A RECONSTRUCTION OF THE ENVIRONMENT OF RETTIG IN THE CITY OF TURKU, FINLAND ON THE BASIS OF DIATOM, POLLEN, PLANT MACROFOSSIL AND PHYTOLITH ANALYSES

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Palynological and palaeobotanical results from three representative cores investigated in 1994–1995 in connection with the archaeological excavations in the Rettig "Palace", Turku, Finland, are discussed. The cultural layer consisted of a heterogeneous urban upper stratum and a more humid and more homogeneous lower stratum, all resting on a clay sequence several metres thick. A chronological series of marine clay, partly river-washed and redeposited clay, and clayey soil characterized by aerophilous diatoms was determined.

Diatom analysis was used to reconstruct sedimentation environment and the development of the natural landscape in relation to land uplift. Pollen analysis was used to trace the transformation of the natural landscape into a cultural landscape and finally into an urban settlement area. The pollen results were complemented by those on plant macrofossils, which consisted of the remnants of 124 species of many different groups, such as natural, cultivated, imported, medical and collected plants. Phytoliths were investigated from the surface material of a grindstone found on the site, and typical morphotypes were described although no typical cereal phytoliths could be identified.

Key words: palaeoecology, archaeological sites, urban environment, pollen analysis, diatom flora, plants, macrofossils, phytoliths, human activity, Medieval, Turku, Finland.

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INTRODUCTION

The aim was to reconstruct the emergence of Turku area and local vegetational changes since medieval times and to investigate the history of the area from a natural landscape to the present-day urban landscape. As well as by climate and human activity, the landscape around the estuary of the River Aura has been dramatically influenced by shore displacement, the current rate of which is c. 5 mm yr^{-1}. This development was investigated by means of diatom analysis by Grönlund (T.G.), whilst the vegetational changes were reconstructed by means of pollen analysis by Vuorela (I.V.) and plant macrofossil analysis by Lempiäinen (T.L.). In addition, the surface material of a grindstone found during the excavations was studied by means of phytolith analysis by Vuorela. All the results from diatom analysis on three cores, pollen analysis on seven cores and plant macrofossil analysis on six soil profiles inside the excavation area (Fig. 2) were reported in detail by Vuorela *et al.* 1996.

Since the flora in all cores studyed has similar information, in this paper, one representative core will be presented for each method. The diatom data on the most extensice Core A (site VII/50 in Vuorela *et al.* 1996) are described. Core B (site IV/41 in Vuorela *et al.* 1996) was studied for pollen records. Even though the interpretation of plant macrofossils is based on all six cores analysed, the emphasis is on Core C (site I/2 in Vuorela *et al.* 1996; Fig. 2). Since the pollen and macrofossil taxa were very similar in all the cores investigated, a list comparing and summarizing the pollen and macrofossil taxa is also given.

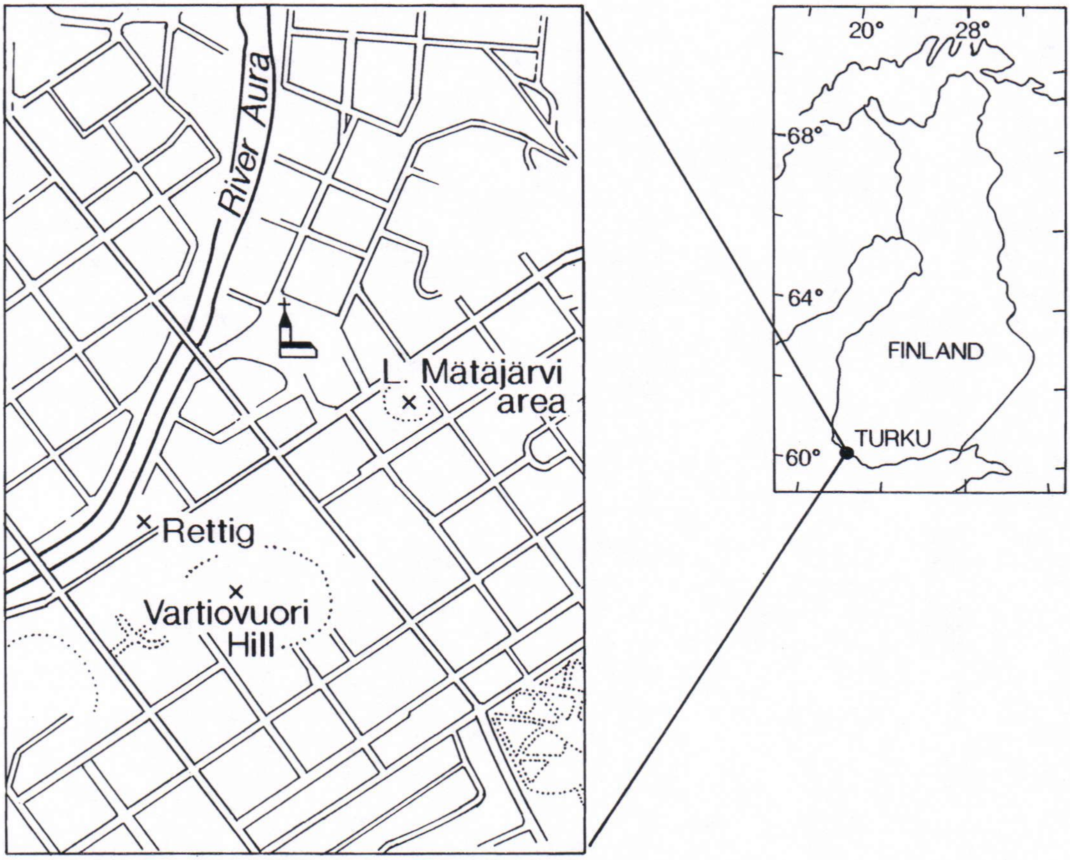

Figure 1. Location of the research area in the town of Turku, SW Finland.

The Rettig quarter lies only 0.5 km south of the former Lake Mätäjärvi (Fig. 1) the bottom deposits of which date to the 12th–18th centuries AD and were investigated in an interdisciplinary project in the mid-1980s (Lempiäinen 1985, 1989, Vuorela 1985, 1989, Lempiäinen *et al.* 1986, Niemi 1989, Salonen *et al.* 1989, Vuorisalo & Virtanen 1989). These investigations, together with the present Rettig material, shed light on the palaeoecology of the medieval town of Turku.

GEOLOGICAL BACKGROUND OF THE STUDY AREA

The Turku area was deglaciated about 10 900 radiocarbon years ago (Glückert 1976, 1977, Ignatius *et al.* 1980). The waters of the Baltic Yoldia Sea, which was then connected to the Atlantic via the Närke Strait in southern central Sweden, inundated the newly emerged land (Alhonen 1979). The rate of land uplift was at its maximum just after the retreat of the ice. During the process of emergence, the areas were gradually transformed from open sea to archipelago and to unbroken land (Fig. 3).

The level of the Yoldia Sea was located more than 100 m higher than present sea level. The water was brackish marine or brackish mixed with glacier freshwater. Uplift was fast during the Yoldia Sea stage in Finland and Sweden, and the connection between the Baltic basin and the ocean became closed. The next event in the history of the Baltic basin was a freshwater

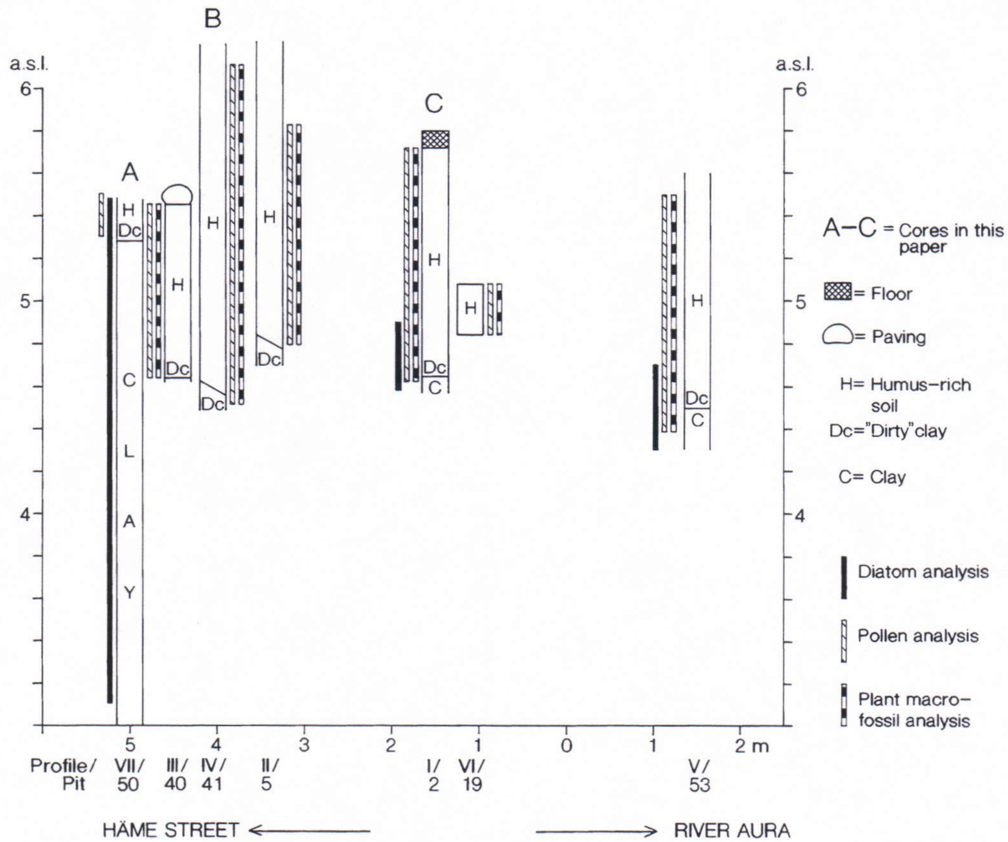

Figure 2. Location of cores investigated at the Rettig excavation site, drawn on a NW-SE axis.

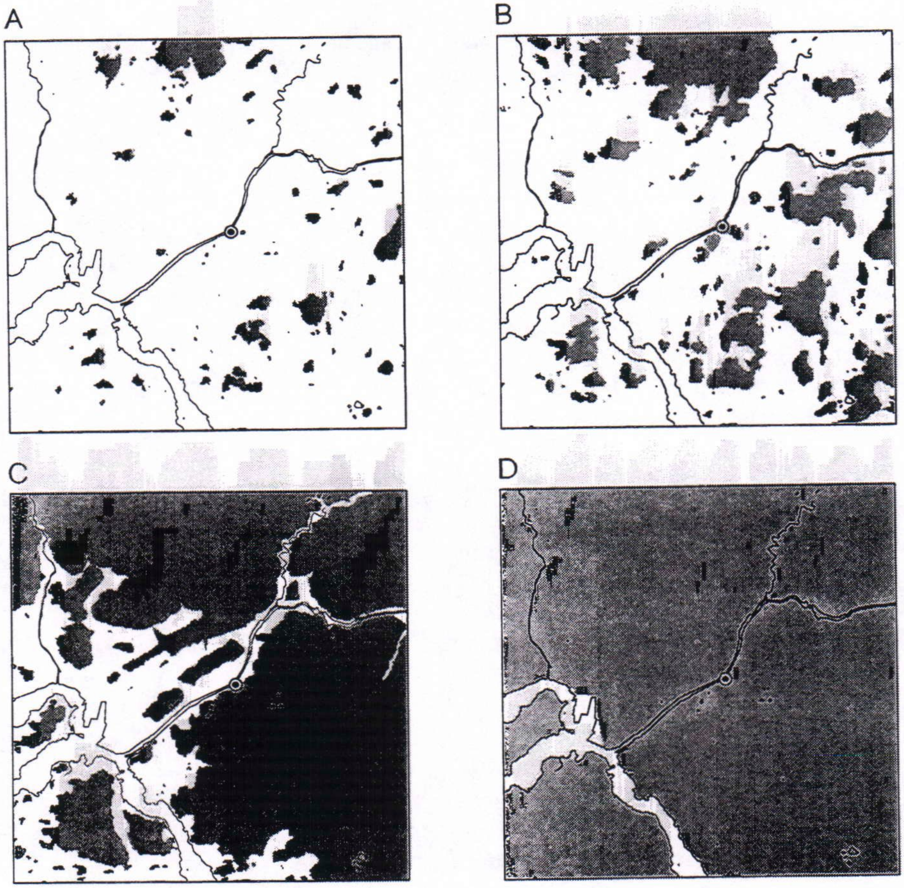

Figure 3. Development of landscape in the course of uplift in the Turku district. A = 35 m contour line, sea level c. 5800 years ago; B = 25 m contour line, sea level c. 4200 years ago; C = 10 m contour line, sea level c. 1800 years ago; D = Present distribution land/sea.. ◉ = Sample site by the River Aura.

stage, called the Ancylus Lake (9500–8500 B.P.). This lake was characterized by a (clear water) diatom flora indicating a large alkaline freshwater basin. The oldest shorelines (about 80 m a.s.l.) in the Turku area were formed during the Ancylus Lake stage (Glückert 1976). The transgressive Ancylus Lake burst through the straits of Denmark, and with the formation of a new connection with the Atlantic the next stage, the Litorina Sea, was formed (7800–8000 B.P.) in the Baltic basin. This sea was larger and more saline than the Baltic Sea has since been. The highest shoreline in the Turku area during the Litorina Sea stage was at c. 50 m a.s.l. (Glückert 1976). The Litorina Sea changed into the present-day brackish and smaller Baltic Sea without any clear ecological turning point.

