# GARASELET — BIOSTRATIGRAPHICAL STUDIES OF HUMAN IMPACT DURING DIFFERENT PERIODS OF SETTLEMENT FROM THE MESOLITHIC TO MEDIEVAL TIMES

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## Abstract

Investigations in collaboration with Skellefteå Museum are in progress on material representing different periods of settlement at Garaselet on the Byskeälven river in Västerbotten, northern Sweden. Archaeological excavations south and north of the bays Garaselviken and Lappviken revealed the existence of a Mesolithic dwelling site dated *c.* 8000 B.P. The area was occupied also during the Neolithic, Bronze, Iron and Middle Ages.

Studies of minerogenic and organogenic material from the excavation area, together with peat from the nearby mires and sediments from the bays, are being carried out using pollen and diatom analysis, organic carbon measurements, total composition analysis and radiocarbon dating.

Preliminary results indicate that the human impact on vegetation and water is registered in the sediments, but was only of minor significance as compared with the natural changes of the palaeoecological and palaeohydrological environment.

Pollen analysis and radiocarbon datings of peat samples from the mires show that the organic sedimentation started contemporary with the immigration of alder *(Alnus)* after 8700 B.P., just after the deglaciation of the area. The spread of spruce *(Picea)* took place after 3600 B.P.

## 1. Introduction

In 1964, contemporary with archaeological excavation of a middle Neolithic dwelling site in Bjurselet on the Byskeälven river (Christiansson 1970), a Mesolithic dwelling site was discovered at Garaselviken (Fig. 1). The site was partly excavated in 1969, 1970—1975 and 1979. Radiocarbon datings of charcoal and animal bones indicate that the site was occupied only some hundred years after the ice retreated from the area. Studies of the deglaciation, including radiocarbon datings and pollen analysis, were carried out in 1978 in an area some 30 km west of Garaselet (Minell 1979). The Geological Survey of Sweden was requested to execute studies of the palaeoecological and palaeohydrological environment at Garaselet.

The investigations started as a pilot study, the results of which have been reported (Miller 1980). The main project has been in progress since 1981 and annual reports have been issued (Robertsson 1983). Complementary excavations were made and cores taken in 1980 and 1982—1984 for sampling material in order to carry out biostratigraphical analyses. In 1977 excavations were also performed on the northern shore of Garaselet on the Byskeälven, at Lappviken about 2 km N.W. of Garaselviken (Fig. 1B). This excavation area is included in the current investigations.

The Garaselet project is included as a reference site in the International Geological Correlation Program (IGCP) project 158: Palaeohydrological changes in the temperate zone in the last 15 000 years.

The archaeological finds at Lappviken and Garaselviken proved to be extremely rich and in part unique for northern Sweden (Sundqvist 1970, 1978, 1983, Andersson and Sundqvist 1982, Åslin 1981). According to radiocarbon datings the oldest finds represent occupation in Mesolithic times *c.* 8 000 years B.P. (Fig. 2). The area south of Garaselviken has since been occupied at different periods, as indicated by finds representing the Neolithic, Bronze, Iron and Middle Ages (Fig. 2). At Lappviken the dwelling site was occupied during the Neolithic, *c.* 4 500 B.P. and later on until the Middle Ages. Hearths of Saamish type found at both Garaselviken and Lappviken date from the last 200—300 years.

## 2. Description of the site, material and methods.

The investigation area is situated on the Byskeälven river about 80 km N.W. of Skellefteå in Västerbotten. The archaeological excavation areas are located along a stretch where the river widens, slows down and forms a backwater (= »sel» in Sw.) called Garaselet (Fig. 3). The soils comprise gravelly sandy tills and coarse-grained tills poor in boulders (Granlund 1943). The bedrock is exposed at Garaselberget south of Garaselviken. The water-level of Garaselet has an altitude of 293 m, which is approximately 70 m above the highest shoreline estimated to be located at about 220 m above sea level (Granlund 1943). Later investigations have shown that the highest shoreline may have formed the delta south-east of Myrheden (about 10 km S.S.E. of Garaselet) situated about 230 m above sea level (Markgren and Lassila 1976).

