type MG). Grain size curves (Fig. 6B) are of the multimodal type. The highest modes cluster mostly at values 2 phi, 2.75 phi, 4 phi and 4.75 phi.

Lithofacies L2 occurs at the depth of between 2.55 m and 10.0 m. The results of the grain size analysis show that the investigated deposit has a uniform grain size composition (Figs. 4 and 5). The main fraction are silts. Their content ranges from 59.11% (sample from the depth of 9.80–9.85 m) to 88.92% (depth of 9.35–9.40 m). Clay forms an admixture, ranging in content from 11.08% (depth of 9.35–9.40 m) to 34.48% (depth 9.40–9.45 m). The sand fraction was present in 6 samples only, and in 2 samples had a content of less than 0.22%. The

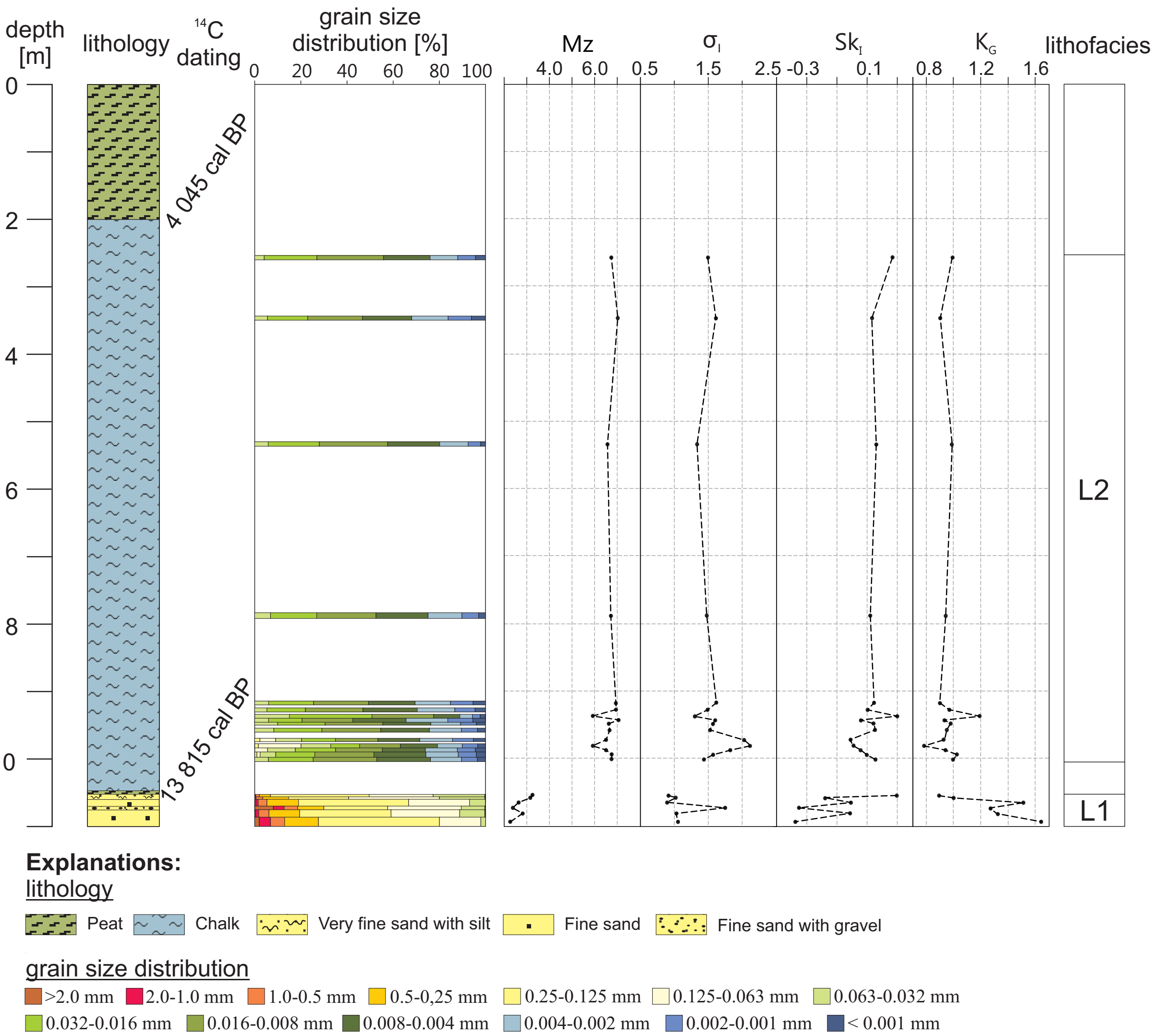

Fig. 5. Rusinowo. Spatial variability of the percentage of individual fractions, Folk and Ward parameters (1957); lithofacies identified in the drill core and the radiocarbon dating results

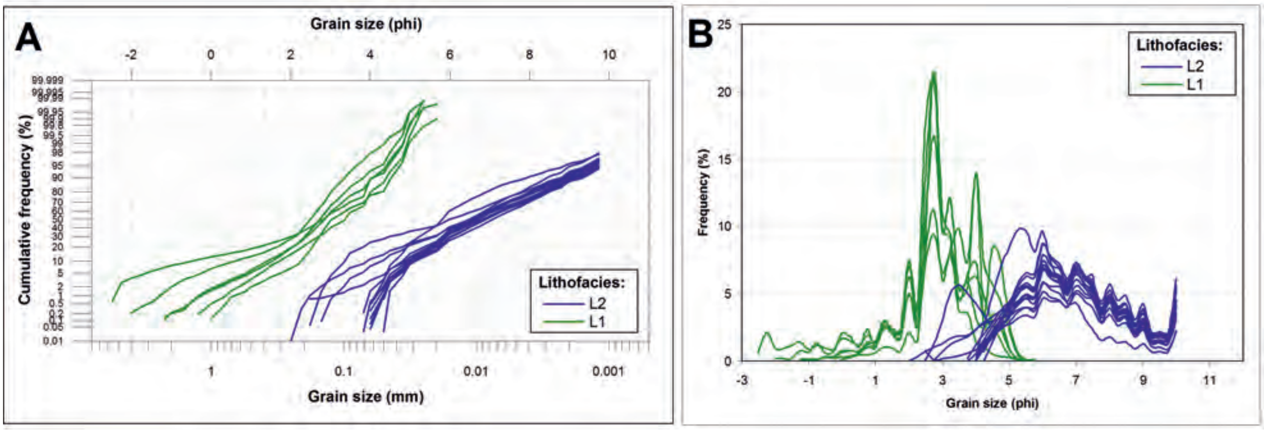

Fig. 6. Rusinowo. Cumulative curves (A) and grain-size curves (B) obtained for sediments identified in the analysed section of the drill core

highest content of the sand fraction was 20.05%, noted in a sample from the depth of 9.80–9.85 m, the lowest content – 0.03%, in a sample from the depth of 9.40–9.45 m.

In general, the investigated samples represent finely dispersed deposits. An admixture of the coarser fraction is seen only at the bottom of the analysed section. From the level of 9.25–9.30 m the content of individual fractions remains virtually unchanged. There is no sand fraction.

Sediments of lithofacies L2 are characterized by poor and very poor sorting (σ_I 1.28–2.12). The skewness parameter is symmetrical and negative (Sk_I = from -0.01 to 0.29). Kurtosis ranges from platykurtic to leptokurtic (K_G from 0.78 to 1.19).

Analysis of spatial variability of mean grain size parameter Mz (Fig. 5) revealed a marked tendency only at the depth of 10.0 m to 9.15 m, where there is some minor fining upwards in the grain size (increased value of the parameter). The tendency observed for the standard deviation is variable. In the 10.0–9.80 m interval, the sorting of the sediment was less marked with a decrease in depth (increased value of the parameter). In the 9.80–9.15 m interval, a reverse tendency is observed – moving up there is an improvement in sorting (decreasing values of this parameter). The skewness parameter in the 10.0–9.80 m interval was marked by a decrease in value moving upward, whereas upwards of 9.80 m the tendency is for the parameter to increase moving up. Analysis of the spatial variability of the kurtosis parameter did not reveal the existence of any more marked tendencies.