MATERIAL AND METHODS

Samples were taken in 1994–1995 at the archaeological excavation site of the Rettig "Palace" in the centre of the town of Turku, southwestern Finland (60°27'N, 22°16'E; topographical map No. 1043 12, x = 6704 96, y 1570 26; Fig. 1).

The general stratigraphy of the site is clay (variably up to 5.30 m a.s.l. in core A) overlain by some 15 cm of terrestrial mineral soil in which the cultural layer is developed (Fig. 2). The cultural layer is genetically very variable, containing irregular strata rich in charcoal, mortar and/or brick fragments alternately with humus rich material. The "dirty" grey clay deposited between the clay and the humic shore deposits of pre-urban days may have been affected by wave action and other natural forces during approximately the first centuries AD. It is also possible that the cultural layer was partly removed in the course of building in medieval time. For precise stratigraphy of the cores B and C see also Fig. 4.

Like most urban cultural layers, the stratigraphy of the profiles varies horisontally and vertically, being in Core A clay at 3.10–5.30 m a.s.l. and "dirty" clay (terrestric mineral soil) at 5.30–5.45 m a.s.l.

The material was prepared for pollen analysis using KOH and cold HF methods (Faegri & Iversen 1989) on 5 cm^{-3} samples. Coarse material was removed by sieving. For the determination of pollen concentration values, recent *Lycopodium* spores were added (Stockmarr 1971). The pollen data were divided into groups as follows: deciduous trees, conifers, broad-leaved trees, shrubs (Fig. 11), aquatics and shore meadow vegetation, natural mineral soil vegetation (Fig. 12), open forest herbs and settlement indicators (Fig. 13).

The method described by Battarbee (1979) was used for diatom and phytolith analyses. The siliceous fossils were fixed with hyrax.

Pollen and macrofossil analyses were made on the same cores. The volume of subsamples for plant macrofossil analysis ranged from 0.5 to 1 l. The material was floated in a saturated NaCl solution with an H_2O:NaCl ratio of 3:1. The plant remains were picked up using a stereomicroscope (WILD M5). Remains were stored in 50% alchohol.

Pollen grains were identified mainly on the basis of the work of Erdtman *et al.* (1961) and Moore *et al.* (1991) and the plant nomenclature is that used by Hämet-Ahti *et al.* (1986). For identification of diatoms the publications of Mölder & Tynni (1967–1973), Tynni (1975–1980) and Krammer & Lange-Bertalot (1986–1991) were used. Some taxa were later transferred to the new genera described by Round *et al.* (1990). New names are given together with the old ones in the text. Plant macroremains were identified on the basis of studies of Beijerinck (1947), Körber-Grohne (1967) and Behre (1976, 1983, 1991). Macrofossil data from the Turku area published earlier by Lempiäinen (1985, 1988, 1989, 1995a,b), Valo (1993) and Aalto (1994) were also referred to. Phytoliths

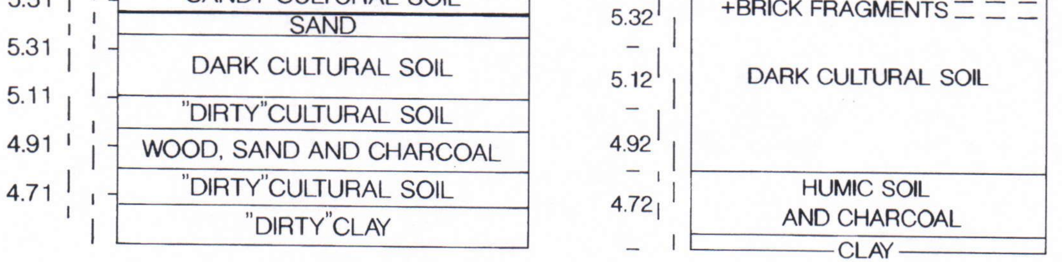

Figure 4. Stratigraphies of Cores B and C.

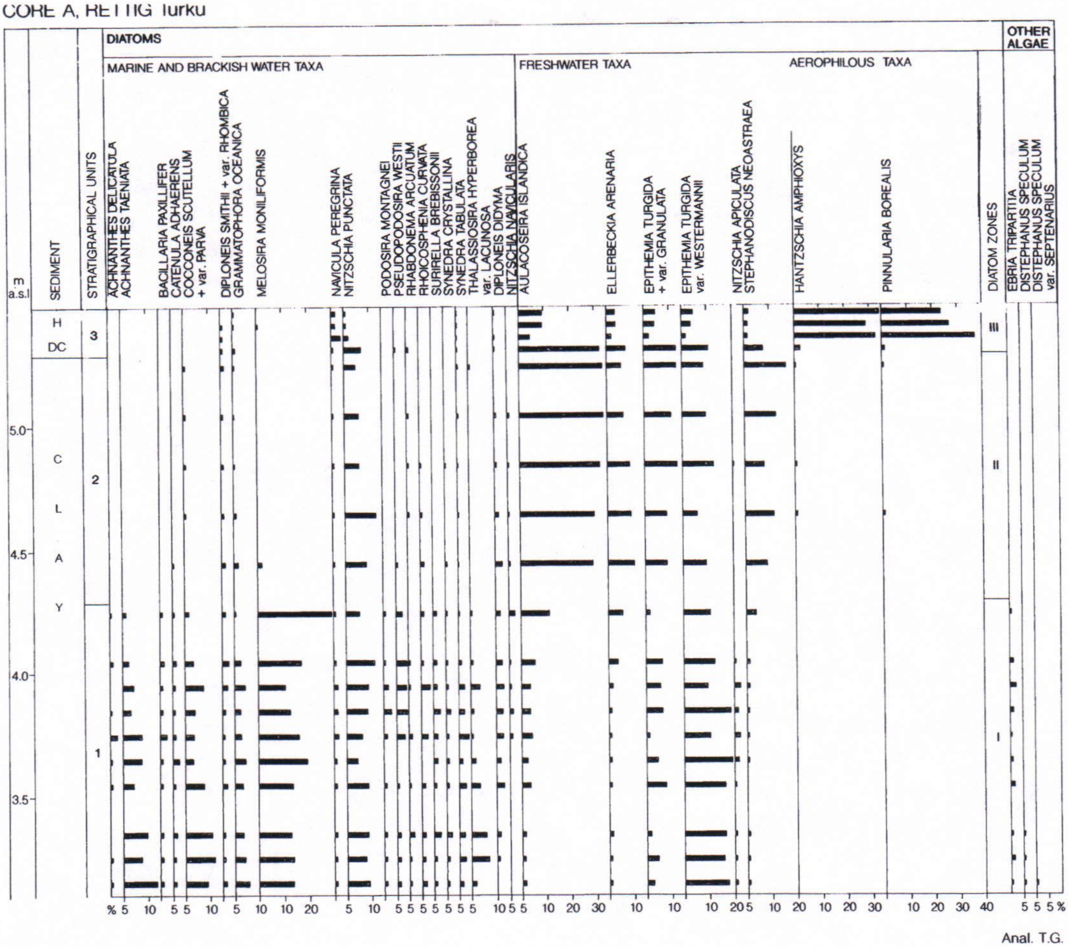

Figure 5. Diatom spectra including species representing > 2% of total diatom sum and other algae in Core A of the Rettig excavation site. DC = "Dirty" clay, H = Humus rich soil.

were determined according to the morphotypes described by Powers *et al.* (1988).

RESULTS

Diatom stratigraphy

The most important results from Core A are given as diagrams (Figs 5–7). The most common diatoms (more than 2% of the total diatom sum) are shown in Fig. 5. The list of diatoms noted from the Rettig site is presented in Vuorela *et al.* (1996). The diatoms were classified as marine-brackish and freshwater species, and the latter group further as freshwater large lake species and ordinary freshwater species (Fig. 6). Depending on the habitat of the diatoms, they were divided into plankton, lagoonal, littoral and aerophilous species (Fig. 7). The diatom succession was divided into three zones (I–III).

Zone I (3.15–4.30 m a.s.l.) contains sediments deposited in the Baltic Litorina Sea. Diatom species typical of the littoral areas of the Litorina Sea dominate (Eronen 1974, Ignatius & Tynni 1974, Miller & Robertsson 1979). The most characteristic species are *Melosira moniliformis* (Müller) Agardh, *Cocconeis scutellum* Ehrenberg including var. *parva* (Grunow) Cleve and *Nitzschia punctata* (W. Smith) Grunow (= *Tryblionella punctata* W. Smith). *Achnanthes delicatula* (Kützing) Grunow including var. *hauckiana* (Grunow) Lange-Bertalot, *Diploneis didyma* (Ehrenberg) Cleve, *Navicula peregrina* (Ehrenberg) Kützing and *Nitzschia apiculata* (Gregory) Grunow (= *Tryblionella apiculata* Gregory) also occur frequently. Some planktonic diatoms such as *Chaetoceros muelleri* Lemmermann, *Chaetoceros* spp., *Coscinodiscus asterom-*

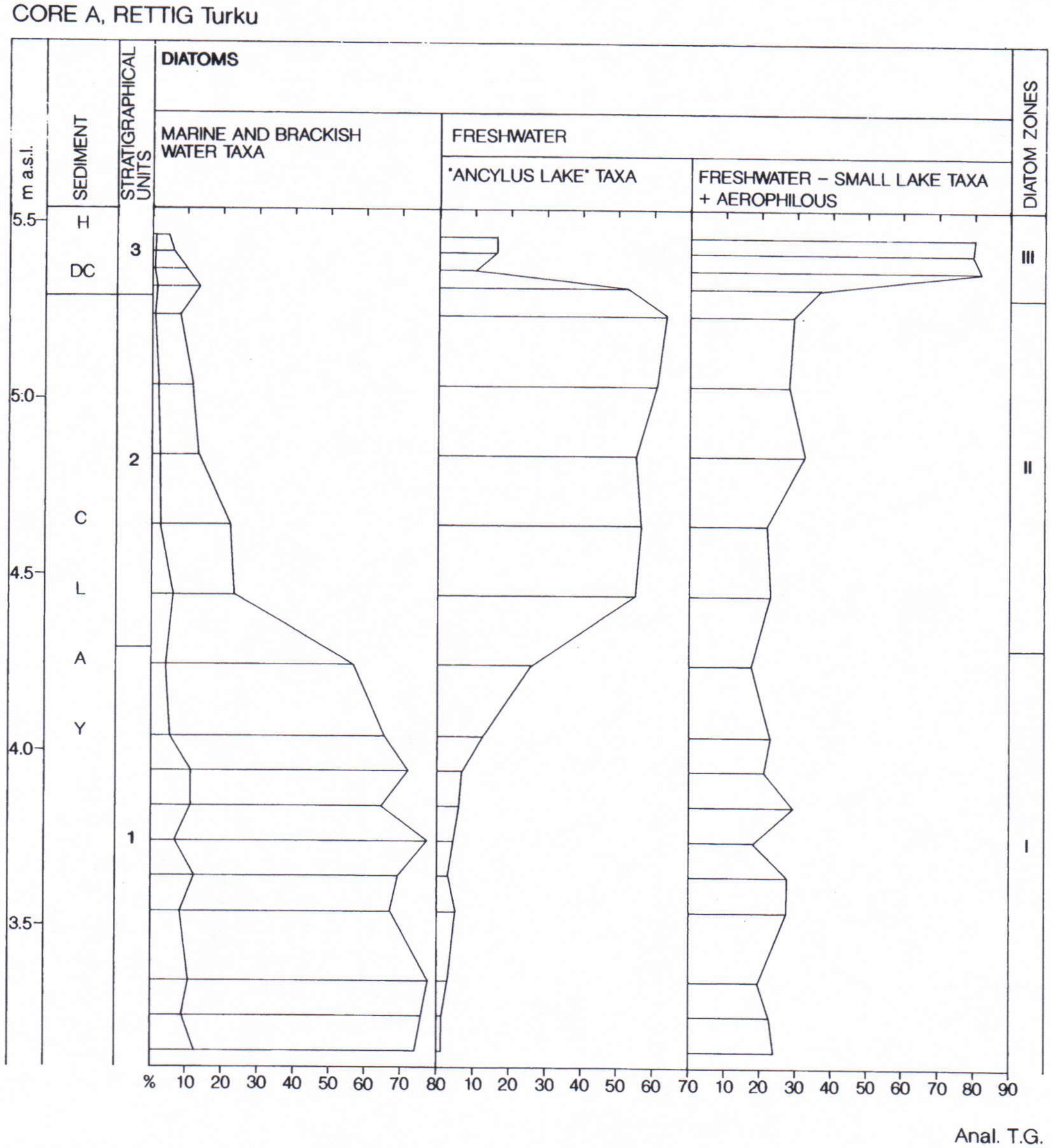

Figure 6. Division of diatom flora of Core A according to their salt tolerance. DC = "Dirty" clay, H = Humus rich soil.