Material for the investigations was taken from the two excavation areas, where samples of 2—5 cm thickness were cut out of the walls of the open trenches. In order to obtain a continuous record of the vegetational development in the area, cores were taken and samples also collected in two nearby mires, Sikträskmyran and Flarkmyran (Fig. 1A). In Garaselet sediment cores were taken in the bays adjacent to the excavation areas. The cores were drilled with Russian peat samplers 5 cm and 10 cm in diameter. In summer 1979 the lowermost parts of the organic sediment (gyttja) were taken for preliminary analysis and datings. Complete cores of the whole organic sedimentary sequence were taken from the ice in April 1984.

The methods used in the biostratigraphical studies of the Garaselet material are pollen analysis, total composition analysis (Sw. »strukturanalys»), measurements of organic carbon, diatom analysis and radiocarbon dating. Hitherto mainly pollen analysis and radiocarbon datings have been carried out. The laboratory work with the other analyses has just begun and only short methodological descriptions will be given.

The total composition analysis is slightly modified as compared with the original method of G. Lundqvist (1927). The method applied is described in connection with the methodological investigations of the Yttersel dwelling site in Ångermanland (Miller, Modig & Robertsson 1979) and in the manual of the IGCP 158 B-project (Berglund, 1979, p. 94—98). The method gives relative values for the quantities of different component particles (mineral grains, detritus, charcoal, microfossils) and is a valuable aid to the reconstruction of changes in the depositional environment.

Organic carbon measurements of gyttja sediments are necessary for classification and also a method of estimating the extent of organic production. Combined with total

