

4 The palaeoenvironment of the 'Antrea Net Find'

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Abstract

The 'Antrea Net Find', found in 1914 in Korpilahti in the Karelian Isthmus, is one of the most important archaeological discoveries in Finland. For a long time, it was the oldest dated net find in Europe.

New sediment samples were taken from the assumed find spot in 1998. The original net material and the new sediment sequence around the find spot were re-investigated using modern physical and palaeoecological techniques. They included AMS radiocarbon dates from the net material and the sediment above the find, as well as lithostratigraphical and isotope analyses from the surrounding sediment sequence. Also the material of the net cord was investigated. The palaeoenvironment of the Korpilahti area around the time of the event was reconstructed using modern biostratigraphical diatom and pollen methods.

The 'Antrea Net Find' was recovered from the uppermost part of silty clay gyttja. The AMS radiocarbon date of the net yielded an age of 9140±135 BP. The net cord has been made of willow bast. The dates from the silty gyttja sediment above the find level yielded the ages 9095±90 and 8965±85 BP. Stable isotope data indicate a rapid change in the sediment c. 9000 BP (8250 calBC).

The radiocarbon dates with the diatom stratigraphy typical for the *Ancylus* Lake stage from Korpilahti suggest that the artefacts sank at the time of the maximum of the *Ancylus* transgression between 9200 and 9100 BP (8400 and 8300 calBC). At this time, the environment was characterized by forests dominated by pine, which had been present for hundreds of years, and thus the bark of old trees was readily available for the bark floats.

4.1 Introduction

In 1914 a remarkable archaeological find was made in the northern part of the Karelian Isthmus, between Lake Ladoga (Fi. Laatokka, Ru. Ladožskoe ozero) and the Gulf of Finland, at the time still within Finnish territory (Fig. 4.1). The find is often called the 'Antrea Net Find' even though the find spot is located at Korpilahti (currently uninhabited) in the former municipality of Vuoksenranta (Ru. Ozërskoje). The find consisted of the remains of a Stone Age fishing net and 57 artefacts, including tools made of stone, bone, and antler (Pälsi 1920; Carpelan 2008, this volume). Bark floats and stone sinkers belonging to the net were preserved, together with some remains of cord and bindings. The artefacts were found during the excavation of a

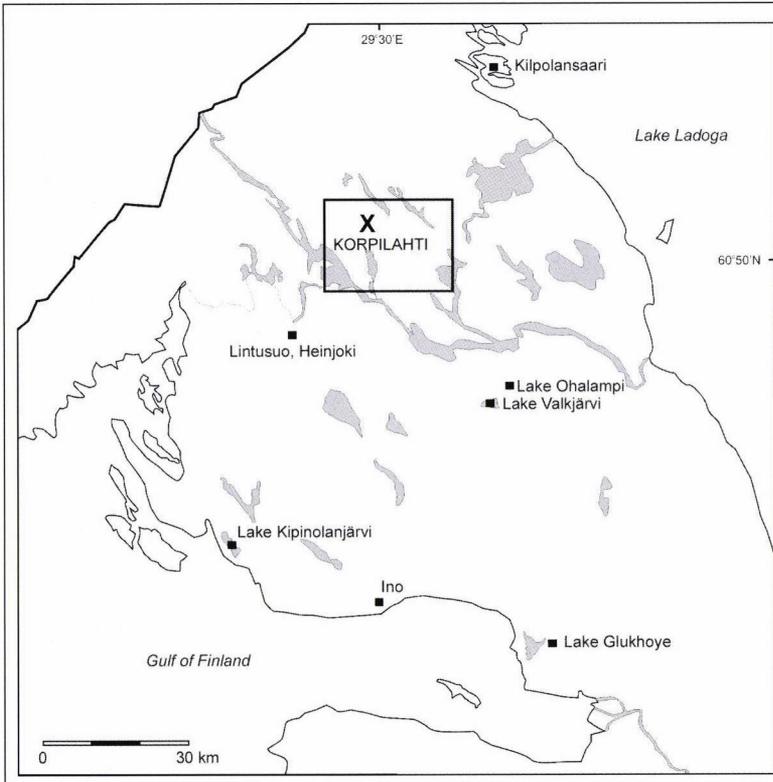


Figure 4.1 The location of Korpilahti and previously radiocarbon dated shore level sites in the Karelialahti. The area covered by the detailed map of Korpilahti (Fig. 4.7) is also shown.

ditch in a wetland. The objects were lying at a depth of about one metre, on the contact horizon of silty clay and silty gyttja, indicating that the artefacts had been deposited in water. Later, the site has emerged from water.

Because there was no direct way to date the find, an attempt was made to date it by applying the shore displacement history of the Baltic basin and the postglacial forest history. Harald Lindberg (1920) carried out a diatom analysis of the sediment samples collected at the site and concluded that the find derived from the early part of the Ancylus Lake stage. Archaeologists, however, did not accept this early date for decades (Carpelan 2008, this volume). Later, the sediment column was re-examined twice applying pollen analysis (Hyyppä 1934; Sauromo 1951). The results suggested that the find derived from the early Holocene, when pine forests had become established. An additional proof was achieved when two of the floats were

radiocarbon dated to an age of c. 9200–9300 BP (c. 8400–8600 calBC) (Jungner 1979; Jungner & Sonninen 1983).

In autumn 1998, a reconnaissance trip to the Karelialahti was arranged by the Department of Archaeology at the University of Helsinki (see Siiriäinen *et al.* 2008, this volume) (Fig. 4.2). The program included a visit to the site of the ‘Antrea Net Find’. The aims of the visit were to define the find location and to collect a new sediment profile in order to continue the research into the date of the find and the palaeoenvironment of the surroundings. The original sample column taken by Pälsi in 1914 could no longer be found in 1998.

The possibility of carrying out a radiocarbon dating of the net cord itself applying the AMS technique provided the starting point. The aim was to compare the date of the net (with a negligible discrepancy between the date and the time of use) to the dates of the floats made of the

Figure 4.2 Sampling underway in Korpilahti; Ari Siiriäinen excavating a test pit, Aleksandr Saksa, Vladimir Timofeev, Christian Carpelan and Matti Eronen observing. (Photo: P. Uino 1998)



shield bark of pine (with a probably noticeable discrepancy between the date and the time of use) (cf. Waterbolk 1983). The date of the net would represent the accurate age of the find and the find level in the stratigraphy.

New sediment samples enable dating features of the stratigraphy for comparison with the date of the net and carrying out a more detailed palaeoenvironmental study with the help of diatom and pollen analysis. The current methods also allow comparing the results with the previous studies carried out in the Isthmus in order to achieve an overall picture of the environment at the time when the net was used.

4.2 Site and sampling

The find spot is located in Korpilahti (60°53'N, 29°27'E) (Carpelan 2008, this volume). At the time of the discovery in 1914, the environment was former wetland that the local farmers were draining in order to obtain additional field area for hay and crops. The name of the village, Korpilahti (En. 'Wilderness Bay'), indicates that this wetland had formed part of a lake up to 1857, when the dredging and opening of a

new direction for the River Vuoksi (Ru. reka Vuoksa) drained the large lake in the middle of the Karelian Isthmus (cf. Saarnisto 2003; 2008, this volume).