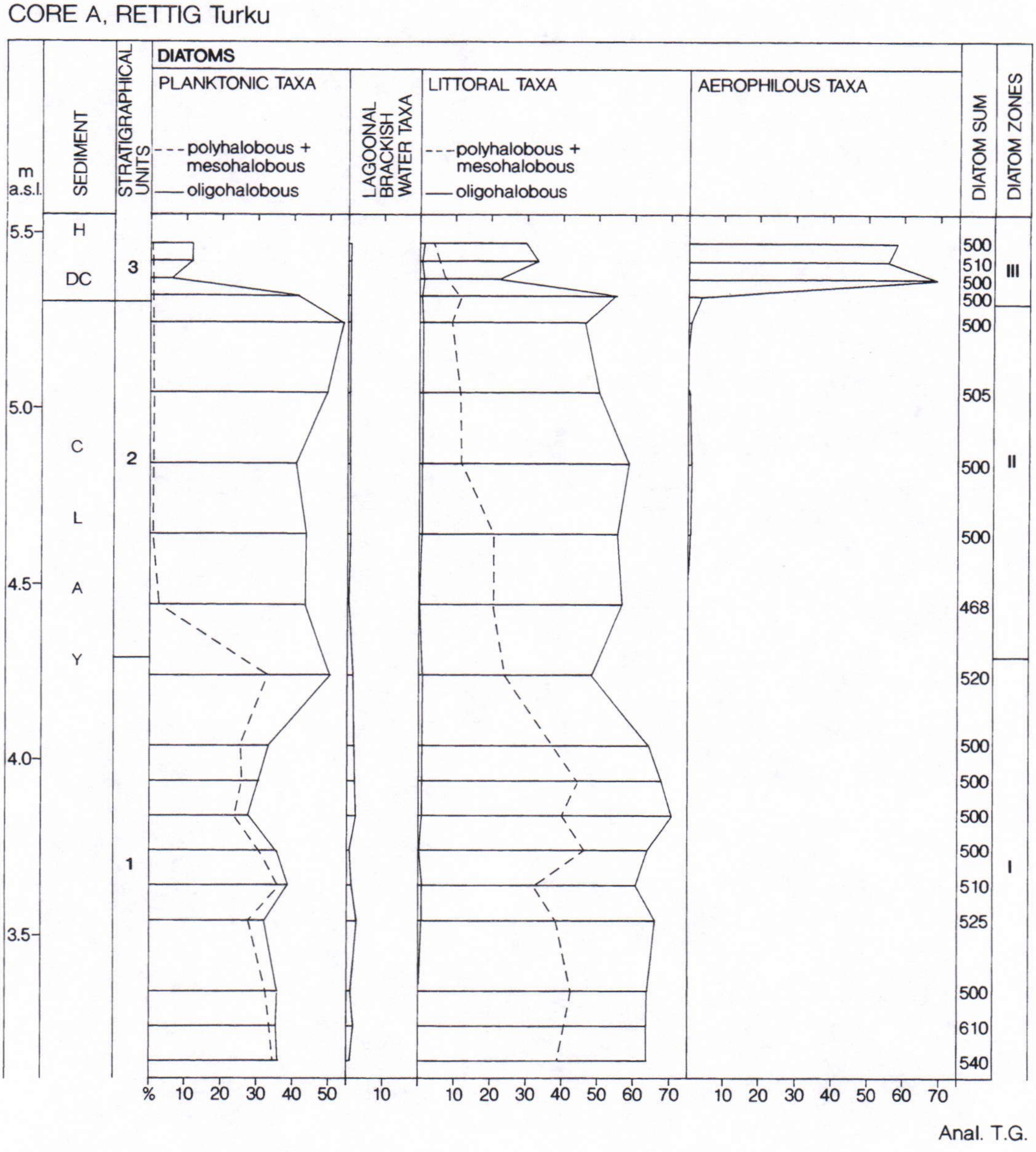

Figure 7. Ecological division of the diatom flora of Core A (according to different habitats). DC = "Dirty" clay, H = Humus rich soil.

phalus Ehrenberg, *Podosira montagnei* Kützing *Pseudopodosira westii* (W. Smith) Sheshukova-Poretzskaya and *Thalassiosira hyberborea* var. *lacunosa* (Berg) Hasle were also encountered. Typical of the lagoonal shallow water phase of the Litorina Sea are *Campylodiscus clypeus* Ehrenberg, *C. bicostatus* W. Smith, *Nitzschia scalaris* (Ehrenberg) W. Smith and *Surirella striatula* Turpin (Florin 1946, Eronen 1974).

Some freshwater diatoms were also found. The most characteristic species was *Epithemia turgida* var. *westermannii* (Ehrenberg) Grunow,

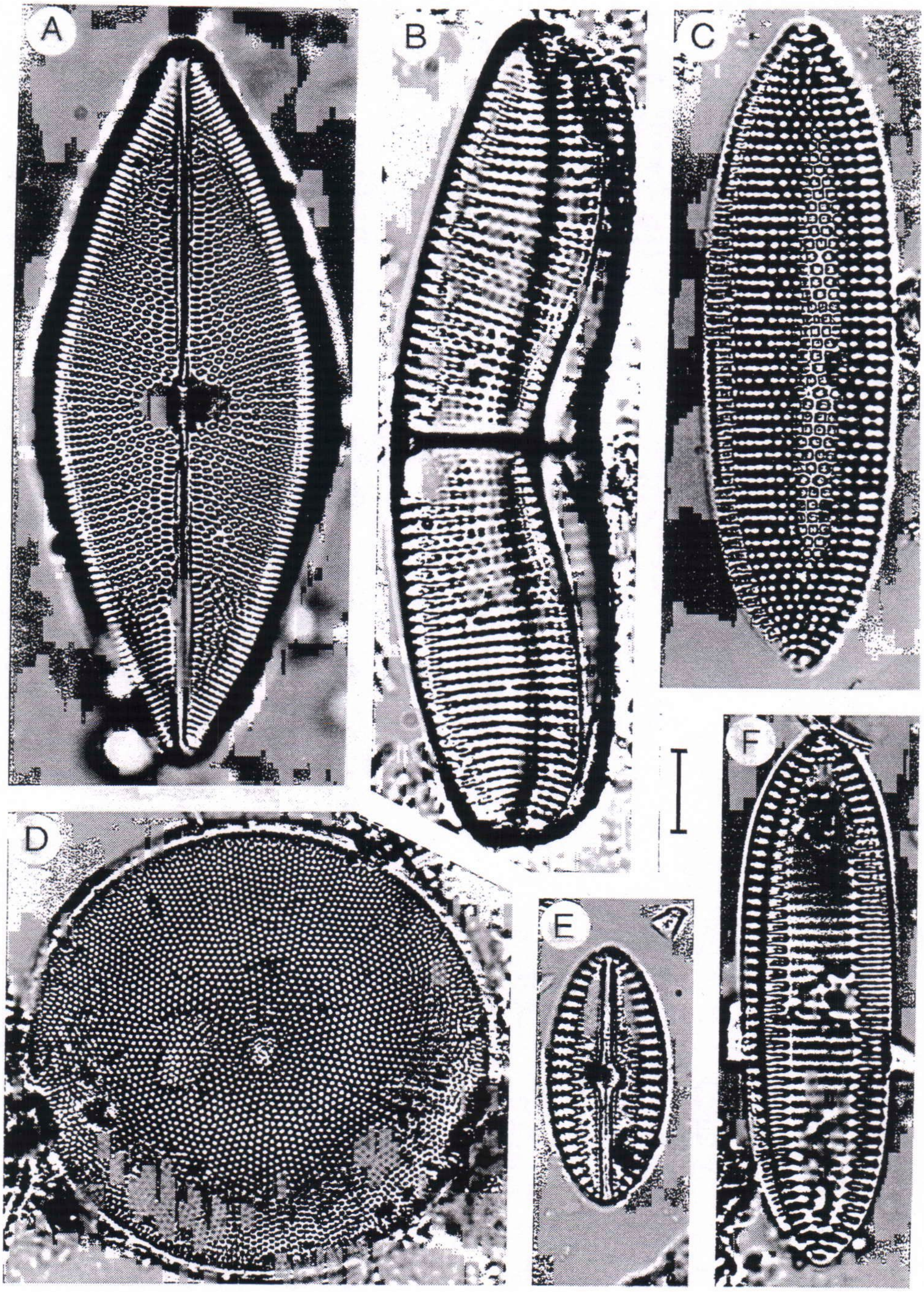

Figure 8. Diatoms represented in the samples analysed. LM photos. Scale bar = 10 µm. **A**. *Navicula marina Ralfs (= Petroneis marina (Ralfs in Prithard) D.G.Mann,* **B**. *Achnanthes longipes Agardh,* **C**. *Nitzschia punctata (W. Smith) Grunow (Tryblionella punctata W. Smith),* **D**. *Thalassiosira baltica (Grunow) Ostenfeld,* **E**. *Diploneis mauleri (Brun) Cleve,* **F**. *Nitzschia navicularis (Brébisson) Grunow ((Tryblionella navicularis (Brébisson ex Kützing) Ralfs in Pritchard. Photo: T. Grönlund.*

which was also interpreted as a halophilous taxon. It is common in littoral sediments of the Litorina Sea (e.g. Miller & Robertsson 1979).

Ebria tripartita (Schumann) Lemmermann, of the order Ebriales, was found occasionally, together with some silicoflagellates such as *Distephanus speculum* (Ehrenberg) Haeckel and var. *septenarius* (Ehrenberg) Joergensen, which are also marine plankton algae.

Zone II is composed of clay at the 4.30–5.30 m a.s.l. The diatom assemblage differs clearly from that in Zone I, although diatoms indicating saline and brackish water are present, freshwater diatoms dominate. *Aulacoseira islandica* (Müller) Simonsen is the most common. It belongs to a diatom flora of the Ancylus Lake which includes *Cocconeis disculus* (Schumann) Cleve, *Cymatopleura elliptica* (Brébisson) W. Smith, *Cymbella aspera* (Ehrenberg) Peragalli, *C. langeolata* (Ehrenberg) Cleve, *Diploneis maulerii* (Brun) Cleve, *Ellerbeckia arenaria* (Moore) Crawford, *Epithemia hyndmannii* W. Smith, *Gyrosigma attenuatum* (Kützing) Rabenhorst and *Opephora martyi* Heribaud (= *Martyana martyi* (Heribaud) Round).

Zone III represents the uppermost part of the core at 5.30–5.45 m a.s.l. and contains a lower number of diatoms than the rest of the core. Aerophilous *Hantzschia amphioxys* Ehrenberg (Grunow) and *Pinnularia borealis* Ehrenberg are dominant. Among other aerophilous species noted are *Navicula cohnii* (Hilse) Lange-Bertalot, *N. contenta* Grunow, *N. mutica* Kützing (= *Luticola mutica* (Kützing) D.G. Mann), *N. pusilla* W. Smith (= *Cosmioneis pusilla* (W. Smith) D.G. Mann & A.J. Stickle) and *Pinnularia lata* (Brébisson) W. Smith. *Ellerbeckia arenaria* was also found. It belongs to the flora of the Ancylus Lake but is also aerophilous in biotype, thriving especially on sandy shores. Aerophilous diatoms indicate low moisture environment.

Conclusions drawn from the diatom stratigraphy

The clay bed at the Rettig site can be divided into two stratigraphical units based on their diatom assemblages. The formation of these two units can be attributed to crustal uplift. The species found in the lower unit, dominated by Litorina diatoms, have been typically deposited in a shallow water environment in a sheltered archipelago. In the upper unit, made up of terrestrial sediments, Litorina diatoms are in minority while the dominant species have clearly been redeposited from old Ancylus Lake sediments that had formed about 9000 years ago. Due to land uplift, these sediments were later exposed to aerial erosion.