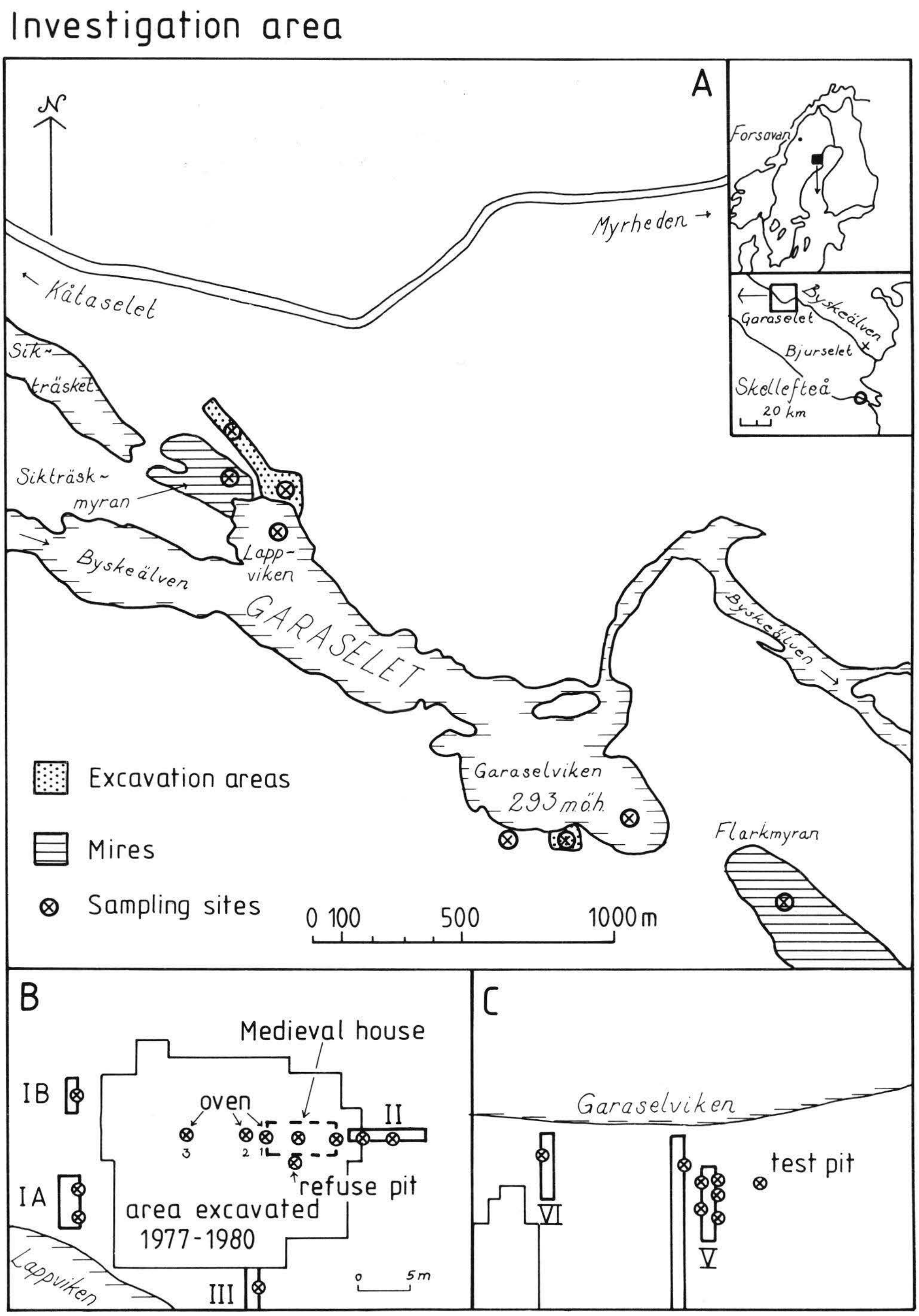


*Fig. 1. A.* Location of the investigation area in Västerbotten, northern Sweden. B. Central part of the excavation area at Lappviken with location of the Medieval house (7 × 11 m in size), and oven constructions. C. North-eastern part of the excavation area at Garaselviken with location of sections V, VI and the test pit.

composition and diatom analysis it is used in reconstructing the development of the palaeohydrological environment.

Diatom analysis is one of the best methods of reconstructing sedimentary environments (Miller 1981). The composition of fossil diatom floras in the sediments reflects the degree of nutrient (trophy), salinity ($Cl^-$-content), acidity (pH-values), water-depth, turbidity, transparency, pollution degree and erosion (Miller & Robertsson 1982).

Pollen analysis was performed to illustrate the vegetational development. Changes in climate, soil conditions and human activities are reflected in the continuous records of the pollen flora. Different kinds of human interferences, e.g. forest clearance, stock-breeding and agriculture can be traced as changes in the composition of the pollen floras.

Conventional preparation methods were used on samples for pollen analyses. Minerogenic sediments were treated according to a sedimentation-separation method (Påsse 1976). *Lycopodium* tablets were added to samples from the Byskeälven (Garaselviken) in order to calculate absolute pollen frequencies. At the pollen analyses about 500 tree pollen grains were counted at each level. The results presented (Figs. 4—7) are