For the sampling, a pit of 1 m² was dug to the depth of c. 103 cm below the surface. The sediment sequence was sampled with cubes cut from the pit walls. In addition, five sediment cores were cored from the side of the pit with a Russian sampler covering the depths between 80 and 190 cm (Fig. 4.3).

4.3 Material and methods

The amount of organic matter in the sediment was determined by the loss-on-ignition (LOI) method (Salonen *et al.* 2002). The stratigraphy of the sediment was confirmed through visual observation and LOI. The LOI% 2, 6, and 20 were used as limit values to determine the sediment type boundaries clay/gyttja clay, gyttja clay/clay gyttja and clay gyttja/gyttja, respectively.

For diatom analysis, volumetric subsamples of 1 cm³ were taken from cubes cut from the pit walls and sediment cores 1, 2, and 4. Sub-

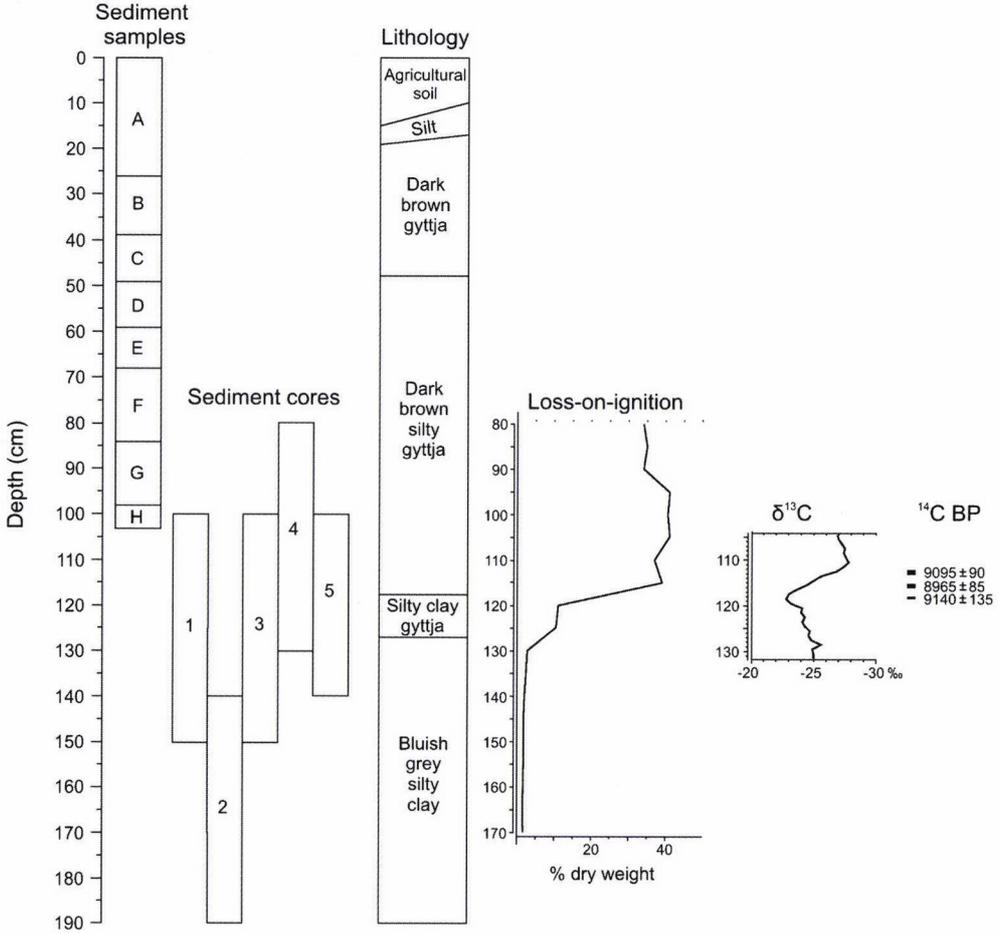


Figure 4.3 Sediment samples and cores, lithology, loss-on-ignition, $\delta^{13}\text{C}$ record and radiocarbon ages of the investigated sediment sequence from Korpilahti.

samples were taken at 5 cm intervals, except between 105 and 130 cm, where the interval was mainly 2.5 cm, and at 80 and 90 cm, where the interval was 10 cm. The diatom samples were prepared according to standard methods (Battarbee 1986). Where possible, at least 300 valves were counted in each sample. The taxonomy and grouping of the diatoms according to their biotype is based on the following sources: Mölder & Tynni (1967–1973), Tynni (1975–1980), Krammer & Lange-Bertalot (1986–1991). The main groups according to biotype are planktonic and littoral forms. The

latter group is divided further into benthic and epiphytic forms. In this paper, the diatoms are also classified into two main groups: large lake and small lake forms.

For pollen analysis, volumetric subsamples of 1 cm³ were taken from cubes cut from the pit walls and sediment cores 1, 2, and 4. Subsamples were taken at 5 cm intervals, except at 170 and 180 cm where the interval was 10 cm. The laboratory treatment followed standard KOH, HF, and acetolysis methods (Fægri & Iversen 1989). The counted pollen sum varied between 131 and 773 terrestrial pollen grains.

In the lowermost samples consisting of silt, the pollen concentrations were very low, resulting in low quantities of counted pollen (c. 200), but in the section of silty gyttja, higher quantities were enumerated (c. 550–700). The total sum of terrestrial pollen was the basic sum for the percentage calculations. The percentages for the spores and the aquatics were counted from the basic sum with the addition of the sum of the spores or the sum of aquatic pollen. The TILIA and TILIA-GRAPH software (Grimm 1991) were used for drawing the pollen and diatom diagrams.

For isotope analyses, samples with a thickness of 1 cm were taken from three different sediment cores, 1, 3, and 4, at depths between 104 cm and 132 cm. Samples were treated with acid to eliminate possible carbonates and combusted with copper oxide in closed tubes to carbon dioxide, which was measured on an isotope ratio mass spectrometer. Results are given as $\delta^{13}\text{C}$ values in per mills against VPDB standard. Repeatability for the $\delta^{13}\text{C}$ values was better than $\pm 0.2\text{‰}$.

For radiocarbon dating, in order to obtain a time scale for the sediment, two samples were taken at the depths of 112–113 cm and 115–116 cm above the contact of silty clay gyttja and silty gyttja. The samples were treated with the standard acid-alkali-acid method before combustion. A sample of the net was obtained from

the collections at The National Board of Antiquities. The net cord was embedded in a piece of clay, which had not been treated in the Museum. The cord was carefully extracted from the clay by washing and then pre-treated. The dating results are given in Table 4.1. The calibrated ages given in the table are based on the IntCal04 calibration curve using the OxCal program (Bronk Ramsey 2005). For the sediment samples, a 50-year smoothing was used.