The upper humic part of the core, Unit 3, indicates a supra-aquatic environment just after the emergence of the new land, which was kept wet by sporadic floods and waves. Only aerophilous diatoms could grow under such conditions.

Pollen analysis

Local pollen taphonomy

In addition to the pollen produced by local vegetation, lots of non-anthropogenic pollen from the catchment was brought in by floods of the River Aura. Palaeoecologically, however, the most important pollen taxa, the settlement indicators, mainly represent the riverside habitation closely connected with the history of Turku. Such mixing is therefore not misleading in the interpretation of the results. On one hand, it is clear that large quantities of pollen grains were washed into the river, along with mineral soils and on the other hand, pollen content was partly affected by rainwater flowing from the adjacent hill of Vartiovuori (Fig. 1). The overall effect is probably to underestimate the cultural indicators and to overestimate the forest.

During the last few centuries, local human activity has modified the landscape and vegetation in various ways. The stone-paved narrow streets between the buildings have acted as tunnels along which the pollen has been trasported by wind. Rainwater streams have used the same routes.

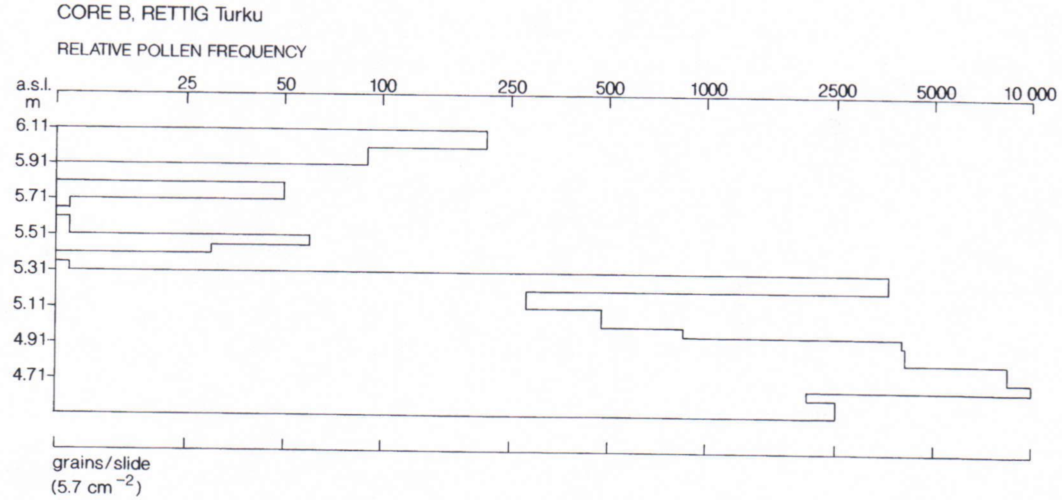

Figure 9. Relative pollen frequency of slides (5.7 cm^2) investigated from Core B.

Pollen contamination has also taken place through material brought into the town by the inhabitants and their domestic animals. Such sources of pollen have included crops, roofing, fodder, bedding, wild food and dung (Clapman & Scaife 1988).

Oxidation and drying of soil layers have been important taphonomic processes which lead to pollen corrosion, as do frost and human activity at urban sites (*cf.* Vuorela 1991, fig. 2). Even though minor contamination of the mineral soil can seldom be confirmed, the material used as infill in the building process is clearly distinguishable due to its more or less total lack of pollen grains. Other palaeoecological methods such as macrofossil analysis may produce useful information on such material.

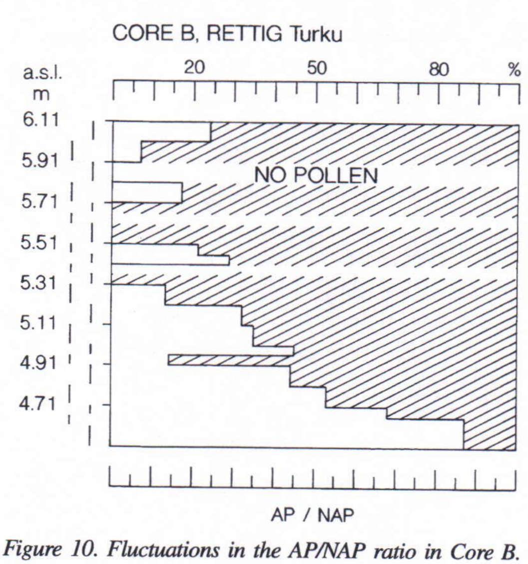

Figure 10. Fluctuations in the AP/NAP ratio in Core B.

Pollen concentration

The relative pollen concentration values of Core B are presented on a logarithmic scale (Fig. 9) giving numbers of pollen grains on each cover slide (5.7 cm^2). Even this imprecise scale shows great variation, making it easy to draw the boundary between the well-preserved, more humic lower part and the dryer upper part with corroded pollen grains at 5.30 m a.s.l. At the intervals 5.36–5.41 m, 5.61–5.66 m and 5.81–5.91 m, there was no pollen noted.

The same division of profile B is also evident in the AP/NAP ratio (Fig. 10), which clearly reflects the local increase in human impact. In the bottommost subsample, AP accounts for 87% of total pollen but decreases steadily to 14% at the 5.21 m level, which already represents urban

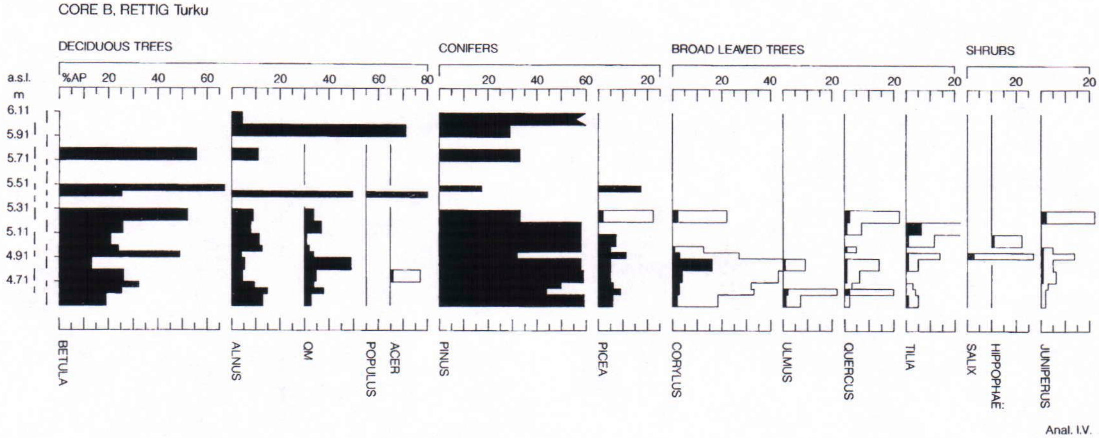

Figure 11. Relative tree and shrub pollen frequencies in Core B.

settlement. Later, the herb pollen frequencies reach 100% at several levels. This development, together with the pollen taxa, is similar to that noted in material from Lake Mätäjärvi (Vuorela 1985), less than 1 km from the Rettig site (Fig. 1), and interpreted as indicating forested meadows which preceded urban environments.

Relative pollen frequencies

In the lower half of the core (Fig. 11) relative pollen frequencies of conifers dominate. *Pinus* remains steady at c. 65% AP whereas the pollen frequencies of deciduous trees are more evenly divided between *Betula* (20–50%), *Alnus* (5–15%) and broadleaved deciduous trees (1–18%). The relatively high frequencies of the last-mentioned group, dominated first by *Corylus*, then by *Tilia*, evidently reflect local grazing on forested meadows and can thus be correlated with the Mätäjärvi material. Such activity seems to have taken place over a broader area on the banks of the River Aura during the period preceding urban habitation, an interpretation that is supported by the regular occurrence of *Juniperus* pollen grains at this level. Pollen grains of *Hippophaë* at the 5.01 m level serve as important evidence of the former distribution of this shrub, which nowadays grows only on the west coast of Finland from latitude 60°40' northwards and in the Åland Islands (Hultén 1971) and indicates specific coastal conditions.

From the 5.31 m level upwards no pollen of broadleaved trees were found in Core B. Instead, the pollen frequencies of *Alnus*, *Populus* and *Picea* fluctuated strongly. Since the decrease in QM species is on a minor scale in most cores (*e.g.* Core I/2; Vuorela *et al.* 1996) these changes most probably reflect intense local human activity. The results from the 5.41 m level upwards are, however, based on relatively low pollen concentration values (cf. Fig. 9) and thus are only partly comparable with those from the lower part of the profile.

Among aquatics (Fig. 12), only *Nymphaea* is represented in Core B, although *Isoëtes lacustris*, *Potamogeton* and *Sparganium* are also present in the local pollen flora (cf. Table 3).

Pollen of *Caltha palustris* represents moist shore vegetation, as does most of the pollen of Cyperaceae, *Thalictrum*, *Filipendula*, *Cornus* and *Valeriana*.

The natural mineral soil vegetation is dominated by Poaceae, even though this pollen type also includes *Phragmites australis*. Among the rich pollen flora of zoogamous herbs, Ranunculceae (+*Ranunculus acris*), Rosaceae, Rubiaceae, Fabaceae, *Achillea*-type, *Centaurea scabiosa*, *Succisa pratensis*, *Aster*-type, Caryophyllaceae, Apiaceae and Campanulaceae refer to forested

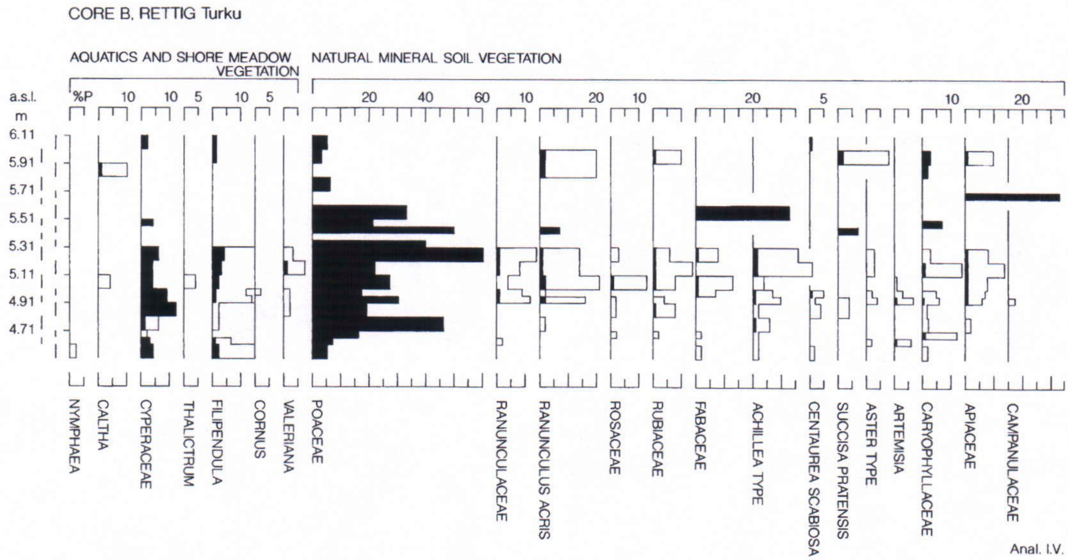

Figure 12. Relative pollen frequencies (% P) of aquatics, shore meadow vegetation and other mineral soil herbs in Core B of the Rettig material.

meadows, while *Artemisia* is typical of settled areas.

Open forest vegetation (Fig. 13) is represented by *Sphagnum*, Polypodiaceae, *Melampyrum*, *Pteridium*, *Anemone*-type, *Equisetum*, Ericaceae and *Calluna*. The boundary between this group and the natural mineral soil vegetation is not clear.

Settlement indicators are overwhelmingly dominated by Cerealia, which reaches 40%P at the

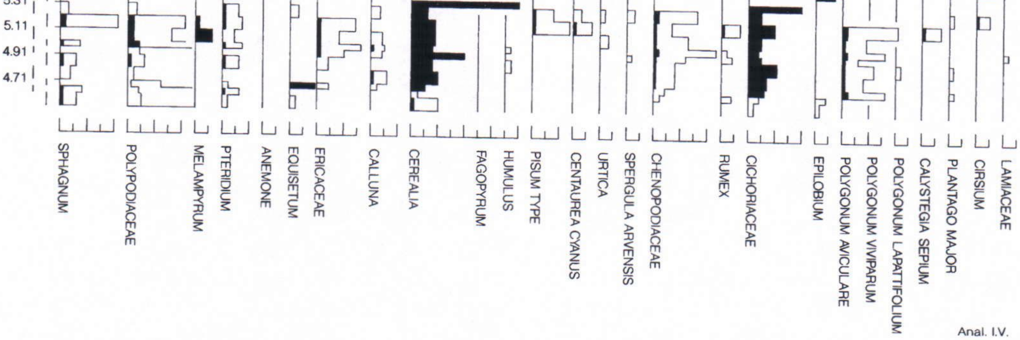

Figure 13. Relative pollen frequencies (% P) of open forest herbs and settlement indicators in Core B of Rettig material.