Analysis of cumulation curves (Fig. 6A) revealed that the sediment in lithofacies L2 is marked by the occurrence of curves initially sharply peaked, with an angle of 60–65°, passing towards finer fractions into relatively flat, with an angle of 15–25°. According to the classification of Sindowski (1958), this is a type PG-FG curve. Grain size curves (Fig. 6B) obtained for the investigated sediments are of the multimodal type. The highest modes occur at the value of 6 phi, 7 phi, 8.5 phi and 9 phi.

Ostracods and molluscs

The lowermost, sandy layer in the drill core, corresponding to the depth of 10.94–10.52 m, lacks ostracods. The ostracod assemblage found at the depth of 10.44–10.20 m (the bottom of lake chalk) included: *Candona candida*, *Candona neglecta*, *Cyclocypris laevis*, *Cypridopsis vidua*, *Fabaeformiscandona fabaeformis*, *Herpetocypris reptans*, *Limnocytherina sanctipatricii*, *Limnocythere inopinata*, and mollusc species Pisidium casertanum and the glochidia of *Anodonta* sp. a large amount of the glochidia of *Anodonta* sp. present in the sediment may serve as an indicator of temperatures of their habitat. Females release a vast quantity of glochidia – larvae protected by a 'shell' – in the spring-summer season, which suggests that the accumulation of the sediment containing glochidia took place also during the warm season (Brodniewicz 1968).

At the depth of 10.15–9.60 m the ostracod assemblage included *Candona candida*, *Candona neglecta*, *Cytherissa lacustris*, *Limnocytherina sanctipatricii*. Out of this group, the species *Cytherissa lacustris* is narrowly specialised as to the habitat type. Its domination in the assemblage suggests living conditions optimal for this species. It occurs in lakes at different depths, mostly in the sublittoral and profundal zone, with a preference for oligotrophic lakes. It is a eurythermal species with a preference for cold waters. Next to the ostracod species named the analysed assemblage included mollusc species: eg, *Pisidium obtusale*, *Pisidium conventus*, *Pisidium milium*, *Pisidium nitidum*.

At the depth of 9.60–8.65 m there was a minor percentage of mollusc species and a high proportion of the glochidia of *Anodonta* sp. The species *Cytherissa lacustris* was no longer present, but there was an increase in shallow-water ostracods: *Cyclocypris laevis*, *Fabaeformiscandona levanderi*, *Cypridopsis vidua*.

At the depth of 8.20–5.30 m was seen, the first time, a large quantity of the following species: *Candona candida*, *Cyclocypris laevis*, with a minor percentage of *Cytherissa lacustris*, which could indicate an increase in trophism, as a result of temperature increase. The species *Cypridopsis vidua* is present once again, possibly indicating the tendency of the palaeolake to grow shallow.

At the depth of between 5.30 m and the upper end of the sequence the ostracod assemblage included: *Candona neglecta*, *Limnocythere sanctipatricii*, *Darwinula stevensoni*, *Cyclocypris laevis*, with some molluscs species present, which possibly reflects the shallowing out and growing over of the palaeolake.

The described faunal assemblages and its sequences are a reflection of the character and changes of the sedimentary environment. The presence of the mollusc and ostracod species named would confirm the existence of a palaeolake in the study area. The character of the ostracod assemblages proves that this was a water body with stabilized conditions of sediment deposition.

During its initial period, the reservoir held nutrient-rich, cold water (presence of cryophilous ostracods). A change in environmental conditions took place at the time of the accumulation of sediments in the central part of the drill core. The faunal analysis reveals the presence at this time of a large quantity of ostracod species which are typical for mesotrophic waters and a decline in mollusc fauna. Only the presence of the glochidia of *Anodonta* sp. suggests a periodical, possibly minor, increase in the temperature of the lake water, most likely associated with seasonal change. Possibly, this change went hand in hand with an increase in the water level, or an increase in trophism, suggested by the observed composition of the ostracod species. No ostracod or mollusc remains survived in the peat deposit overlying the sediments of lake chalk.