4.4 Results

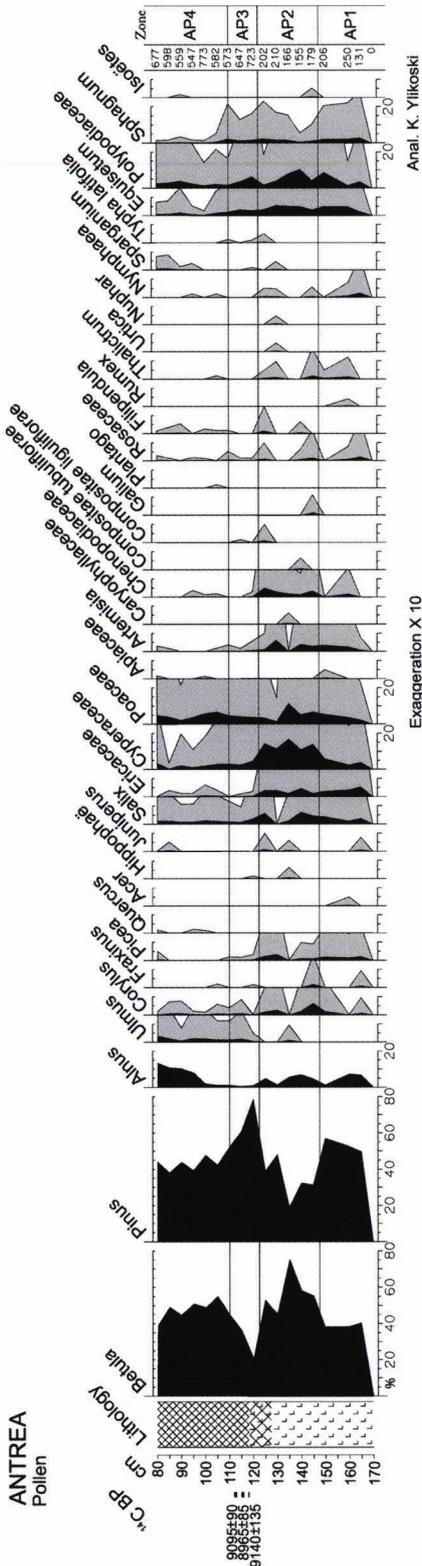
4.4.1 Lithostratigraphy

The examination of the profile revealed the following stratigraphy: agricultural soil (0–10/15 cm), silt (+3/7 cm), dark brown gyttja (+30 cm), dark brown silty gyttja (+70 cm), brownish grey silty clay gyttja (+ 9 cm), under which bluish grey silty clay (Fig. 4.3).

The basal part of the sequence consists of bluish silty clay with LOI values of less than 2 % (Fig. 4.3). At 130 cm the organic content of the sediment begins to increase, and at 127 cm the sediment changes to silty clay gyttja with LOI

Figure 4.4 The sediment sequence at 100–150 cm. At the bottom (on the left) bluish silty clay, in the middle silty clay gyttja, and on the top dark brown silty gyttja. (Photo: C. Carpelan 1998)





Zone AD4 (117–93 cm). *Ellerbeckia arenaria* dominates in the basalt part of the zone, but it is very soon replaced by the epiphytic *Epithemia* spp. *Gyrosigma attenuatum*, *Opephora martyi*, *Diploneis mauleri* and *Cocconeis disculus* disappear. The planktonic *Cyclotella bodanica*, meroplanktonic *Aulacoseira* spp., epiphytic *Tabellaria* spp., and *Eunotia* spp. appear and are common only in this zone. *Cocconeis placentula* and the epiphytic *Achanthes clevei* are dominant species in the upper part of the zone.

Zone AD5 (93–80 cm). *Fragilaria* spp. dominate this zone. Also *Aulacoseira islandica* and *Epithemia* spp. are common. The proportions of *Aulacoseira* spp. and *Tabellaria* spp. decrease. *Achnanthes joursacense*, *A. lanceolata*, *A. exigua* and *Surirella robusta* increase.

4.4.3 Pollen

Four local pollen assemblage zones were determined (Fig. 4.6).

Zone AP1 (170–147.5 cm). Pollen of *Pinus* (pine) and *Betula* (birch) dominate the zone. *Alnus* (alder), *Corylus* (hazel), *Fraxinus* (ash), *Picea* (spruce) and *Acer* (maple) also occur. Furthermore, several non-arboreal pollen (NAP) types were found, e.g. *Salix* (willow), *Ericaceae* (heath family), *Cyperaceae* (sedge family), *Poaceae* (grass family), *Artemisia* (wormwood) and *Chenopodiaceae* (goosefoot family).

Zone AP2 (147.5–122.5 cm). *Betula* dominates in this zone, whereas *Pinus* has decreased. Pollen of *Alnus*, together with *Ulmus* (elm), *Corylus*, *Fraxinus* and *Picea* are also present. The same NAP types as in the previous zone occur, but *Cyperaceae* and *Chenopodiaceae* occur in higher proportions.

Figure 4.6 Pollen diagram for Korpilähti. Figure 4.5 shows sediment symbols.

Table 4.1

Material	Lab code	¹⁴ C age yrs BP	δ ¹³ C ‰ VPDB	Calendar yrs	
				BC	BP
Sediment 112-113 cm	Hela-416	9095±90	-21.6	8450 – 8200	10400 – 10150
Sediment 115-116 cm	Hela-417	8965±85	-23.0	8300 – 7950	10250 – 9900
Cord	Hela-404	9140±135	-29.5	8560 – 8240	10510 – 10190
Bark float ¹	Hel-269	9230±210		8800 – 8200	10750 – 10150
Bark float ²	Hel-1303	9310±140		8730 – 8340	10680 – 10290
Bark floats, mean		9285±115		8650 – 8300	10600 – 10250

¹Jungner 1979

²Jungner & Sonninen 1983

Zone AP3 (122.5–110 cm). The zone is characterized by a sudden maximum in *Pinus* and a corresponding decrease in *Betula*. *Alnus* occurs only in very low proportions, whereas the continuous curves of *Ulmus* and *Corylus* begin. Many NAP types have disappeared or decreased.

Zone AP4 (110–80 cm). *Pinus* has decreased and *Betula* has increased, both now being equally dominant. *Alnus* increases in the upper part of the zone. Sporadic pollen grains of *Fraxinus* and *Quercus* (oak) occur. There are no significant changes in other pollen types.

4.4.4 Date

Three new radiocarbon ages were determined by using the AMS technique (Table 4.1). The dates are discussed in detail by Carpelan (2008, this volume). The date Hela-404 (9140±135) was determined from net cord of willow bast attached to the bark floats. Two bark floats from the net find had been previously dated (Jungner 1979; Jungner & Sonninen 1983) and resulted in ages 9230±210 BP (Hel-269) and 9310±140 BP (Hel-1303). The difference of age between the bark floats and the net cord results from the fact that the shield bark had been taken from old pine trees (age > 100 yr). The willow bast was considerably younger and therefore gives a dating result closer to the exact age of the net. The calibrated ages are given in Table 4.1.