Table 1. Macrofossil plant remains from the deposit in Rettig 1994, Core C. The finds are seeds or fruits if not otherwise mentioned.

Plant species	Depth m a.s.l.												
	5.72	5.62	5.52	5.42	5.32	5.22	5.12	5.02	4.92	4.82	4.72	4.62	4.47-4.27	SUM
A. Plants used by man														
Hordeum vulgare	-	-	-	3	4	2	-	-	1	-	-	-	-	10
Linum/Cannabis/fibre	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Cannabis sativa	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Humulus lupulus	-	-	-	2	1	3	2	-	17	3	-	-	-	28
Ficus carica	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Fragaria vesca	2	-	33	5	6	3	8	12	2	-	-	1	-	72
Hyoscyamus niger	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Myrica gale	-	-	-	-	1	-	1	-	-	-	-	-	-	2
Vaccinium myrtillus	-	-	-	-	-	1	-	2	2	-	-	-	-	5
Vaccinium sp.	-	-	-	-	-	-	-	-	-	-	-	1	-	1
B. Trees and shrubs														
Corylus avellana	6	-	4	-	2	1	-	-	-	-	-	-	-	13
Juniperus communis	-	-	-	-	1	1	-	-	-	-	-	-	-	2
Picea abies	-	-	1 *	1	1	-	1	-	-	-	-	-	1 *	5
Quercus robur	-	-	-	-	-	-	-	-	2	-	-	-	-	2
Rosa sp.	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Sorbus aucuparia	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Tilia cordata	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. Weeds and ruderals														
Agrostemma githago	-	-	-	-	1	1	-	5	1	-	-	-	-	8
Atriplex patula	-	-	6	1	4	8	5	1	1	-	-	-	-	26
Brassicaceae/Cruciferae	-	-	-	-	-	-	2	-	-	-	-	-	-	2
Brassica/Raphanus	-	-	-	-	1	1	-	-	-	-	-	-	-	2
Centaurea cyanus	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Chenopodium album	4	2 *	42	10	15	48	34	27	4	-	-	4	-	190
Chrysanthemum segetum	-	-	1	-	-	-	1	-	-	-	-	-	-	2
Cirsium arvense	-	-	1	-	-	-	1	-	-	-	-	-	-	2
Cuscuta europaea	-	-	1	1	-	1	1	-	-	1kä	-	-	-	5
Fallopia convolvulus	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Galeopsis speciosa	-	-	-	1	-	1	1	-	-	-	1	1	-	5
Galium sp.	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Lamium purpureum	-	-	3	-	-	-	-	1	-	-	-	-	-	4
Lapsana communis	-	-	-	-	1	1	-	-	-	-	-	-	-	2
Plantago major	-	-	-	-	1	-	1	-	-	-	-	-	-	2
Poa annua	-	-	1	2	4	3	-	1	1	-	-	2	-	14
Polygonum aviculare	-	-	2	1	9	10	1	1	5	-	-	1	-	30
Polygonum hydropiper	1	-	-	-	1	-	3	-	-	-	-	-	-	5
Polygonum lapathifolium	-	-	-	-	4	14	-	12	1	-	-	1	-	32
Polygonum persicaria	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Prunella vulgaris	-	-	1	2	-	-	-	-	2	-	-	-	-	5
Ranunculus acris	-	-	-	-	-	-	2	-	-	-	-	-	-	2
Ranunculus repens	-	-	-	-	2	1	-	3	-	-	-	-	-	6
Ranunculus sceleratus	-	-	38	24	15	1	1	2	-	-	-	-	-	81
Rumex acetosella	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Solanum nigrum	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Sonchus arvensis	-	-	-	-	-	12	-	-	-	-	-	-	-	12
Spergula arvensis	-	-	1	-	-	-	4	1	-	-	-	-	-	6
Stellaria graminea	-	-	2	-	-	-	-	1	-	-	-	-	-	3
Stellaria media	-	-	3	2	7	9	16	6	1	1	-	1	-	46
Thlaspi arvense	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Tripleurospermum inodorum	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Urtica dioica	-	-	49	45	-	-	-	-	-	-	-	-	-	94
Urtica urens	-	2	2	-	-	-	1	-	-	-	-	-	-	5
D. Meadow plants														
Agrostis sp.	-	-	-	3	-	-	-	3	2	-	1	1	-	10

	Depth m a.sl. 5.72	5.62	5.52	5.42	5.32	5.22	5.12	5.02	4.92	4.82	4.72	4.62	4.47-4.27	SUM
Alchemilla sp.	1	-	-	-	-	-	-	1	-	-	-	-	-	2
Cerastium sp.	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Dianthus deltoides	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Filipendula ulmaria	-	-	-	1	-	-	-	-	3	-	-	-	-	4
Hypericum maculatum	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Leucanthemum leucanthemum	-	-	-	-	1	-	1	-	-	-	-	-	-	2
Luzula campestris	-	-	-	-	-	-	4	-	-	-	-	-	-	4
Luzula pilosa	-	-	-	-	1	1	-	-	-	-	-	-	-	2
Pimpinella saxifraga	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Poa pratensis/trivialis	-	-	1	1	8	4	5	-	6	2	-	1	-	28
Poaceae	-	-	-	-	2	-	-	-	-	-	-	-	-	2
Sagina sp.	-	-	-	-	1	-	1	-	3	-	-	3	-	8
Scleranthus annuus	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Solidago virgaurea	-	-	1	-	2	-	-	-	-	-	-	-	-	3
Spergularia sp.	-	-	-	-	1	-	4	-	1	-	-	-	-	6
Trifolium repens	-	-	-	1k	-	-	1ku	-	-	-	-	3ku	-	5
Viola sp.	-	-	-	1ko	1ko	2+2ko	-	1	-	-	-	1	-	8
E. Plants of shore, marsh and water														
Batrachium sp.	-	-	1	6	2	-	-	-	-	-	-	-	-	9
Carex 2-	5	-	27	29	36	99	39	50	3	-	-	-	-	288
Carex 3-	1	-	4	10	12	5	-	3	-	-	-	-	-	35
Potentilla palustris	-	-	-	6	1	5	1	1	2	-	-	-	-	16
Eleocharis palustris	-	-	1	-	1	1	2	-	-	-	-	-	-	5
Empetrum nigrum	1	-	-	1	-	-	-	1	-	-	-	-	-	3
Juncus compressus/gerardi	-	-	-	-	24	-	-	21	-	1	-	-	-	46
Juncus sp.	-	-	13	18	-	3	61	-	7	-	1	-	-	103
Lychnis flos-cuculi	-	-	-	1	-	1	-	-	1	-	-	-	-	3
Phragmites australis	-	-	-	1	1	-	-	-	-	1	-	-	-	3
Potentilla erecta	-	-	10	-	-	1	3	3	1	-	-	-	-	18
Ranunculus flammula	-	-	3	1	15	2	1	-	-	-	-	-	-	22
Scirpus sylvaticus	-	-	1	1	2	4	2	-	-	-	-	-	-	10
Solanum dulcamara	-	-	-	-	2	-	-	-	-	-	-	-	-	2
Stellaria palustris	1	-	-	-	-	-	1	-	-	-	-	-	-	2
F. Plants of cliffs														
Calluna vulgaris	-	-	-	-	-	4ku	3ku+2	-	-	-	-	1ku	-	10
INDET.	-	-	-	-	-	-	-	2	-	-	-	-	-	2
G. Other remains														
Bryophyta/stems, leaves	-	-	4	5	6	41	-	26	-	-	-	-	-	82
Dicranum	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Mnium	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Polythrichum	3	1	-	-	-	1	-	-	-	-	-	-	-	5
Sphagnum	-	-	2	1	3	1	2	10	-	-	-	1	-	20
Wood/uncharred	-	-	-	-	-	11	-	10	1	9	8	12	-	51
Wood/charred	-	-	7	4	-	-	-	-	-	-	-	2	3	16
Betula/bark	-	-	-	-	-	1	-	1	-	-	-	-	-	2
Linum/fibre?	-	4	-	-	-	-	-	-	-	-	-	-	-	4
Plant remains/mixed	-	-	-	+++	-	+++	+++	+++	+++	-	+++	-	-	-
Pisces/scales	-	6 *	-	-	-	2	1	-	-	-	-	-	-	9
Lumbricus terrestris/cocoon	-	-	13	-	-	10	3	14	-	-	-	-	-	40
Bone	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Insecta	-	-	10	+	-	-	10	10	-	-	-	2	-	32
Hairs	-	-	-	-	-	-	-	-	+	+	-	-	-	-
SUM	25	15	294	191	206	330	234	234	71	18	11	41	3	1673

*/h=charred, k=calyx, ku=flower, ko=capsule, kä/kär=tendril, n/ne=needle, +++=common

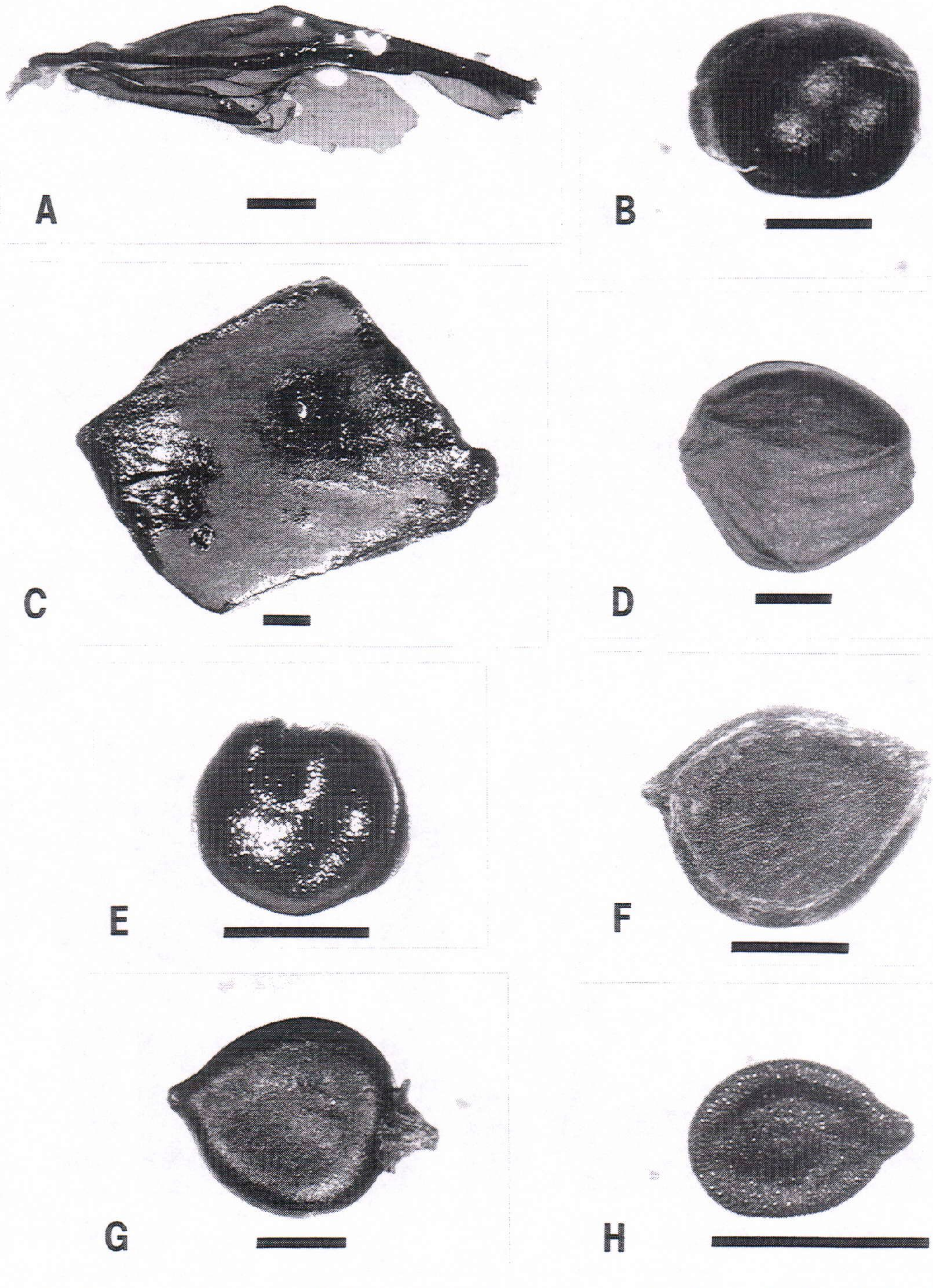

Figure 14. Plant remains found at the Rettig site: A = Hordeum vulgare, uncharred grain, B = Humulus lupulus, seed, C = Corylus avellana, nut fragment, D = Alnus sp., seed, E = Chenopodium album, seed, F = Ranunculus repens, seed, G = Polygonum lapathifolium, seed, and H = Dianthus deltoides, seed. Scale = 1 mm. Photo: T. Lempiäinen.