Geochemical analysis

In the present study, we drew on results of analyses completed while making the geological documentation of the Krosino–Mołstowo lake chalk deposit (Włodarczak 1993).

The chemical analysis of the lake chalk was made using methods described in the norm PN-76/B-04350. Variation in total alkalinity was determined, converted into calcium oxide (CaO) values. The variation in the content of oxides and carbonates of calcium and magnesium demonstrates a level of variation in environmental conditions prevailing in the sedimentation basin. This variation is observed both in the vertical profile and in cross-sections at different locations. The chemical analysis results are presented in the synthetic geological log (Fig. 7). The carbonate content in the sediments converted into CaO values is on the average on the level of approximately 40%, with some decrease in content moving towards the bottom of the stratum (down to 32.0%) - at ca. 47.0 m a.s.l.,

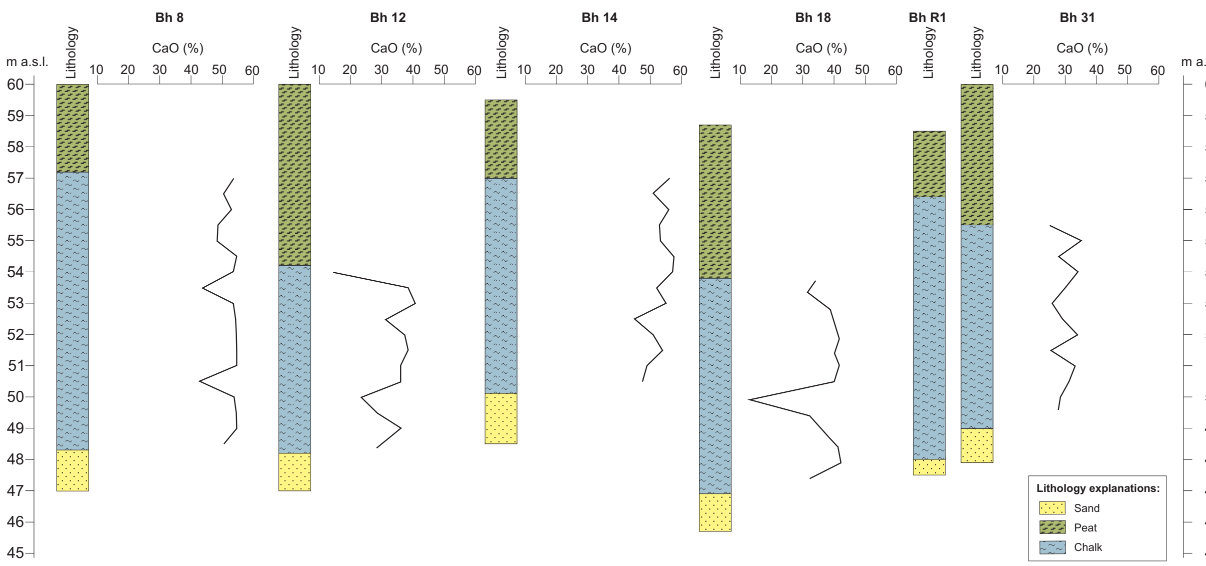

Fig. 7. Rusinowo. Calcium compounds content converted into CaO (based on data from: Włodarczak 1993). The lithological profile sampled from borehole R1 is given here for comparison. The location of the borehole is shown in Fig. 2

and 12.5%, at 50.0 m a.s.l. The decrease in the carbonate content may be interpreted as resulting from the fluctuation of the water level in the palaeolake caused by seasonal changes in climate humidity (amount of precipitation) and in the afforestation in the catchment. Another contributing factor during the Allerød and the Younger Dryas could have been changes in flow caused by the melting of blocks of dead ice. The sediment is characterized by a high mean pH of 7.7. The colour of the dried sediment is grey, although when wet the shades of this colour reflected a moisture level ranging from 45.0% to 68.0%, with an average of a 55.0%.