4.5 Palaeoenvironmental reconstructions

4.5.1 A history of water systems in the Korpilahti area

The understanding of the history of the variable water systems related to the development of the Baltic Sea and Lake Ladoga is important in the attempt to reconstruct the palaeoenvironment that prevailed in the Korpilahti area at the time when the net sank. Recently, shore displacement studies have been carried out in many parts of the Karelian Isthmus: in the central part of the Isthmus, Lakes Valkjärvi (Ru. ozero Mičurinskoe) and Ohalampi (Ru. ozero Uzornoe) (Davydova *et al.* 1996), on the Island of Kilpolansaari (Ru. ostrov Kil'pola), Lake Ladoga (Saarnisto & Grönlund 1996), in the former municipality of Heinjoki (Ru. Veščevo) (Saarnisto *et al.* 1999), and along the coast of the Gulf of Finland (Miettinen 2002) (Fig. 4.1). The general development of the Baltic Sea between 13 000–8000 BP (13 400–6850 calBC) has been summarized by Björck (1995) as follows: The Baltic Ice Lake stage 13 000–10 300 BP (13 400–10 150 calBC), the Yoldia Sea stage 10 300–9500 BP (10 150–8800 calBC), and the Ancylus Lake stage 9500–8000 BP (8800–6850 calBC). The maximum of the Ancylus transgression occurred between 9200–9100 BP (8400–8300 calBC).

In the diatom stratigraphy of Korpilahti, the clear dominance of freshwater species (especially benthic *Gyrosigma attenuatum* and planktonic *Aulacoseira islandica*) in the lowermost zone AD1 suggests a freshwater environment (Fig. 4.5). At the bottom of the zone, the frequency of *Aulacoseira islandica* suggests a pelagic, deep water environment. The diatom flora contains many species typical for the Ancylus Lake stage of the Baltic. Most of the species are halophiles forms, which can also thrive in an environment of low salinity. Although the diatom flora does not contain any mesohalobous brackish-water forms, it is possible that this zone represents a non-saline phase of the Yoldia Sea stage in the history of the Baltic basin. This interpretation is also supported by the chronostratigraphy of this study.

According to the radiocarbon dates, the age of the upper limit of the zone can be estimated to c. 10 000 BP (9600 calBC), which represents the Yoldia Sea stage (e.g. Saarnisto & Grönlund 1996). Also in the Heinjoki area, located c. 25 kilometres south-west of Korpilahti, the diatom lithostratigraphy of a non-saline Yoldia Sea stage contains diatom taxa common at Korpilahti, e.g. *Aulacoseira islandica*, *Gyrosigma attenuatum* and *Diploneis domblittensis* (Saarnisto *et al.* 1999). However, the brackish-water diatom flora of the Yoldia Sea stage observed at Heinjoki cannot be recognised at Korpilahti. The reason for this can be the location of Korpilahti in the area affected by the waters from the local catchment area (Fig. 4.1), where the influence of the saline water was smaller. Also the waters from a large catchment area of Lake Ladoga were directed towards the Gulf of Finland. The diatom flora in AD1 is relatively poor in species, which is a common feature in the Yoldia Sea sediments, and also, the flora found in the zone is very common during the freshwater phase of the Yoldia Sea (cf. Heinsalu 2001).

Hence, the diatom zone AD1 probably represents the Yoldia Sea stage of the Baltic.

The diatom zone AD2 contains almost the same diatom flora as the previous zone. In addition to the different proportions in the composition of the diatom flora, the most significant differences are the dominance of benthic *Diploneis mauleri* and the decreasing of *Gyrosigma attenuatum* and planktonic *Aulacoseira islandica*. As a whole, the diatom flora indicates a typical large lake environment (e.g. Ancylus Lake), but because of the clear dominance of littoral (benthic and epiphytic) species, the environment suggests shallow water conditions. This zone probably no longer represents the Yoldia Sea stage. Lake Ladoga could have been isolated from the Baltic Sea basin during the Yoldia regression, but this cannot be seen at Korpilahti, because the diatom flora represents a large lake environment. It is possible that the diatom flora which dominated at Korpilahti during the Yoldia Sea stage could have thrived also in the Lake Ladoga basin. Nevertheless, the lithostratigraphy with silty and clayey sediments still suggests a Baltic Sea environment. Also according to Saarnisto *et al.* (1999), it is not clear whether Lake Ladoga became isolated from the Baltic basin at all before the onset of the Ancylus transgression in 9600 BP (9050 calBC). However, it cannot be said for certain whether the zone AD2 already represents an actual Ancylus Lake stage. Because the diatom flora indicates a shallower environment compared to the previous zone, it is possible that the zone AD2 represents the transition phase between the Yoldia Sea and Ancylus Lake stages.

In the zone AD3, the diatom flora becomes richer and represents a freshwater large lake environment. Many new diatom species typical for the Ancylus Lake stage appear (e.g. *Ellerbeckia arenaria*, *Cocconeis disculus* and *Navicula scutelloides*), and thus the zone represents the actual Ancylus Lake stage. The proportion

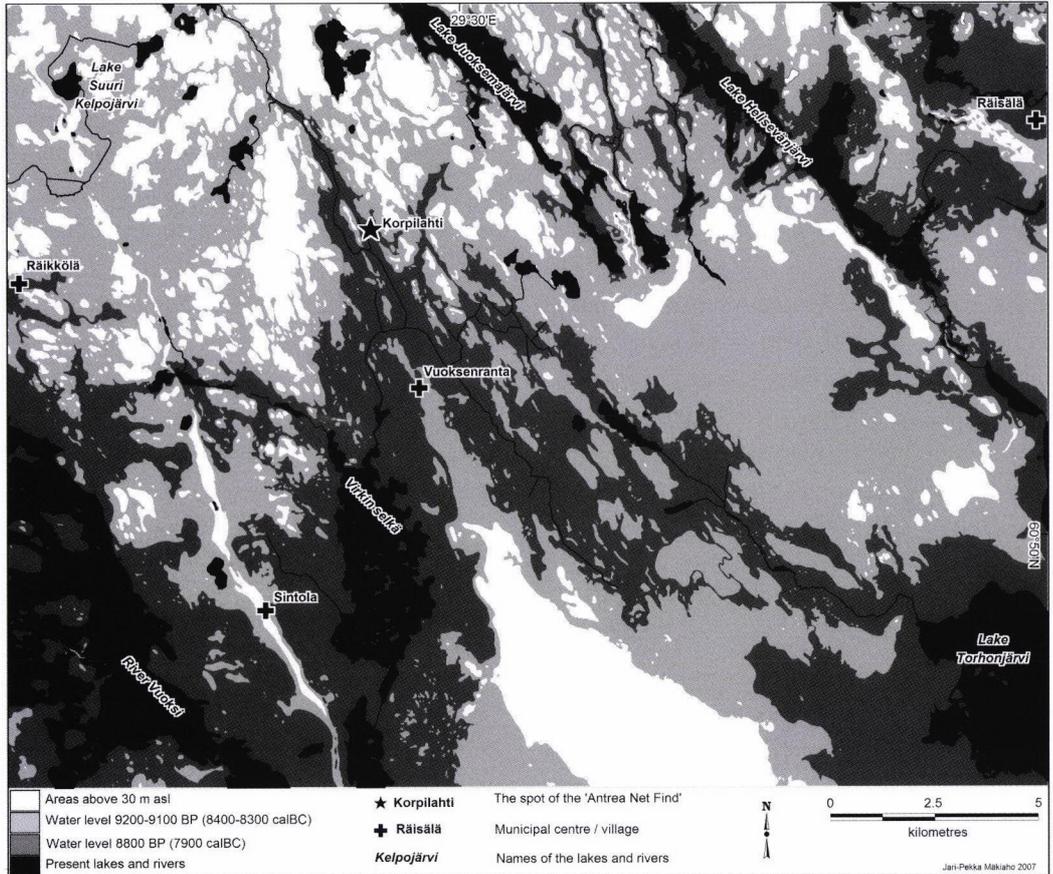


Figure 4.7 Palaeoenvironment of the Korpilahti region during the maximum phase of the Ancylus transgression 9200–9100 BP (8400–8300 calBC) when water level was located c. 30 m asl (lighr grey), and after the isolation of Lake Ladoga from the Ancylus Lake c. 8800 BP (7900 calBC), when water level was located c. 20 m asl (dark grey). (Map: J-P. Mäkiäho)

of the benthic *Ellerbeckia arenaria* increases notably towards the upper part of the zone. *E. arenaria* is a species thriving on sandy sediments, and its appearance as a dominant species probably reflects the increasing erosion that was caused by a rising water level during the Ancylus transgression.