5.31–5.36-m level. Although this pollen type mainly reflects local cultivated fields, most clearly in the lower part of the diagram, it could indicate any activity related to crop growing in the intensily influenced anthropogenic upper layers (*cf.* Greig 1982, fig. 26). Among other cultivated plants, pollen of *Fagopyrum esculentum* was found at the 6.01–6.11-m level, that of *Humulus lupulus* at the 4.81–5.01 m level and *Pisum*-type pollen grains at the 5.11–5.31 m level. At the Rettig site as at several other urban sites studied earlier, *e.g.* Turku Mätäjärvi (Vuorela 1989), Porvoo (Vuorela & Hiekkanen 1991), Käkisalmi (Vuorela *et al.* 1992) and Helsinki (Vuorela & Lempiäinen 1993, Vuorela 1994), pollen of Cichoriaceae is strongly represented, increasing in frequency at the rural/urban boundary. According to the present macrofossil data, this pollen type could represent *Lapsana communis*, *Leontodon autumnalis*, *Sonchus asper* or *Sonchus arvensis* (see Table 3). Other features in common with the investigations referred to are the relatively high pollen frequencies of Chenopodiaceae, *Polygonum aviculare* and *Centaurea cyanus*, the last in no relation to the *Secale* frequencies.

Among other settlement indicators, *Urtica*, *Spergula arvensis*, *Rumex*, *Epilobium*, *Polygonum viviparum* and *P. lapathifolium* (Fig. 14:G), *Plantago major*, *Cirsium* type and Lamiaceae were recorded, mainly in the upper part of the more or less naturally deposited lower half of the profile. *Calystegia sepium* most probably grew under the local shrubs.

It should be stressed that the above pollen types were almost equally present in all seven profiles investigated in the Rettig area (cf. Table 3).

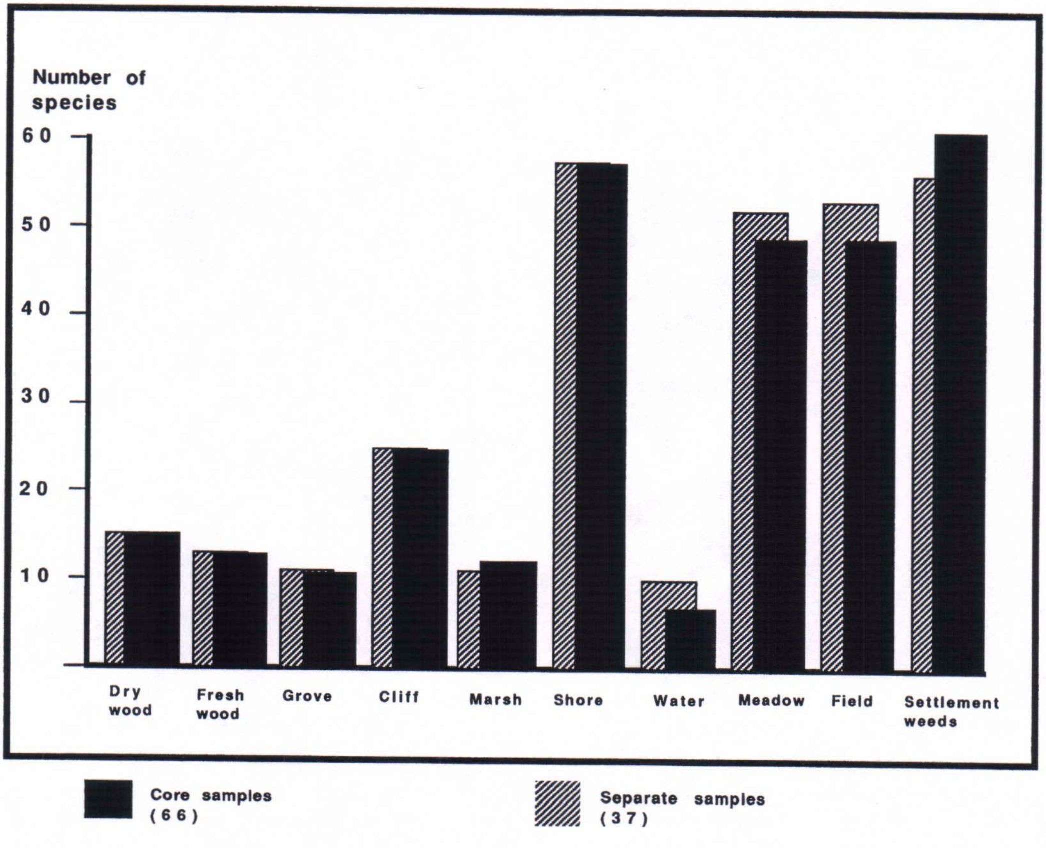

Figure 15. Distribution of inferred original habitats of the macrofossil flora found at the Rettig site in 1994–1995.

Macrofossils

It is a rule rather than an exception that macrofossil plant remains stay where the plant once grew. That is why they provide such important evidence of the local vegetation of former settlement sites. They are particularly useful as remains of plants used by man, cereals and settlement weeds.

Macrofossil plant remains, especially soft plant cells, are very sensitive to corrosion, oxidation and decomposition. Not all plants used by man are represented in the lists because many of them, for instance, many cabbage species and spice plants, are harvested before they produce seeds. This is one of the reasons why we cannot get complete plant lists for the cores investigated. The interpretation of the natural macrofossil flora was based on the same factor as that of the pollen flora; the ecological requirements of the plants identified are largely known.

It is most important to identify cereals at species and subspecies levels. For that we need to compare them with macrofossils of old cereal species, forms and types.

The Rettig quarter was densely inhabited during the Middle Ages. It was part of the medieval centre of Turku (Ranta 1975), from where streets and main roads ran out into the countryside. In those days, people used to throw their rubbish into the streets or courtyards and refuse heaps were often formed. Plant remains accumulated in these heaps, in wells and ditches, on floors, around fireplaces, and also in manure. In the latter, the remains have been well preserved due to the mechanical shelter and favourable moisture conditions.

In this context only Core C will be presented (Fig. 2, Table 1) but the macrofossil results of all six profiles, together with the 33 samples analysed separately (Lempiäinen 1995a), are also referred to (Table 3). The total number of plant macrofossils found from the six profiles investigated by means of pollen and macrofossil analysis was 5563, 508 of them from Core B. Altogether 9986 macrofossils have been identified (Lempiäinen 1995b, Vuorela *et al.* 1996).

Macrofossil results

Plants used by man

Table 2 lists all macrofossil finds of cultivated/-alien origin species in the Rettig area.

The total number of plant remains of cultivated/alien plants was 443. It is c. 4.4% of the total amount of plant macroremains found in the Rettig area.

*Table 2. Total number of plant macrofossils of cultivated/alien origin used by man found in the core samples plus the separate macrofossil samples from the Rettig excavation site. * = charred*

Plant species	Core samples (66)	Separate samples (37)
Avena sativa		8*
Hordeum vulgare	13*	134*
Secale cereale	1*	12*
Triticum cf. aestivum		1*
Triticum compactum		1*
Cerealia	1*	174*
Cannabis sativa	2	6
Humulus lupulus	61	20
Linum usitatissimum	1	
Pisum sativum		5*
Ficus carica	2	1
Total sum	81	362

Cereals and other cultivated plants

The most common cereal grain found in the Rettig material was *Hordeum vulgare* (Fig. 14:A). Barley was the main cereal in Finland in the Middle Ages (*e.g.* Soininen 1974, T. Vuorela 1975) and it was used both for food and for making beer. Other cereals still cultivated today, *e.g. Secale cereale*, *Avena sativa* and *Triticum* cf. *aestivum* were also found but less frequently than *Hordeum*. One grain of *Triticum compactum* was even found; this is an important find because *T. compactum* is a very primitive cereal with small grains and was probably not cultivated in Finland after the Middle Ages. A greater number of *T. compactum* grain finds dated to this age was found in the Old Market Place of

Turku, nearby the Rettig site (Lempiäinen 1995a).

Eighty-one small nuts of *Humulus lupulus* (Fig. 14:B) were found. Hop is one of the most common macrofossil species dated to the Middle Ages in Turku (Lempiäinen 1985, 1988, 1995a, Aalto 1994). It was an important spice plant for beer and was cultivated by law in Finland at that time. Churchtithes also had to be paid in the form of hops (Suominen 1982).

Another spice used for beer was *Myrica gale*, and its seeds, too, were found in the Rettig area. As a native plant in the flora of Finland, it was collected from shores and marshes in southern Finland but is not known to have been cultivated. Leaves, seeds and also other parts of *Myrica* were used. Its toxicity in beer was not discovered until the 18th century. Drinking too much *Myrica* beer was a cause of death, and the use of the plant was prohibited (Vasari 1965, Behre 1984).

Important fibre plants in the Middle Ages were *Cannabis sativa* and *Linum usitatissimum*, both of which were found as macrofossils in the medieval layers of the Rettig site. Hemp was still an important cultivated fibre plant in Finland at the beginning of the 20th century (Linkola 1916). It was used for making coarse clothes and especially for sails, ropes and fishing tools which were important in Turku, Finland's main port (T. Vuorela 1975, Lempiäinen 1995a). Macrofossils of flax have been found in several medieval contexts in Turku (*e.g.* Lempiäinen 1985, 1995a,b, Valo 1993, Aalto 1994). No weeds of flax fields or flax capsules were found in the Rettig material. Flax was probably brought as a more or less ready processed fibre from Häme, central Finland or from Tallinn, Estonia, to be sold in Turku. *Pisum sativum* was mentioned in 1673 in the Catalogus plantarum of Elias Tillandz. Gadd (1751) also mentioned pea as a common cultivated plant in Satakunta, western Finland. Pea was widely cultivated in continental Europe in the Middle Ages (Behre 1983).

Other useful plants

Hyoscyamus niger was not very common in the Rettig material. The plant is not native in Finland but was known in the Viking Age (AD 800–1050; Lempiäinen 1991). The richest macrofossil finds are from Turku. It was an important medicinal plant, used especially for easing aches and rheumatic pain. It also played a role as a hallucinant in witch rituals. The plant was brought to the Nordic countries from southern Europe or western Asia by merchants, monks and soldiers. Henbane was first cultivated, but later spread as a weed. In the Middle Ages, henbane may also have been common as a herb in gardens in Turku.

Seeds of *Chelidonium majus* were also found. This plant was cultivated for its medicinal properties in Spain in the 14th century and may also have been brought to the Nordic countries by monks, merchants and travellers. The plant is mentioned in a letter written by King Gustaf Wasa of Sweden to the soldiers of the town of Viborg in 1556 (Pettersson 1965).

Collected natural growing plants.

Many remains of wild berries were found in the material analysed. Common were *Fragaria vesca*, *Rubus idaeus*, *Vaccinium* spp., *Juniperus communis*, *Sorbus aucuparia*, *Rosa* sp. and *Corylus avellana* (Fig. 14:C). They are native to southwestern Finland and common in the vicinity of Turku. *Juniperus*, for instance, is known to have been used as a medicine plant and as a disinfectant during plague epidemics, when its branches were burnt inside houses. It also served as a spice for beer (Erkamo 1944, Nikula & Nikula 1987). A small piece of rope made of the cambium layer of *Tilia cordata* was also found. The fragments of *Tilia* nut shells were very common in all medieval layers of Rettig. Pieces of nuts were picked up from the soil at the time of excavation; whole nuts were rare. Nuts were used as a food or for making oil. They were also economically important in Finland (Suominen 1965).