Discussion and conclusion

The aim of the present study was recognition of environmental conditions prevailing during the Late Glacial period and early Holocene in the area of the find-site of an object of Palaeolithic art thought to date to the Allerød – Younger Dryas transition (10 750–10 470 BC). The study area emerged 15 200 years uncal. BP from under the ice-sheet. In the Allerød and Younger Dryas, the route of migrations of the hunters ran SE to NW, across the southern and south-western shelf of the Baltic, then in the stage of the Baltic Ice Lake, gradually encroaching on dry land with time, over the landbridge of the Darss sill, to the area of today's Denmark (Kramarska *et al.* 1995; Björck 1995; Jensen *et al.* 1999). Convenient conditions on this route of animal and human migration were provided by the valley of the Mołstowa River. Rich in water springs, with a large lake to fish in, sheltered by surrounding hills, it offered a local niche with conditions suitable for human settlement.

The borehole investigation and the interdisciplinary study of samples from the drill core taken from borehole R1, assisted by the analysis of the geological structure and local topography enable a number of conclusions regarding the palaeogeography of the area, particularly as it was during the late Weichselian. The investigated area lies on the northern slope of Pomerania, which forms part of a lakeland visible within the topography of the European Lowland. The date of the lower peat (11 960 ± 70 BP) establishes for us the time of the origin of a body of standing water, site of the discovery of the artefact. This layer correlates also with a peat deposit stratum in the valley of the Rega near Łobez (Cedro 2005) where the peat documents well the stage of the development of the landscape which was followed by changes caused by the melting of the blocks of dead ice. According to Błaszkiewicz (2005) already Bølling warming could have triggered the melting of the blocks of dead ice, only this did not immediately lead to the formation of the palaeolake. Peat started accumulating over the sandy deposits overlying the thinning ice; as ice continued to melt, this peat was submerged, forming the basal peat layer in the series of the lacustrine deposits. Pollen analysis made for this case study (Malkiewicz, in this volume) confirms the development of the landscape and geological processes described here.

Parallel with the melting of the dead ice the water level rose in the sedimentation basin then accumulating a deposit of lake chalk (layer B). Analysis of the grain size of the mineral sediment indicates undisturbed conditions of sedimentation. The palaeolake was fed by carbonate-rich water from the waterbearing layer underneath and from springs found in its vicinity. The analysis of the geochemistry study results indicates a relatively small dynamics of the groundwater and waters from surface runoff flowing into the isolated sedimentation basins. The reduced calcium carbonate content in the lowermost part of the geological profile in the discussed site is interpreted in terms of change in the rate of the flow and in the level of waters, caused by the melting of blocks of dead ice. The analysis of faunal remains confirmed the existence of a cold-freshwater lake, from the Allerød to the Subboreal period. According to the environmental data, the accumulation of the sediments under analysis occurred in a shallow freshwater lake, in conditions of a cold climate. This process started during the late Pleistocene (Allerød) and continued into the Subboreal period.

The investigated assemblages of mollusc and ostracod fauna have been correlated with the local pollen assemblage zones (L PAZ). In the Allerød and Younger Dryas, the lacustrine environment of accumulation of the investigated sediments is confirmed by the presence of molluscs and freshwater ostracods which include cold-climate forms (*Armiger crista* f. *cristatus*, *Pisidium milium*, *Pisidium nitidum*, *Pisidium obtusale*, *Candona candida*, *Candona neglecta*, *Cytherissa lacustris*, *Limnocytherina sanctipatricii*). In the Preboreal period, the lake continued evolving, as reflected by its mollusc and ostracod fauna, until the Boreal period when it became shallower and grew over, as indicated by the presence of shallow-water ostracod species such as *Cypridopsis vidua, Darwinula stevensoni* and the

Tab. 2. Rusinowo. Species composition of mollusc and ostracod fauna identified in the analyzed samples