On the top of the zone AD3, the silty clay gyttja changes into silty gyttja. Radiocarbon dates carried out on the silty gyttja 2–3 cm and 5–6 cm above the upper boundary of silty clay gyttja yielded dates of 8965±85 BP and 9095±90 BP, respectively. In the light of these dates, the age

for the boundary of the diatom zones AD2/AD3 could well be c. 9600 BP (9050 calBC), which corresponds with the age for the beginning of the Ancylus Lake stage (cf. Saarnisto *et al.* 1999).

According to the diatom data and radiocarbon dates, the zone AD3 represents the actual Ancylus Lake stage of the Baltic. The 'Antrea Net Find' was recovered from the topmost part of the silty clay gyttja at a depth of 118 cm. The radiocarbon date of the net yielded a date of 9140±135 BP. This date is close to the age of the maximum of the Ancylus transgression, which culminated between 9200 and 9100 BP (8400 and 8300 cal

BC) (Björck 1995; Saarnisto & Grönlund 1996). During the transgression maximum, Korpilahti was connected to the Ancylus Lake via a strait in the north and south (Fig. 4.7). At that time, the water level was located c. 30 m asl in this area. Immediately after the culmination of the transgression, c. 9100 BP (8300 calBC), the water level of Ancylus Lake started to drop.

The change in the diatom stratigraphy at the top of the zone AD3 and a synchronous change of the silty clay gyttja into silty gyttja at a depth of 118 cm probably indicate the shallower conditions in the northern threshold area of the Korpilahti strait immediately after the maximum of the Ancylus transgression. This was caused by the lowering water level in the Ancylus Lake and the more rapid land uplift rate in the north of Korpilahti. At this time, i.e. after 9100 BP (8300 calBC), Korpilahti was a narrow strait of the Ancylus Lake. In the diatom flora of the zone AD4, many species indicating a small lake environment appear (e.g. *Tabellaria* spp., *Aulacoseira granulata*, *A. ambigua* and *Eunotia* spp.), and the large lake species disappear or at least decrease (except *Epithemia* spp.).

The $\delta^{13}\text{C}$ record (Figs. 4.3 and 4.5) shows a change of c. 5 ‰ from the value -22.8 ‰ at a depth of 118 cm to the value -27.7 ‰ at a depth of 112 cm. The $\delta^{13}\text{C}$ record was measured from samples with a thickness of 1 cm and therefore gives a better time resolution than what can be obtained from the diatom and pollen records. The sharp change in the $\delta^{13}\text{C}$ values within less than 4 cm indicates a rapid change in the conditions in the basin. Two radiocarbon dates give an age of about 9000 BP (8250 calBC) for the event.

The palaeoenvironmental reconstruction in connection with the date of the net (9140±135 BP) suggests that the net and the other artefacts went down at the time of the maximum of the Ancylus transgression, when Korpilahti was a strait in the Ancylus Lake.

In the zone AD5, some small lake diatom species common in the previous zone AD4 disappear (e.g. *Aulacoseira granulata* and *Eunotia* spp.), but they are replaced by other small lake species, especially *Fragilaria* spp. However, there are still some species (e.g. *Aulacoseira islandica*) that indicate the environment of a large lake. This diatom flora suggests that Korpilahti was finally isolated from the Ancylus Lake, but it was still connected to the Lake Ladoga basin. According to Saarnisto & Grönlund (1996), the Heinjoki threshold emerged and Lake Ladoga became an isolated lake c. 8800 BP (7900 calBC). The uppermost date 9095±90 BP from Korpilahti suggests that the environment changed as the bay of Lake Ladoga at the same time. At this time, the water level was at c. 20 m asl in the Korpilahti area (Fig. 4.7).

It is probable that the Korpilahti bay became isolated from Lake Ladoga as a part of the local water system as late as c. 3100 BP (1400 calBC) when the River Neva (Ru. reka Neva) outlet opened (Davydova *et al.* 1996; Saarnisto 2003) and the water level dropped in the Lake Ladoga basin.

4.5.2 Vegetation history

Pollen grains were scarce in the silty sediments below the net find horizon in the zones AP1 and AP2 and might contain secondary pollen from pre-Holocene sediments (Fig. 4.6). This is suggested especially by the presence of *Corylus* and *Fraxinus*. Therefore, it is not possible to estimate whether the pollen proportions of the other trees (*Pinus* and *Betula*, *Alnus* and *Picea*) reflect the real composition of the vegetation in the area. Some of the pollen may also have been long-distance transported from further south where forests had already become established.

Wohlfarth *et al.* (2002; 2004) studied lakes east of the Karelian Isthmus, on the eastern side of Lake Onega (Fi. Ääninen, Ru. Onežskoe oze-

ro) where the formation of forests begun at the beginning of the Holocene, c. 10 000 BP (9600 calBC). *Betula* and *Populus tremula* (European aspen) were the first colonizers, followed by *Picea* and perhaps also *Pinus*. Subetto *et al.* (2002) studied sediments of two lakes in the Karelian Isthmus. They concluded that at c. 9600 BP (9050 calBC) open *Picea-Pinus-Betula* forests were formed, and developed into boreal forests c. 9400 BP (8650 calBC). Later, c. 9000 BP (8250 calBC), also *Alnus* and *Corylus* were established. This indicates that spruce (*Picea*) was probably present also at the Korpilahti site and its pollen may not be secondary in the silty sediment.

In the zone AP2, the maximum of *Betula* pollen suggests that birch became the dominant tree. *Corylus* increased in this zone and possibly immigrated to the area. The high proportions of e.g. Ericaceae, Cyperaceae and Poaceae, together with other NAP types, indicate that the forests were open and light with ample ground floor vegetation.

The next zone (AP3) indicates the maximum occurrence of *Pinus* which became the dominant tree in the forests. It also appears that *Ulmus* arrived at this point, because its continuous pollen curve begins. The forests were now denser and more closed, indicated by the low NAP proportions. *Betula*, however, started to increase again. The zone AP4 indicates forests dominated by *Betula* and *Pinus* and mixed with *Ulmus* and *Corylus*. Some time later *Alnus* increased, considerably later than at the sites investigated by Subetto *et al.* (2002). *Picea* was almost absent in this zone and it may be argued that it had disappeared from the site. The early Holocene spread of the tree took place at low population densities (Giesecke & Bennett 2004) and the small stands may have been vulnerable to the changes in forest composition and densities.