Remains of other native plants that are thought to have been used by man (Tillandz 1673, 1683, Lönnrot 1838, 1860) were found in abundance, *e.g. Arctostaphylos uva-ursi*, *Em-*

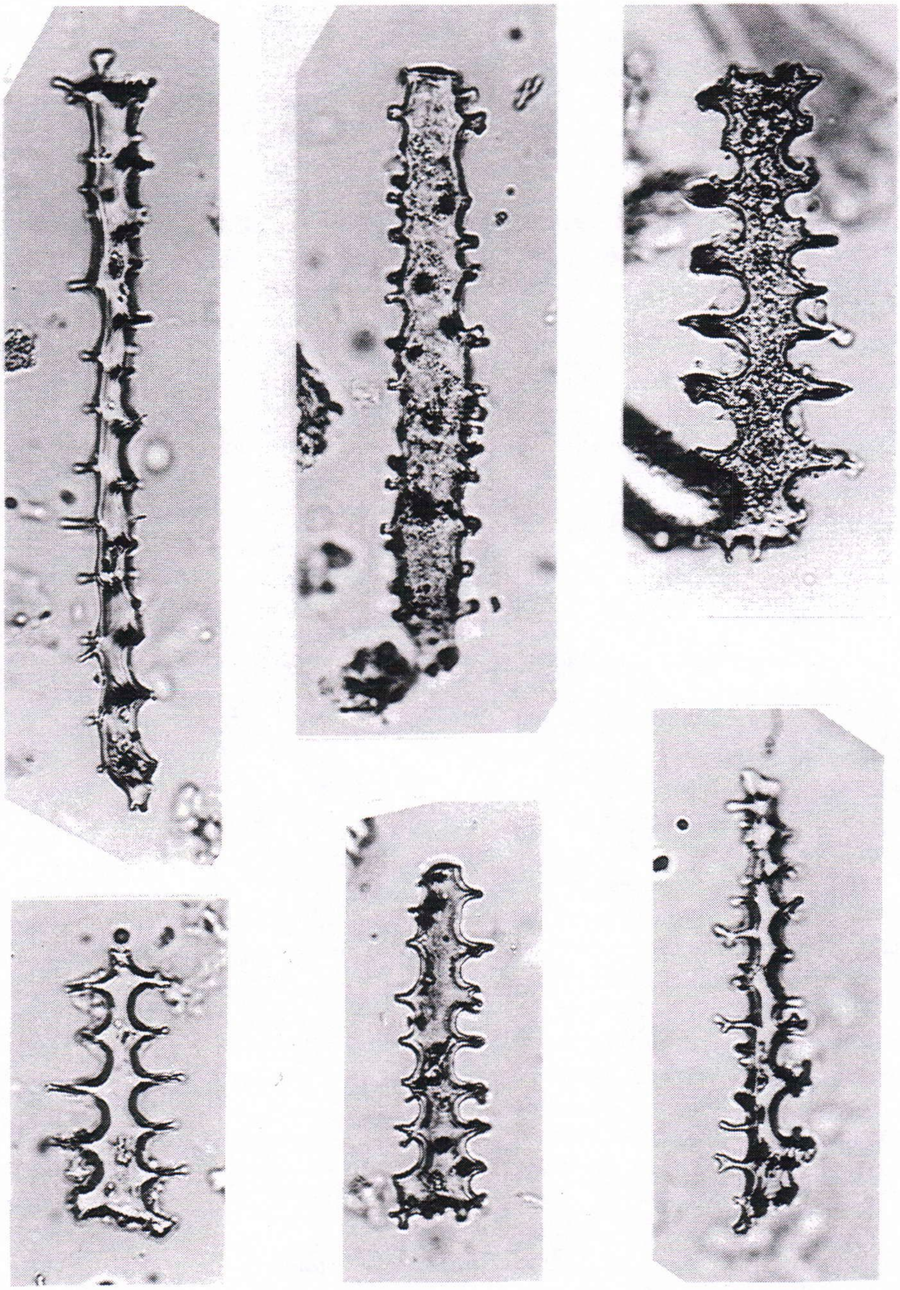

Figure 16. Phytoliths of Poacoid type (narrow elongated morphotypes) from the surface material of a grindstone found at the Rettig site. Photo: I. Vuorela.

petrum nigrum, *Urtica dioica*, *Calluna vulgaris*, *Galium* sp., *Viola* sp., *Stellaria media*, *Plantago major*, *Alchemilla* sp., *Veronica* sp., *Potentilla erecta*, *Ranunculus acris* and *Solanum dulcamara*.

Plants introduced by trade

Seeds of fig (*Ficus carica*) are fairly common in the layers of medieval Turku (Lempiäinen 1995a,b). Fig may have been used as a medicinal plant (Erkamo 1944) but also as food by the wealthy inhabitants of Turku and the occupants of the castle (Aalto 1994). Another useful plant was *Juglans regia*; this was easy to transport by ship from the continent and to store dry like fig. However, very few finds of *Juglans* have been made in Finland. Macrofossil nuts of *Juglans regia* have been found in medieval Lund, southern Sweden (Hjelmqvist 1963).

Natural vegetation

Figure 15 shows the inferred original habitats and numbers of macrofossil plant species found at the Rettig site (Lempiäinen 1995b, Vuorela *et al.* 1996) classified according to Ellenberg (1979), Linkola (1916) and Hämet-Ahti *et al.* (1986). The most frequent plants derive from cultural habitats (settlement weeds) and shores or wetlands (together accounting for 20.4% of total). Equal proportions of plants, 16.4%, grew in fields and meadows. The nearest pastures were located on the banks of the river Aura and the shores of Lake Mätäjärvi. They were habitats of plants such as *Carex* sp., *Eleocharis palustris*, *Juncus* sp., *Phragmites australis*, *Filipendula ulmaria*, *Ranunculus flammula*, *Scirpus sylvaticus* and *Solanum dulcamara*, all of which were found in the macrofossil material. A representative of sea-shore plants was *Aster tripolium*. The remains of plant species of woods, marshes, groves and waters were all equally represented. The following plants come from moist or wet habitats: *Lychnis flos-cuculi*, *Alisma plantago-aquatica* and *Caltha palustris*, *Callitriche* sp., *Elatine* sp., *Potamogeton* sp., *Sparganum* sp., and *Batrachium*. Plants growing on rocks, cliffs and dry hillsides were fairly common as the rock of Vartiovuori is in the immediate vicinity of the site.

COMPARISON OF MACROFOSSIL AND POLLEN DATA

In Table 3 the macrofossil and pollen taxa identified from all the Rettig samples are placed side by side. Most of the anthropogenic macrofossil species can be identified at species level, whilst the pollen types are often identified at family level. Of the 72 pollen taxa identified, 57 have a corresponding taxon among the macrofossils. Mainly due to the well represented large families such as Caryophyllaceae, 124 plant macrofossil taxa have corresponding pollen taxa. Anthropogenic plants reflecting the local vegetation of the site are best represented in the mutual pollen and macrofossil data. Most of the macrofossil plant species found belong to the families Caryophyllaceae, Ranunculaceae, Rosaceae, Lamiaceae, Asteraceae, Cichoriaceae, Cyperaceae and Poaceae.

Table 3. Pollen and plant macrofossil taxa identified from the Rettig material in 1994–1995.

Pollen taxa	Macrofossil taxa
Cerealia	*Avena sativa*
	Hordeum vulgare
	Triticum aestivum
	Triticum compactum
	Cerealia
Secale cereale	*Secale cereale*
Polypodiaceae	*Dryopteris thelypteris*
Picea	*Picea abies*
Pinus	*Pinus sylvestris*
Juniperus	*Juniperus communis*
Ranunculus acris	*Ranunculus acris*
Ranunculaceae	*Batrachium* sp.
	Ranunculus flammula
	Ranunculus repens
	Ranunculus sceleratus
Caltha	*Caltha palustris*
Thalictrum	*Thalictrum flavum*
Cannabis sativa	*Cannabis sativa*
Humulus lupulus	*Humulus lupulus*
Urtica	*Urtica dioica*
	Urtica urens
Quercus	*Quercus robur*
Alnus	*Alnus* sp.
Betula	*Betula* sp.
Corylus	*Corylus avellana*
Caryophyllaceae	*Agrostemma githago*

Table 3. Continuing.

	Cerastium sp.
	Dianthus deltoides
	Lychnis flos-cuculi
	Sagina sp.
	Scleranthus annuus
	Silene nutans
	Spergularia sp.
	Stellaria graminea
	Stellaria media
	Stellaria palustris
Spergula arvensis	*Spergula arvensis*
Chenopodiaceae	*Atriplex patula*
	Chenopodium album
	Chenopodium suecicum
	Chenopodium glaucum/rubrum
	Chenopodium hybridum
Polygonum aviculare	*Polygonum aviculare*
Polygonum persicaria type	*Polygonum lapathifolium*
	Polygonum persicaria
	Polygonum minus
Fallopia convolvulus	*Fallopia convolvulus*
	Fallopia dumetorum
Rumex	*Rumex acetosa*
	Rumex acetosella
	Rumex crispus
Hypericum	*Hypericum maculatum*
Brassicaceae	*Brassica/Raphanus*
	Camelina sp.
	Capsella bursa-pastoris
	Rorippa palustris
	Thlaspi arvense
Salix	*Salix* sp.
Calluna vulgaris	*Calluna vulgaris*
Ericaceae	*Arctostaphylos uva-ursi*
	Empetrum nigrum
	Vaccinium myrtillus
	Vaccinium sp.
Tilia	*Tilia cordata*
Rosaceae	*Alchemilla* sp.
	Rosa sp.
Potentilla	*Potentilla anserina*
	Potentilla erecta
	Fragaria vesca
	Comarum palustris
Filipendula	*Filipendula ulmaria*
Trifolium	*Trifolium repens*
Pisum type	*Pisum sativum*
Vicia type	*Vicia* sp.
Fabaceae	*Lathyrus pratensis*
Apiaceae	*Pimpinella saxifraga*
Rubiaceae	*Galium mollugo*
	Galium sp.
	Galium aparine
Valeriana	*Valeriana officinalis*
Lamiaceae	*Galeopsis speciosa*
	Lamium purpureum
	Lycopus europaeus
	Prunella vulgaris
Plantago major/media	*Plantago major*
Asteraceae	*Leucanthemum vulgare*
	Chrysanthemum segetum
	Gnaphalium sylvaticum
	Solidago virgaurea
	Aster tripolium
Antennaria	*Antennaria dioica*
Artemisia	*Artemisia vulgaris*
Centaurea cyanus	*Centaurea cyanus*
Cirsium	*Cirsium arvense*
Cichoriaceae	*Lapsana communis*
	Leontodon autumnalis
	Sonchus asper
	Sonchus arvensis
Alisma	*Alisma plantago-aquatica*
Potamogeton	*Potamogeton sp.*
Sparganium	*Sparganium simplex*
Cyperaceae	*Carex nigra*
	Carex ovalis
	Carex rostrata
	Carex sp.
	Eleocharis palustris
	Scirpus sylvaticus
Poaceae	*Agrostis sp.*
	Alopecurus geniculatus
	Bromus secalinus
	Festuca sp.
	Phragmites australis
	Poa annua
	Poa pratensis/trivialis
	Puccinellia sp.
	Poaceae
Sphagnum	*Sphagnum* sp.
No pollen	*Ficus carica*
	Juglands regia
	Linum usitatissimum
	Rubus idaeus
	Sorbus aucuparia
	Juncus articulatus
	Juncus bufonius
	Juncus compressus/gerardii
	Juncus sp.
	Luzula campestris
	Luzula pilosa
	Veronica officinalis
	Chelidonium majus
	Hyascyamus niger

PHYTOLITHS

Even though the samples for phytolith analysis were all taken from one object – a grindstone – the plant stones represent two different collections. In the samples taken from the upper surface only a few phytoliths were found, the majority of them narrow elongate morphotypes of Poacoid type (Fig. 16; cf. Rovner 1971). The uniform collection of morphotypes suggests certain plant species but no phytoliths from cereals were identified. Most samples from the base of the stone showed relatively high frequencies of phytoliths of several morphotypes, probably originating from the former local vegetation. Similar elongate morphotypes have been found among *Elymus* *repens* and *Dactylis glomerata* (cf. Tingvall 1995).

CONCLUDING REMARKS

The cultural layer and the underlying clay deposits beneath act as an archive of major historical value. The diatom flora reflect the development of the coastal landscape from open sea through archipelago to the mainland of today. Pollen and plant macrofossils record the changes in vegetation during the transformation from a natural landscape to a cultural landscape and finally to an urban settlement. They also provide insight into the plants used for food, medicine and fibres in the medieval town of Turku.

The phytoliths found and described from the surface of a grindstone at the Rettig site add to the fossil data currently available on pollen and plant macrofossils.

LITERATURE

Aalto, M. 1994. Turun Linnan esilinnan kasvillisuus. In: Knut Drake (ed.) Turun Maakuntamuseon (TMM) Raportteja 16, 21–38.

Alhonen, P. 1979. The Quaternary history of the Baltic, Finland. In: Gudelis, V. & Königsson, L.-K. (eds) The Quaternary history of the Baltic. Acta Universitas Upsaliensis Symposia Universitatis Uppsaliensis. Annum Quingentesimum Celebrantis 1, 101–113.

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

Behre, K.-E. 1976. Die Pflanzenreste aus der frühgeschichtlichen Wurt Elisenhof. Die frühgeschichtliche Marschensiedlung beim Elisenhof in Eiderstedt 2. Bern. Lang. 144 p.