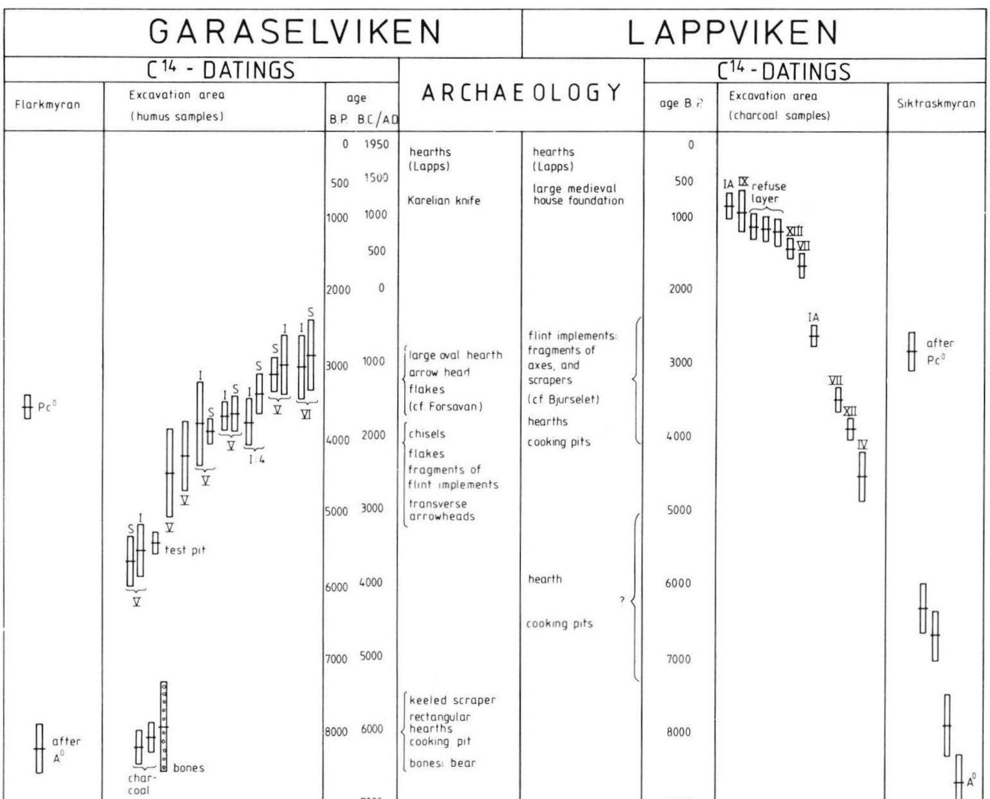


*Fig. 2.* Archaeology and radiocarbon datings of material from the excavation areas and mires. The datings are given with two standard deviations.

constructed as total pollen diagrams, where pollen of terrestrial plants constitute the basic sum for the calculations of the components: trees, shrubs and herbs. Culture-indicating plants (CIP) include pollen of *Juniperus, Calluna,* Cerealia, *Artemisia,* Cannabaceae, Caryophyllaceae, Chenopodiaceae, Compositae, Cruciferae, *Epilobium, Melampyrum, Plantago lanceolata, P. major, Rumex, Urtica* and spores of *Pteridium* (cf. Florin 1957, Vuorela 1970, Hicks 1976, Engelmark 1978, Reynaud and Hjelmroos 1980, Behre 1981).

Radiocarbon datings were made at the Laboratory for Isotope Geology in Stockholm. The results of the datings are given in Tables 1, 2 and Fig. 2. Two standard deviations are included in the dating columns in Fig. 2. The half-life is 5 570 ± 30 years.

The first datings of the Mesolithic dwelling at Garaselviken were obtained by means of radiocarbon analyses of charcoal and bones (Sundqvist 1978). In the present study the material dated consists of charcoal, humus embedded in silt, gyttja and peat (Tables 1 and 2). Gyttja representing the first organic production in the Byskeälven was dated using samples taken in 1979 (Miller 1980).

## 3 Results: Pollen analysis and radiocarbon datings.

### *3.1. Garaselviken*

#### *3.1.1. Excavation area*

Samples were collected from seven sections at the excavation area: I, II, III A, III B, IV, V, VI (Fig. 1 C). Pollen analyses have hitherto been carried out on samples from

*Fig. 3.* View over Garaselviken from the S.W. (Photo L. Sundqvist, Skellefteå Museum).