The stratigraphical horizon of the net find almost co-occurs with the maximum of *Pinus*

pollen, only slightly preceding it. In Hyypää's diagram (1934) the *Pinus* maximum lies slightly above the net find horizon. In Sauramo's diagram (1951) the *Pinus* maximum is at the same depth as the net find. These differences are minor and may derive from the smaller amount of pollen counted at the early stages of pollen analysis or a slight difference at subsampling level. All diagrams, however, indicate that the net find was deposited during the climax point of the pine forest phase.

At the beginning of the Holocene, c. 10 000 BP (9600 calBC), pine was already present in Estonia (Huntley & Birks 1983; Raukas *et al.* 1995) and probably soon spread to the Karelian Isthmus (Subetto *et al.* 2002). According to Tolonen & Ruuhijärvi (1976) the rise of the *Pinus* pollen curve occurred c. 9100 BP in the St. Petersburg area and c. 9020 BP in southern Finland. They gave an average age of c. 8500 BP for the *Pinus* maximum in southern Finland. Therefore, the age 9140±135 BP (Hela-404) for the net find and the *Pinus* maximum indicate that the maximum took place considerably earlier in the Karelian Isthmus.

According to Carpelan (2008, this volume) the floats were made of shield bark of old pine trees (age > 100 yr), which is well in agreement with the fact that the find coincides with the culmination of pine frequency and that the tree had become established in the forests hundreds of years earlier. It is difficult to define the actual time of the arrival of pine as the lowermost pollen stratigraphy appears to include secondary pre-Holocene pollen, and probably also long-distance transported pollen is frequent. Most probably pine was present in the Korpilahti area also during the dominance of birch as suggested by Subetto *et al.* (2002).

Some of the Greenland ice core results (annual temperatures) (Johnsen *et al.* 2001) suggest that the early Holocene warming was very

Figure 4.8 Piece of the net cord. (Photo T. Lempiäinen)



fast and continued until c. 8000 ice core years BP in the North Atlantic Region. The rapid warming was probably interrupted by short, cool periods in the North Atlantic region, one of which occurred around c. 9200 BP (10 350 calBP) (Björck *et al.* 2001; Seppä *et al.* 2002). Subetto *et al.* (2002) suggested that the early Holocene climate in the Karelian Isthmus was humid. However, the early Holocene pollen evidence or succession of vegetation itself in the Korpilahti area cannot be literally taken to represent climate development. For example, the immigration of trees from their glacial refugia may have had considerable time lags and some trees may have had requirements for soil development (e.g. humus content) until they could become established.

4.6 The net cord

Kujala (1948) identified the material of the net cord as bast of a willow species (*Salix* spp.), probably *Salix cinerea*. Earlier it had been tentatively identified as bast of linden (*Tilia cordata*) or fibre of nettle (*Urtica dioica*) (Pälsi

1920; Äyräpää 1936; Luho 1948). It was also supposed that the bindings of the sinkers were made of the stems of an aquatic plant. Bast of European aspen (*Populus tremula*) was another suggestion (Kujala 1948). Later, however, the bindings were identified as shavings of wood taken from beneath bast of willow (Sauramo 1951).

A small piece of net cord (Fig. 4.8) was studied at the Botanical Museum of the University of Turku for the present project. The piece, c. 10 mm long, was taken from the remains of the net preserved in a clay clod kept at the National Board of Antiquities, Helsinki. The sample was handled according to the methods described by Kujala (1948), except for heating in lactophenol. The sample was placed on a slide and studied under a light microscope and compared with recent wood samples of *Tilia cordata*, *Populus tremula* and several *Salix* species, including *Salix cinerea*, *S. phylicifolia* and *S. caprea*. It was also compared with fibre of *Urtica dioica*.

Kujala (1948) showed that in his net cord sample, the cells of the phloem tissue were mostly damaged and changed when compared to recent wood. During the present study, only

very limited pieces of the cell structure could be seen. However, *Urtica dioica* and *Tilia cordata* could be excluded. Also the characteristics of the cortex of the other foliage trees and shrubs differed remarkably from the studied wood material (cf. Grosser 1977; Schweingruber 1990; Fagerstedt *et al.* 2004). *Salix* and *Populus* remained the only possible alternatives, because in the outer parts of the bundles of phloem fibres there were plenty of cells with thickened walls in the fibre-like lines. These cells are missing from the phloem cells of *Tilia*. Also the medullary rays of *Tilia* are of the two-row type, but those of *Populus* and *Salix* are of the one-row type. The difference between *Salix* and *Populus* lies in the cortex: *Populus* has plenty of stone cells in the cortex with strongly lignified walls and they are tightly fixed to the bundles of phloem fibres. Such stone cells were entirely missing from the studied sample.

Thus, the 'Antrea Net' has been made of willow bast (*Salix* sp.). As mentioned above, Kujala (1948) suggested *Salix cinerea* as a possible source. According to K.-E. Behre (2003, pers. comm.), the difference in the cells of phloem between different *Salix* species is so small that it is very difficult even to identify recent *Salix* wood samples to species level. Therefore, material as old as the 'Antrea Net' cannot be identified reliably. Pollen diagrams only show *Salix* sp. as the pollen grains cannot be identified to species level (e.g. Matiskainen 2002; Simola 2003). Because the exact climate or soil type in the Korpilahti area during the net accident cannot be reconstructed, it is difficult to determine what *Salix* species could have been present. The modern quantity of *Salix* species + subspecies/hybrids in Finland is c. 30. The possible modern *Salix* species which may have been present at the Korpilahti area are *Salix pentandra*, *S. fragilis*, *S. phyllicifolia*, *S. myrsinifolia*, *S. cinerea*, *S. aurita*, *S. caprea*, *S. starkeana*, *S. myrtilloides*,

S. repens and *S. lapponum*. Even *Salix polaris*, a species tolerant of severe conditions, is presently found in the southern Karelian Isthmus (Lindberg 1901; Kalliola 1973; Simola 2003) and may have been present also in the early Holocene.

The properties of the phloem/bast were very important for preparing nets. The stems and branches should have been long and rich in fibres, and they should also have a tough cortex so that extracting bast in spring was easy. These characteristics are found in e.g. *Salix cinerea*, *S. caprea*, *S. fragilis*, *S. pentandra* and *S. phyllicifolia* whereas *Salix myrtilloides*, *S. aurita* and *Salix repens* are perhaps too small and their branches/stems are too short or hard for net cord material.

4.7 Conclusions

The re-investigation of the 'Antrea Net Find' with the help of modern physical and palaeoecological techniques confirmed earlier results. The 'Net Find' was recovered from the uppermost part of silty clay gyttja at a depth of 118 cm. The new radiocarbon date of the net yielded an age of 9140±135 BP. This is in good agreement with the previous dates on the floats (Jungner 1979; Jungner & Sonninen 1983), taking into account that the cord of willow represents short-lived material compared to the bark in the floats. The net cord has been made of the bast of willow (*Salix* sp.), but the specific willow species cannot be identified.