Behre, K.-E. 1983. Ernährung und Umwelt der wikingerzeitlichen Siedlung Haithabu. Die Ausgrabungen in Haithabu. Neumünster. 219 p.

Behre, K.E., 1984. Zur Geschichte der Bierwürzen nach Fruchtfunden und schriftlichen Quellen. In: W.van Zeist & W.A.Casparie (eds) Plants and ancient man, 115–122.

Behre, K.-E. 1991. Umwelt und Ernährung der frühmittelalterlichen Wurt Niens/Butjadingen nach den Ergebnissen der botanischen Untersuchungen. Probleme der Küstenforschung in südlichen Nordseegebiet. Band 18, 141–168 + Tafel I–V.

Beijerink, W. 1947. Zadenatlas der Nederlandsche Flora. Wageningen. 316 p.

Clapman, A.J. & Scaife, R.G. 1988. A pollen and plant macrofossil investigation of Oakbank Crannog, Loch Tay, Scotland. In: Murphy, P. & French, Ch. (eds) The exploitation of Wetlands. BAR British Series 186, 293–325.

Ellenberg, H. 1979. Zeigerwerte der Gefässpflanzen Mitteleuropas. 2. Aufl.- Scripta Geobotanica 9. Göttingen. 97 p.

Erdtman, G., Berglund, B.E. & Praglowski, J. 1961. An introduction to a Scandinavian pollen flora. Almqvist & Wiksell, Stockholm. 92 p. + 74 Plates.

Erkamo, V., 1944: Vanhin Suomesta tunnettu lääkeopillinen kirjoitus. (Deutsch Referat: Die Älteste aus Finnland bekannte medizinische Schrift). Duodekim 60, 210222.

Eronen, M. 1974. The history of the Litorina Sea and associated Holocene events. Commentationes Physico-Mathematicae 44, (4). 195 p.

Faegri, K. & Iversen, J. 1989. Textbook of Pollen Analysis. K. Faegri, P.E. Kaland & K. Krzywinski eds. John Wiley & Sons. New York. 328 p.

Florin, M.-B. 1946. Clypeusfloran i postglaciala fornsjölagerföljder i östra Mellansverige. Geologiska Föreningens i Stockholm Förhandlingar 68, 429–438.

Gadd, P.A. 1751. Försök till en oekonomisk Beskrifning öfwer Satakunda Häraders Norra Del. Stockholm, 148 p.

Glückert, G. 1976. Post-glacial shore-level displacement of the Baltic in SW Finland. Annales Academiae Scientiarum Fennicae A III, 811. 92 p.

Glückert, G. 1977. Itämeren rannansiirtymisestä Turussa ja sen lähiympäristössä. Turun yliopiston maaperägeologian osaston julkaisuja 21. 36 p.

Greig, J. 1982. The interpretation of pollen spectra from urban archaeological deposits. In: Hall. A.R. & Kenward, H.K. (eds) Environmental archaeology in the urban context. Council of Brittish Archaeology (CBA) Research Report Nr. 43, 47–65.

Hämet-Ahti, L., Suominen, J., Ulvinen, T., Uotila, P. & Vuokko, S. 1986. Retkeilykasvio. Suomen Luonnonsuojelun Tuki. Helsinki. 598 p.

Hjelmqvist, H. 1963. Frön och frukter från det äldsta Lund. Archaeologica Lundensia 2, 233276.

Hultén, E. 1971. Atlas of the distribution of vascular plants in northwestern Europe. 2nd Ed. AB Kartografiska institutet, Stockholm. 531 p.

Ignatius, H. and Tynni, R. 1974. Itämeren vaiheet ja piilevätutkimus. Turun yliopiston maaperägeologian osaston julkaisuja 36. 26 p.

Ignatius, H., Korpela, K. & Kujansuu R. 1980. The deglaciation of Finland after 10,000 B.P. Boreas 9, 217–228.

Körber-Grohne, E. 1967. Geobotanische Untersuchungen auf der Feddersen-Wierde, Bd. 1. Wiesbaden. 357 p.

Krammer, K. & Lange-Bertalot, H. 1986–1991. Bacillariophyceae. Teil 1–4. Süsswasserflora von Mitteleuropa 2/1, 876 p. (1: Naviculaceae, 1986), 2/2, 596 p. (2: Bacillariaceae, Epithemiaceae, Surirellaceae, 1988), 2/3, 576 p. (3: Centrales, Fragilariaceae, Eunotiaceae, 1991a), 2/4, 437 p. (4: Achnantheaceae & Kritische Ergänzungen zu Navicula (Lineolate) und Gomphonema, 1991b).

Lempiäinen, T. 1985. Plant remains from the ancient Lake Mätäjärvi. ISKOS 5, 258–271.

Lempiäinen, T. 1988. Pflanzliche Makroreste von dem Innenhof des Qwenselschen Anwesens in Turku, SW Finnland, vom 17.–19.-Jh. Annales Botanici Fennici 25, 47–54.

Lempiäinen, T. 1989. Turun muinaisen Mätäjärven kasvijäänteet. Turun Maakuntamuseon (TMM) Raportteja 10, 193–205.

Lempiäinen, T. 1991. Past occurrence of Hyoscyamus niger L. (Solanaceae) in Finland according to the macrofossil finds. Annales Botanici Fennici 28, 261–272.

Lempiäinen, T. 1995a. Macrofossil finds from the Medieval Turku, SW Finland. Res archaeobotanicae 1995, 149–164.

Lempiäinen, T. 1995b. Rettigin tontin makrofossiilitutkimukset vv. 1994–1995. Aboa Vetus-tutkimushanke. Tutkimusraportti. Turun yliopisto, Biologian laitos. 41 p.

Lempiäinen, T., Niemi, R., Räsänen, M., Salonen, V.-P., Terho, A., Vuorela, I. & Vuorisalo, T. 1986. Mätäjärvi-projektin luonnontieteelliset tutkimustulokset kertovat ympäristön muutoksista Turun seudulla. Luonnon Tutkija 90(3), 120–129.

Linkola, K. 1916. Studien über den Einfluss der Kultur auf die Flora in den Gegenden nördlich vom Ladogasee I. Allgemeiner Teil. Acta Societas Fauna Flora Fennica 45(1), 1485.

Lönnrot, E. 1838. Suomalaisen talonpojan kotilääkäri. Tampere, 153 p.

Lönnrot, E. 1860. Flora Fennica. Suomen Kasvisto. Helsinki. Suomalaisen Kirjallisuuden Seura. 376 p.

Miller, U. & Robertsson, A.-M. 1979. Biostratigraphical investigations in the Anundsjö region, Ångermanland, Northern Sweden. Early Norrland 12, 1–76.

Mölder, K. & Tynni, R. 1967–1973. Über Finnlands rezente und subfossile Diatomeen I–VII. Bulletin of the Geological Society of Finland 39: 199–217; 40: 151–170; 41: 235–251; 42: 129–144; 43: 203–220; 44: 141–149; 45: 159–179.

Moore, P.D., Webb, J.A. & Collinson, M.E. 1991. Pollen analysis. 2nd edition. Blackwell Scientific Publications. Oxford. 216 p.

Niemi, R. 1989. Mätäjärven punkkijäännökset (Sw. Kvalsterreliktema från Mätäjärvi). Turun Mätäjärvi (Mätäjärvi i Åbo). Turun maakuntamuseo/Åbo landskapsmuseum, 215–219 (220–221).

Nikula, O. & Nikula, S. 1987. Turun kaupungin historia 15211600. III. 776 p.

Pettersson, B. 1965. Humala (*Humulus lupulus* L.). In: Jalas, J. (ed.) Suuri Kasvikirja II. Helsinki. 851 p.

Powers, A.H., Padmore, J. & Gilbertson, D.D. 1988. Studies of Late Prehistoric and Modern Opal Phytoliths from Coastal Sand Dunes and Machair in North West Britain. Journal of Archaeological Science 16(1), 27–45.

Ranta, R. 1975. Turun kaupungin historia 16001721. I. Turku. 529 p.

Round, F.E., Crawford, R.M. & Mann, D.G. 1990. The diatoms – Biology and morphology of the genera. Cambridge University Press, Cambridge. 747 p.

Rovner, I. 1971. Potential of opal phytoliths for use in palaeoecological reconstruction. Quaternary Research 1(3), 343–359.

Salonen, V.-P., Räsänen, M. & Terho, A. 1989. Mätäjärven paleolimnologinen kehitys (Sw. Mätäjärvis paleolimnologiska evolution), Turun Mätäjärvi (Mätäjärvi i Åbo). Turun maakuntamuseo/Åbo landskapsmuseum, 169–173 (174–186).

Soininen, A.M. 1974. Vanha maataloutemme. Maatalous ja maatalousväestö Suomessa perinnäisen maatalouden loppukaudella 1720luvulta 1870luvulle. Journal of the Scientific Agricultural Society of Finland 46 (Suppl.). 459 p.

Stockmarr, J. 1971. Tablets with spores in absolute pollen analysis, Pollen et Spores 4, 615–621.

Suominen, J. 1965. Pähkinäpensas (*Corylus avellana* L.). In: Jalas, J. (ed.) Suuri Kasvikirja. Helsinki. 851 p.

Suominen, J. 1982. Suomen luonnonvarainen humala (*Humulus lupulus L.). Alkon keskuslaboratorio. Seloste 8174.*

Tillandz, E. 1673. Catalogus plantarum tam in excultis, quam in cultis locis prope Aboam superiore aestate nasci observatarum. Aboae.

Tillandz, E. 1683. Catalogus plantarum quae prope Aboam tam in excultis, quam in cultis locis hucuscue in ventae sunt. Aboae.

Tingvall, C. 1995. Studier av fytoliter hos några recenta sädesslag och andra gräs. (Phytolith studies of selected cereals and other grasses). Bot. Inst. Göteborgs Univ. 17 p. Unpublished.

Tynni, R. 1975–1980. Über Finnlands rezente und subfossile Diatomeen, VIII–XI. Geological Survey of Finland, Bulletin 247: 55 p.; 284: 37 p.; 296: 55 p.; 312: 93 p.

Valo, O. 1993. Kasveja 1600-luvun Turusta. Paleoetnobotaaninen tutkimus Julinin tontilta. Pro Gradututk. Turun yliopisto, Biologian laitos. 43 s.

Vasari, Y. 1965. Suomyrtti (Myrica gale L.). In: Jalas, J. (ed.) Suuri Kasvikirja II. Helsinki, 851 p.

Vuorela, I. 1985. The polla data of Mätäjärvi, Turku, SW Finland. ISKOS 5. Helsinki: Suomen Muinaismuistoyhdistys, 247–257.

Vuorela, I. 1989. Utvecklingen omkring Mätäjärvi i ljuset av pollenanalys. In: Turun Mätäjärvi. Mätäjärvi i Åbo, Turun maakuntamuseo/Åbo landskapsmuseum. Raportteja 10. Turku: Turun Maakuntamuseo, 187–193.

Vuorela, I. 1991. Airborne charcoal particles as components of urban cultural layers. Pact 33 (II.8), 187–192.

Vuorela, I. 1994. Palynological investigations in the old town of Helsinki. In: Korhola, A. & Lunkka, J.P. (eds) The Second Meeting of Finnish Palaeobotanists: Late Quaternary Vegetation and Climate Changes, Tvärminne, 26.–28.4.1993. Bulletin of the Geological Society of Finland 66(2), 125–128.

Vuorela, I. & Hiekkanen, M. 1991. The urban milieu of the late- and postmedieval town of Porvoo, southern Finland investigated by means of pollen analysis. Annales Botanici Fennici 28, 95–106.

Vuorela, I., Saksa, A., Lempiäinen, T. & Saarnisto, M. 1992. Pollen and macrofossil data on deposits in the wooden fortress of Käkisalmi dated to about AD 1200–1700. Annales Botanici Fennici 29, 187–196.

Vuorela, I. & Lempiäinen, T. 1993. Palynological and palaeobotanical investigations in the area of the post-medieval Helsinki Old Town. Vegetation History and Archaeobotany 2 (2), 101–123.

Vuorela, I., Grönlund, T. & Lempiäinen, T. 1996. Paleoekologisia tutkimuksia Rettigin tontilta Turusta. Geological Survey of Finland, Unpublished archieval Report P 34.4.115. 143 p.

Vuorela, T. 1975. Suomalainen kansankulttuuri. Porvoo-Helsinki-Juva. 776 p.

Vuorisalo, T. & Virtanen, T. 1989. Mätäjärven luulöydöt (Sw. Benfynden från Mätäjärvi). Turun Mätäjärvi, Mätäjärvi i Åbo, Turun maakuntamuseo/Åbo landskapsmuseum, 222–226 (227–229).