humus-layers in sections V and VI and the test pit. Total pollen spectra show three different compositions (Fig. 4):

a) a marked dominance of *Pinus,* about 90 %, very low herb frequencies, 2—3 %, and hardly any incidence of culture-indicating plants (CIP). This type of spectrum is present in section V at 58—64 cm depth and in the test pit at 70—75 cm.
b) dominance of *Pinus,* about 65 % and *Betula* values around 20 %. Herb pollen occur with 5—10 % including 1—2 % of CIP, represented by *Juniperus, Artemisia* and Compositae. The occurrence of this type of pollen spectrum was noted in section VI at 32—40 cm and in the test pit at 67—68 cm.
c) *Pinus* frequencies of 30—40 %, *Betula* occurring with 20—30 % and *Alnus* 25—30 %. Among CIP *Juniperus, Calluna, Artemisia, Pteridium* and Caryophyllaceae were noted. This spectrum type appears in section V at 36—38 cm and in the test pit at 25—30 cm depth.

The radiocarbon datings of the humus layers and charcoal show widely spread values from 5 410 ± 75 B.P. to 2 855 ± 235 B.P. (Table 1). The datings can be placed in four groups at 5 600—5 400, 4 400—4 200, 3 900—3 300 and 3 100—2 800 B.P.

*Table 1.* Radiocarbon datings of samples from Garaselviken: the excavation area, the Byskeälven and Flarkmyran.

| SITE/POSITION | | MATERIAL/ Pollen-analytical level | DEPTH (cm) below surface | AGE $C^{14}$ B.P. | $\delta$ $C^{13}$ ‰ | Dat. No. |
|---|---|---|---|---|---|---|
| **I. GARASELVIKEN** | | | | | | |
| a) Excavation area: | | | | | | |
| Section I:4 | 220/239 | Humus in silt | 56—64 | 3390 ± 135 sol. | —29.4 | St 8783 |
| | » | » | » | 3790 ± 160 ins. | —30.6 | St 8782 |
| Section V: | 222/239 | » | 36—47 | 3130 ± 110 sol. | —30.2 | St 9414 |
| | » | » | » | 2980 ± 205 ins. | —29.8 | St 9415 |
| » | 222/238 | » | 62—69 | 3905 ± 85 sol. | —29.0 | St 9416 |
| | » | » | » | 3790 ± 285 ins. | —29.0 | St 9417 |
| » | 222/236 | » | 70 | 5560 ± 220 sol | —32.4 | St 9418 |
| » | » | » | » | 5500 ± 175 ins. | —32.4 | St 9419 |
| » | 221.2/236.4 | » | 67 | 4460 ± 295 sol. | —28.1 | St 9420 |
| » | 221.2/238.8 | » | 59—64 | 3660 ± 120 sol. | —29.0 | St 9422 |
| » | » | » | » | 3670 ± 90 ins. | —28.9 | St 9423 |
| » | 221.2/238.6 | » | 36—38 | 4225 ± 230 sol + ins. | —26.5 | St 9424 |
| Section VI: | 210/241.3 | » | 36—40 | 2855 ± 235 sol. | —26.6 | St 9425 |
| | | » | » | 3020 ± 215 ins. | —26.9 | St 9426 |
| Test pit | (*c.* 227/240) | Humus in silt | 70—75 | 5410 ± 75 sol. | — | St 8423 |
| cooking pit | | Charcoal | | 8160 ± 110 | — | St 5190 |
| hearth | | » | | 8040 ± 100 | — | St 5193 |
| near the shore | | Fragments of burnt bones | 150 | 7885 ± 300 | — | St 5191 |
| b) Byskeälven (boring 1979) | | gyttja/A° | 465—475 | 8990 ± 345 | —32.4 | St 7222 |
| c) Flarkmyran, mire *c.* 700 m east of | | gyttja/after A° | 385—394 | 8195—170 | —28.4 | St 7221 |
| excavation area | | *Carex* peat/before Pc° | 105—115 | 3570 ± 85 | —27.0 | St 8427 |