Depth (m)	*Molluscs*																		
	Acroloxus lacustris	*Armiger f. cristatus*	*Bithynia leachi*	*Bithynia tentaculata-wieczka*	*Gyraulus rossmaessleri*	*Lymnaea peregra*	*Segmentina nitida*	*Valvata cristata*	*Valvata piscinalis*	*Valvata piscinalis f. antiqua*	*Pisidium casertanum*	*Pisidium casertanum f. ponderosa*	*Pisidium conventus*	*Pisidium milium*	*Pisidium nitidum*	*Pisidium obtusale*	*Pisidium pseudosphaerium*	*Pisidium subtruncatum*	***Anodonta - glochidium***
2.55-2.60	×			×			×	×		×	×								
3.15-3.20				×															
3.45-3.50				×															
3.65-3.70				×															
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Depth (m)	*Ostracods*																	
	Candona candida	*Candona neglecta*	*Candona weltneri*	***Cyclocypris laevis***	***Cypridoposis vidua***	*Cyprinotus salinus*	*Candona hyalina*	***Cytherissa lacustris***	***Darwinula stevensoni***	*Fabaeformiscandona caudata*	*Fabaeformiscandona fabaeformis*	*Fabaeformiscandona levanderi*	*Fabaeformiscandona protzi*	*Herpetocypris reptans*	*Metacypris cordata*	*Pseudocandona compressa*	*Limnocythere inopinata*	*Limnocytherina sanctipatricii*
2.55-2.60	×	×		×	×		×		×			×			×	×	×	
3.15-3.20	×	×		×					×	×								
3.45-3.50	×	×		×					×		×							
3.65-3.70	×	×		×														×
4.15-4.20	×	×			×				×									
4.40-4.45	×	×		×					×									
4.65-4.70	×	×		×					×				×					
4.80-4.85	×	×		×						×								
5.00-5.05	×	×		×					×	×			×					
5.15-5.20	×	×		×					×								×	×
5.30-5.35	×	×		×					×	×	×							×
5.60-5.65	×	×		×					×								×	×
5.80-5.85	×	×																
6.00-6.05	×	×		×														×
6.05-6.10	×	×		×														×
6.10-6.15	×	×							×				×					×
6.15-6.20	×	×		×														
6.20-6.25	×	×							×				×					
6.25-6.30	×	×							×									×
6.30-6.35	×	×		×	×				×									×
6.35-6.40	×	×			×													
6.40-6.45	×	×			×							×	×					×
6.45-6.50	×	×							×			×	×					×
6.50-6.55	×	×		×														×
6.55-6.60	×	×		×								×	×					

6.60-6.65	6.65-6.70	6.70-6.75	6.75-6.80	6.80-6.85	6.85-6.90	6.90-6.95	6.95-7.00	7.15-7.20	7.65-7.70	7.80-7.85	7.85-7.90	8.15-8.20	8.65-8.70	8.80-8.85	9.15-9.20	9.25-9.30	9.35-9.40	9.40-9.45	9.45-9.50	9.50-9.55	9.55-9.60	9.60-9.65	9.65-9.70	9.70-9.75	9.75-9.80	9.80-9.85	9.85-9.90	9.90-9.95	9.95-10.00	10.00-10.05	10.05-10.10	10.10-10.15	10.15-10.20	10.20-10.25	10.25-10.30	10.30-10.35	10.35-10.40	10.40-10.44
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Tab. 3. Rusinowo. Environmental change around the site at Rusinowo in the late Pleistocene and Holocene