New diatom results from Korpilahti suggest that the artefacts sank at a time of the maximum of the Ancylus transgression. At that time, the Lake Ladoga basin and the Baltic Sea basin were connected for the last time during the Holocene. Also the radiocarbon date from the net 9140±135 BP is very close to this event. New

radiocarbon dates 9095±90 and 8965±85 BP from the silty gyttja sediment just above the find level (118 cm) with the diatom data clearly support the conclusion that the net sank during the maximum of the *Ancylus* transgression, which culminated between 9200 and 9100 BP (8400 and 8300 calBC).

The pollen results suggest that at this time, the environment was characterized by forests dominated by pine during its maximum early Holocene occurrence. The forests were mixed with birch and possibly also with spruce, alder, and even hazel. It is difficult to define the time of the arrival of pine, but most probably the tree had been present for hundreds of years and thus bark of old trees was readily available for bark floats.

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Sources and printed references

Unpublished sources

Personal communications

Karl-Ernst Behre, prof., 2003: Information about the identification of the net cord material.

Published sources

WWW-sources

Bronk Ramsey, C., 2005: *OxCal v.3.10*. <http://www.rlaha.ox.ac.uk/oxcal/oxcal.htm> [read 25.1.2007].

Printed maps

Finnish Topographic Map Sheet 4113 01 Sintola, scale 1:20 000, Helsinki 1938, Military Topographic Survey.

Finnish Topographic Map Sheet 4113 02 Sokkala, scale 1:20 000, Helsinki 1944, Military Topographic Survey.

Finnish Topographic Map Sheet 4113 04 Kaskiselkä, scale 1:20 000, Helsinki 1938, Military Topographic Survey.

Finnish Topographic Map Sheet 4113 05 Vuoksenranta, scale 1:20 000, Helsinki 1939, Military Topographic Survey.

Finnish Topographic Map Sheet 4113 07 Oravankytö, scale 1:20 000, Helsinki 1938, Military Topographic Survey.

Finnish Topographic Map Sheet 4113 08 Räisälä, scale 1:20 000, Helsinki 1939, Military Topographic Survey.

Printed references

Äyräpää, A., 1936: Die geographischen Datierungen in der Vorgeschichte Finnlands. *Swiatowit XVI* (1934/35): 35–46.

Battarbee, R. W., 1986: Diatom analysis. In: *Handbook of Holocene Palaeoecology and Palaeohydrology* (ed. by B. E. Berglund): 527–570. Chichester: John Wiley & Sons.

Björck, S., 1995: A review of the history of the Baltic Sea, 13.0–8.0 ka BP. *Quaternary International* 27: 19–40.

Björck, S., Muscheler, R., Kromer, B., Andresen, C. S., Heinemeier, J., Johnsen, S. J., Conley, D., Koç, N., Spurk, M., & Veski, S., 2001: High-resolution analyses of an early Holocene climate event may imply decreased solar forcing as an important climate trigger. *Geology* 29: 1107–1110.

Carpelan, C., 2008: On the history and recent studies of the 'Antrea Net Find'. *Iskos* 16 (this volume).

Davydova, N. N., Arslanov, Kh. A., Khomutova, V. I., Krasnov, I. I., Malkhovskiy, D. B., Saarnisto, M., Saksa, A. I., & Subetto, D. A., 1996: Late- and post-glacial history of lakes of the Karelian Isthmus. *Hydrobiologia* 322 (The First International Ladoga Symposium, ed. by H. Simola, M. Viljanen, T. Slepukhina & R. Murthy): 199–204.

Fagerstedt, K., Pellinen, K., Saranpää, P., & Timonen, T., 2004: *Mikä puu – mistä puusta*. Helsinki: Yliopistopaino.

Fægri, K., & Iversen, J., 1989: *Textbook of pollen analysis*. Chichester: John Wiley & Sons Ltd. Fourth Edition.

Giesecke, T., & Bennett, K. D., 2004: The Holocene spread of *Picea abies* (L.) Karst. in Fennoscandia and adjacent areas. *Journal of Biogeography* 31: 1523–1548.