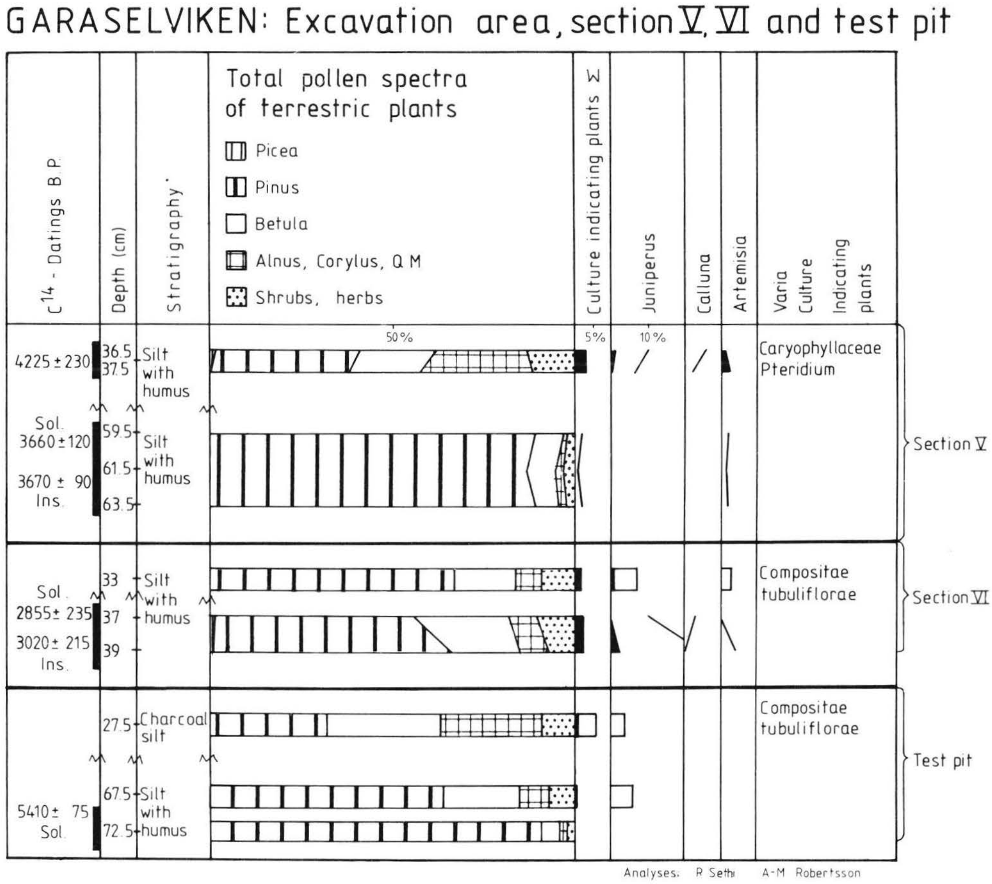


*Fig. 4.* Pollen spectra from the excavation area at Garaselviken.

### *3.1.2. The Byskeälven*

The 245 cm long sediment core taken in 1984 in the bay at Garaselviken, consists of gyttja and clay gyttja, underlain by clay. The top sediments are red-coloured of Fe-precipitation and rich in diatoms (10—50 cm). The deeper parts of the gyttja are varved (110—140 cm and 150—175 cm).

Diatom analysis, total composition analysis of the sediment, measurement of organic carbon and radiocarbon datings are in progress. The preliminary results of diatom analysis indicate an oligotrophic environment with several representatives of acidophilous diatoms which prefer pH-values below 7.

The sediments have been studied by means of pollen analysis (Fig. 5). The most distinct change in the composition of the pollen flora is the immigration of spruce *(Picea)* reflected above 170 cm. Five different small maxima of CIP occur in the diagram at 240—200, 180, 140—120, 80 and 60—20 cm depth. The CIP represented include *Juniperus, Calluna, Artemisia, Pteridium* and *Rumex*. There are scattered appearance of Compositae, Chenopodiaceae, *Epilobium, Plantago major, P. lanceolata* and *Melampyrum*.