Age (years BP)	Chronozones	Sedimentation series	Water level elevation	Living conditions determined by interdisciplinary research
0	Subatlantic period	C (fluvial and marsh sediments) – sedge peat	▼ 58.5 m a.s.l.	• agricultural drainage work in the 19th century; • regulation of the Mołstowa River – a canal
2 500	Subboreal period			• onset of the deposition of peat (3705 ± 35 BP) accumulated over the basins filled with chalk; peninsulas and islands; • the runoff from the extensive source area takes form
5 000	Atlantic period	B (lacustrine) – lake chalk	▼ 56.5 m a.s.l. 2.40 m	• end of the lacustrine sedimentation; • basins originally separated by islands are filled in; • diagenesis of lake chalk – transition from a colloid system to gel form (soft-plastic and plastic); • due to compaction, the lowering of the uppermost layer of the lake chalk
8 000	Boreal period			• a fairly deep reservoir of standing water takes form fed by surface and groundwaters rich in calcium carbonate, especially the latter; • the palaeolake bottom accumulates carbonate sediment formed as a result of chemical and biochemical precipitation of calcium carbonate in waters rich in phytoplankton and aquatic vegetation, and bacteria absorbing CO_2 influencing the capacity of the lake water to dissolve calcium carbonate; • water level fluctuation associated with long-term fluctuation in precipitation (changes in the content of CaO, ostracod species, presence of molluscs)
9 000	Preboreal period		7.18 m 7.85 m 9.55 m	
10 000	Younger Dryas		>>>	• hunting activity by Palaeolithic foragers, the making of the Palaeolithic ornamented artefact dated to 10 700 ± 60 BP); • human settlement favoured by the varied shoreline of the initial phase of the lake – with many islands and peninsulas, and the presence of groundwater springs; • well defined surface water catchment formed by the old postglacial upland; • difficult living conditions – the margin of the sedimentation basin affected by intensive mass movement (sliding and slumping) with the loss of support from dead ice, and also as a result of the angle of slope of 3-8%; • the hills around the lake reach the relative altitude of 40-50 m
10 700	Allerød		10.0 m ▼ 48.0 m a.s.l.	
11 800	Older Dryas	A (fluvial) – peat in the uppermost layer over fine sand		• accumulation of peat containing chemically precipitated calcium compounds (11 960 ± 70 BP); • the melting of the blocks of dead ice, meltwaters flowing from the thawing glacier and waters groundwater seepage lead to the formation of the first shallow lake and to the accumulation of peat
12 000	Bølling			
12 300	Oldest Dryas			• blocks of dead ice remaining after the retreat of the continental ice-sheet from the northern slope of Pomerania survived in depressions within the upland, eg, in the subglacial valley of the Mołstowa

Key:

▼ groundwater table [m a.s.l.]

mollusc shell fragments suggesting a shallowing out of the lake and the depth within the drill core R1 at which they were found

>>> artefact

decline of the mollusc fauna. The youngest sediments, from the Atlantic period, contain mollusc and ostracod fauna indicative of a shallow, overgrowing lake with a lush vegetation.

With a 14C date of 3705 ± 35 BP (2200–1980 BC) the base of the upper peat layer (layer C) marks the time-boundary for the accumulation of lake chalk. Peat building the layer C forms a deposit which covers the entire area, overlying depressions filled with lake chalk, and sandy elevations separating them. Furthermore, peat also encroached on adjacent areas subjected to natural water seepage, at elevations higher than those of the sedimentation basin.

In the geological studies, focus was placed on the full range of the palaeogeographic development of the upper reaches of the Mołstowa River so as to explain possibly comprehensively the geological conditions of the life of late Palaeolithic hunters during a narrow time-period, around the transition from Allerød to the Younger Dryas. Surrounded by moraine ranges with a relative elevation of 50.0 m, the natural landscape of the upper Mołstowa valley was a catchment of surface and groundwater rich in calcium carbonate. Some of the conditions in the valley assisted while others discouraged human life. The towering hills sheltered from cold winds, and the numerous springs supplied good quality potable water. With a depth of approximately 6.0 m the palaeolake had a shoreline more irregular than the one suggested by the modern day view of the peatland. The varied shoreline, sandy islands and peninsulas offered favourable conditions for settlement and fishing, whereas the melting of blocks of dead ice buried in the sands would have been a hindrance. As kettle hole lakes gradually came into being there were some intensive geodynamic processes – mass movement – sliding and slumping of the lake shores. The gradient of the slopes may have reached the natural angle of repose of 33%. After the accumulation of peat at 14C 11 960 ± 70 BP the water level rose and *Cytherissa lacustris*, a predominant species in the ostracod fauna, indicates cold waters of the sublittoral and the profundal zone. By 14C 10 700 ± 60 BP the thickness of the carbonate deposits had reached 100 cm, with its uppermost layer at 47.0 m a.s.l.; during the same period the water level in the palaeolake was at ca. 56.0 m a.s.l. When it came to rest on the palaeolake bottom, the ornamented antler artefact sank into the lake chalk then having a jelly-like consistency. The chemical properties of this sediment: high alkalinity at pH 7.7, an environment hostile to bacteria and oxygen-poor, guaranteed the survival of the osseous tissue of the antler complete with the morphology of its surface.