Grimm, E., 1991: *Tilia 1.12 and Tilia*Graph 1.18*. PC

- spreadsheet and graphics software for pollen data. Springfield, Illinois: Illinois State Museum, Research and Collection Center.
- Grosser, D., 1977:** *Die Hölzer Mitteleuropas. Ein mikro-photographischer Lehratlas.* Berlin: Springer.
- Heinsalu, A., 2001:** Diatom stratigraphy and the palaeoenvironment of the Yoldia Sea in the Gulf of Finland, Baltic Sea. *Annales Universitatis Turkuensis, A II*, 144: 1–41.
- Huntley, B., & Birks, H. J. B., 1983:** *An atlas of past and present pollen maps for Europe: 0–13 000 years ago.* Cambridge: Cambridge University Press.
- Hyypä, E., 1934:** Antrean Korpilahden kivikautisen verkolöydön geologinen iijänmääritys. *Suomen Museo* XL (1933): 9–14.
- Johnsen, S. J., Dahl-Jensen, D., Gundestrup, N., Steffensen, J. P., Clausen, H. B., Miller, H., Masson-Delmotte, V., Sveinbjörnsdóttir, A. E., & White, J., 2001:** Oxygen isotope and palaeotemperature records from six Greenland ice-core stations: Camp Century, Dye-3, GRIP, GISP2, Renland and NorthGRIP. *Journal of Quaternary Science* 16: 299–307.
- Jungner, H., 1979:** *Radiocarbon Dates I. Report No 1,* Radiocarbon Dating Laboratory, University of Helsinki.
- Jungner, H., & Sonninen, E., 1983:** *Radiocarbon Dates II. Report No 2,* Radiocarbon Dating Laboratory, University of Helsinki.
- Kalliola, R., 1973:** *Suomen kasvimaantiede.* Porvoo: WSOY.
- Krammer, K., & Lange-Bertalot, H., 1986:** Bacillariophyceae 2/1. Naviculaceae. In: *Süßwasserflora von Mitteleuropa* (ed. by H. J. Ettl, J. Gerloff, H. Heynig & D. Mollenhauer). Stuttgart: Gustav Fisher Verlag.
- Krammer, K., & Lange-Bertalot, H., 1988:** Bacillariophyceae 2/2. Bacillariaceae, Epithemiaceae, Surirellaceae. In: *Süßwasserflora von Mitteleuropa* (ed. by H. J. Ettl, J. Gerloff, H. Heynig & D. Mollenhauer). Stuttgart: Gustav Fisher Verlag.
- Krammer, K., & Lange-Bertalot, H., 1991a:** Bacillariophyceae 2/3. Centrales, Fragilariaceae, Eunotiaceae. In: *Süßwasserflora von Mitteleuropa* (ed. by H. J. Ettl, J. Gerloff, H. Heynig & D. Mollenhauer). Stuttgart: Gustav Fisher Verlag.
- Krammer, K., & Lange-Bertalot, H., 1991b:** Bacillariophyceae 2/4. Achnantheaceae, Kritische Ergänzungen zu Navicula (Lineolatae) und Gomphonema. In: *Süßwasserflora von Mitteleuropa* (ed. by H. J. Ettl, J. Gerloff, H. Heynig & D. Mollenhauer). Stuttgart: Gustav Fisher Verlag.
- Kujala, V., 1948:** Antrean Korpilahden kivikautisen verkon kuituaines. *Suomen Museo* LIV–LV (1947–1948): 24–27.
- Lindberg, H., 1901:** Om förekomsten i Kivinebb af subfossila växter i glaciala aflagringar. *Meddelanden af Societas pro Fauna et Flora Fennica* XXIV: 99–103.
- Lindberg, H., 1920:** Die Schichtenfolge auf dem steinzeitlichen Fundplatz bei Korpilahti, Kirchspiel Antrea, Län Wiborg. *Suomen Muinaismuistoyhdistyksen Aikakauskirja* XXVIII-3. Helsinki.
- Luhov, V., 1948:** *Suomen kivikauden pääpiirteet.* Helsinki: Otava.
- Matiskainen, H., 2002:** *Riihimäen esihistoria.* Hämeenlinna: Karisto Oy.
- Miettinen, A., 2002:** Relative sea level changes in the Eastern part of the Gulf of Finland during the last 8000 years. *Annales Academiae Scientiarum Fennicae A III, Geologica-Geographica* 162.
- Mölder, K., & Tynni, R., 1967:** Über Finnlands rezente und subfossile Diatomeen, I. *Comptes Rendus de la Société géologique de Finlande* 39: 199–217.
- Mölder, K., & Tynni, R., 1968:** Über Finnlands rezente und subfossile Diatomeen, II. *Bulletin of the Geological Society of Finland* 40: 151–170.
- Mölder, K., & Tynni, R., 1969:** Über Finnlands rezente und subfossile Diatomeen, III. *Bulletin of the Geological Society of Finland* 41: 235–251.
- Mölder, K., & Tynni, R., 1970:** Über Finnlands rezente und subfossile Diatomeen, IV. *Bulletin of the Geological Society of Finland* 42: 129–144.
- Mölder, K., & Tynni, R., 1971:** Über Finnlands rezente und subfossile Diatomeen, V. *Bulletin of the Geological Society of Finland* 43: 203–220.
- Mölder, K., & Tynni, R., 1972:** Über Finnlands rezente und subfossile Diatomeen, VI. *Bulletin of the Geological Society of Finland* 44: 141–149.
- Mölder, K., & Tynni, R., 1973:** Über Finnlands rezente und subfossile Diatomeen, VII. *Bulletin of the Geological Society of Finland* 45: 159–179.
- Pälsi, S., 1920:** Ein steinzeitlicher Moorfund bei Korpilahti im Kirchspiel Antrea, Län Viborg. *Suomen Muinaismuistoyhdistyksen Aikakauskirja* XXVIII-2. Helsinki.
- Raukas, A., Saarse, L., & Veski, S., 1995:** A new version of the Holocene stratigraphy in Estonia. *Proceedings of the Estonian Academy of Sciences. Geology*. 44: 201–210.
- Saarnisto, M., 2003:** Karjalan geologia; Karjalan luonnonmaiseman synty. In: *Karjalan synty. Viipurin läänin historia* 1 (ed. by M. Saarnisto): 21–80. *Sine loco:* Karjalaisen Kulttuurin Edistämissäätiö, Karjalan Kirjapaino Oy/Karjala-lehti.
- Saarnisto, M., 2008:** Emergence history of the Karelian Isthmus. *Iskos* 16 (this volume).
- Saarnisto, M., & Grönlund, T., 1996:** Shoreline displacement of Lake Ladoga – new data from Kilpolansaari. *Hydrobiologia* 322 (The First International Ladoga Symposium, ed. by H. Simola, M. Viljanen, T. Slepukhina & R. Murthy): 205–215.
- Saarnisto, M., & Grönlund, T., & Ikonen, L., 1999:** The Yoldia Sea – Lake Ladoga connexion. Biostratigraphical evidence from the Karelian Isthmus. In: *Dig it All. Papers dedicated to Ari Siiriäinen* (ed. by M. Huurre): 117–130. Helsinki: The Finnish Antiquarian Society & The Archaeological Society of Finland.
- Salonen, V.-P., Eronen, M., & Saarnisto, M., 2002:** *Käytännön maaperägeologia.* Turku: Kirja-Aurora.
- Sauramo, M., 1951:** Antrean verkolöydön uusittu paleontologinen ajoitus. *Suomen Museo* LVIII (1951): 87–98.
- Schweingruber, F. H., 1990:** *Anatomie europäischer Hölzer.* Bern: Paul Haupt.
- Seppä, H., Birks, H. H., & Birks, J. J. B., 2002:** Rapid climatic changes during the Greenland stadial 1 (Younger Dryas) to early Holocene transition on the Norwegian Barents Sea coast. *Boreas* 31: 215–225.
- Siiriäinen, A., Halinen, P., Carpelan, C., Uino, P., Lavento, M., & Kirkinen, T., 2008:** An archaeological reconnaissance trip to the Karelian Isthmus; Excursion diary 28 September – 2 October 1998. *Iskos* 16 (this volume).

- Simola, H., 2003:** Karjalan luonto ja ihminen. In: *Karjalan synty. Viipurin läänin historia 1* (ed. by M. Saarnisto): 81–115. *Sine loco*: Karjalaisen Kulttuurin Edistämissäätiö, Karjalan Kirjapaino Oy/Karjala-lehti.
- Subetto, D. A., Wohlfarth, B., Davydova, N. N., Sapelko, T. V., Björckman, L., Solovieva, N., Wastegård, S., Possnert, G., & Khomutova, V. I., 2002:** Climate and environment on the Karelian Isthmus, northwestern Russia. *Boreas* 31: 1–19.
- Tolonen, K., & Ruuhijärvi, R., 1976:** Standard pollen diagrams from the Salpausselkä region of Southern Finland. *Annales Botanici Fennici* 13: 155–196.
- Tynni, R., 1975:** Über Finnlands rezente und subfossile Diatomeen, VIII. *Geological Survey of Finland Bulletin* 274: 1–55.
- Tynni, R., 1976:** Über Finnlands rezente und subfossile Diatomeen, IX. *Geological Survey of Finland, Bulletin* 284: 1–37.
- Tynni, R., 1978:** Über Finnlands rezente und subfossile Diatomeen, X. *Geological Survey of Finland Bulletin* 296: 1–55.
- Tynni, R., 1980:** Über Finnlands rezente und subfossile Diatomeen, XI. *Geological Survey of Finland Bulletin* 312: 1–93.
- Waterbolk, H. T., 1983:** Ten guidelines for the archaeological interpretation of radiocarbon dates. *PACT Publication* 8 (Proceedings of the First International Symposium '14C and Archaeology' Groningen 1981, ed. by W. G. Mook & H. T. Waterbolk): 57–70. Strasbourg: Council of Europe.
- Wohlfarth, B., Filimonova, L., Bennike, O., Björckman, L., Brunberg, L., Lavrova, N., Demidov, I., & Possnert, G., 2002:** Late-glacial and early Holocene environmental and climatic change at Lake Tambichozero, southeastern Russian Karelia. *Quaternary Research* 58: 261–272.
- Wohlfarth, B., Schwark, L., Bennike, O., Filimonova, L., Tarasov, P., Björckman, L., Brunberg, L., Demidov, I., & Possnert, G., 2004:** Unstable early-Holocene climatic and environmental conditions in northwestern Russia derived from a multidisciplinary study of a lake-sediment sequence from Pichozero, southeastern Russian Karelia. *The Holocene* 14: 732–746.