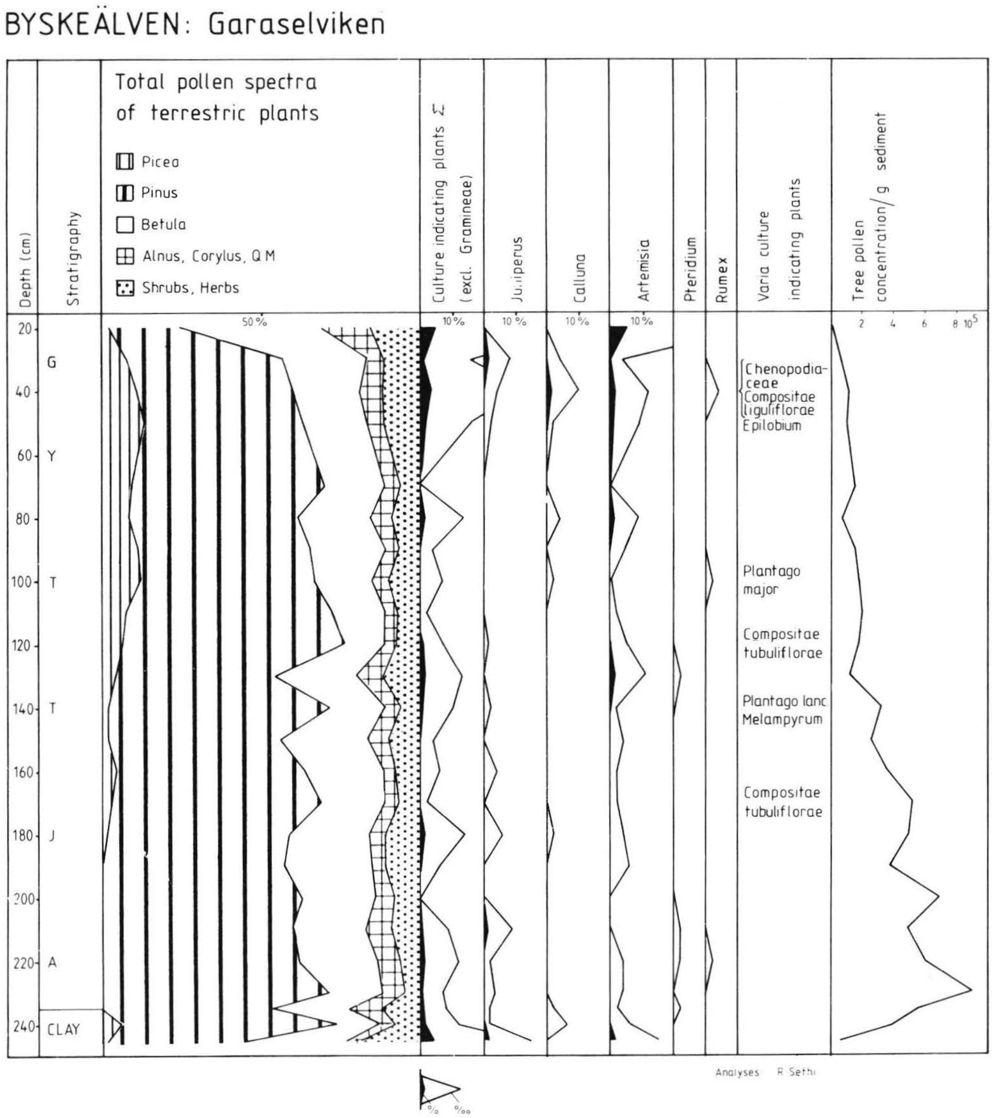


*Fig. 5.* Pollen diagram representing sediments from the Byskeälven river at Garaselviken.

### 3.2. *Lappviken*

#### 3.2.1. *Excavation area*

Material for pollen analyses was taken at the large Medieval house foundation, from both inside and outside, and from three different oven constructions (Fig. 1 B). Samples were also collected from six sections at the excavation area: I A, I B, II, III, IV and XIII.

Some of the results are presented in Fig. 6. *Pinus* dominates the pollen flora and constitutes 70—80 % of the total pollen sum, except in the sediment from oven 2,

*Table 2.* Radiocarbon datings of samples from Lappviken: the excavation area, the Byskeälven and Sikträskmyran.

| SITE/POSITION | | MATERIAL/ Pollen-analytical level | DEPTH (cm) below surface | AGE $C^{14}$ B.P. | $\delta C^{13}$ ‰ | Dat. No. |
|---|---|---|---|---|---|---|
| **II. LAPPVIKEN** | | | | | | |
| a) Excavation area: | | | | | | |
| refuse pit, south of | | Charcoal, upper sample | | 1170 ± 85 | —26.4 | St 8779 |
| Medieval house | | » , middle » | | 1220 ± 90 | —25.9 | St 8780 |
| | | » , lower » | | 1130 ± 85 | —25.1 | St 8781 |
| Section I:A | 175/54 | Charcoal | ? | 845 ± 95 | — | St 9224 |
| » | 177/61 | » | 20—25 | 2615 ± 80 | —27.6 | St 9225 |
| Section IV | 222/8 | » | 30 | 4530 ± 160 | —26.5 | St 9226 |
| Section VII | 65/141 | » | 17—24 | 1670 ± 80 | —28.3 | St 9227 |
| » | 63.8/141 | » | 23—25 | 3580 ± 90 | —28.3 | St 9228 |
| Section IX | —75/274 | » | ? | 925 ± 140 | —27.0 | St 9231 |
| Section XII | —195/315.5 | » | 35—40 | 3880 ± 80 | —27.6 | St 9229 |
| Section XIII | —195/292.4 | » | 23—25 | 1430 ± 70 | —27.6 | St 9230 |
| b) Byskeälven (boring 1979) | | gyttja/after A° | 530—538.5 | 8065 ± 220 | —31.9 | St 7223 |
| c) Sikträskmyran | | *Carex-Equisetum* peat/A° | 290—297 | 8695 ± 180 | —36.4 | St 7220 |
| » | | *Carex* peat | 240—250 | 7945 ± 205 | —27.9 | St 8431 |
| » | | » » occurrence | 205—210 | 6345 ± 165 | —28.1 | St 8430 |
| » | | » » of CIP | 180—190 | 6695 ± 165 | —27.3 | St 8229 |
| » | | *Sphagnum-Carex*/Pc° peat | 40—50 | 2825 ± 130 | —27.9 | St 8428 |

where the value is 50 %. *Betula* and *Picea* occur with frequencies below 10 %. CIP are present with 5—10 % (27 % in oven 2).

Cerealia was recorded together with *Epilobium,* Caryophyllaceae, Chenopodiaceae, *Artemisia,* Compositae, *Urtica* and *Rumex.*

No pollen grains were found in samples from the refuse pit just outside the house foundation. The same was valid for samples from section I A, the culture layer at 17 cm depth, section I B, sand at 50 cm depth, and the culture layer with charcoal in section II at 18 cm depth.

Radiocarbon datings of charcoal from the different sections gave ages of c. 4 500—3 500, 2 600, 1 700—1 400, 1 200—1 100 and 900—800 B.P. (Table 2).

### *3.2.2. Sikträskmyran*

The results are presented in the pollen diagram (Fig. 7). The organic sedimentation started contemporary with the immigration of alder *(Alnus)* into the area, reflected as the rise of the *Alnus* curve in the lowernmost part of the diagram *(Carex-Equisetum* peat at 290 cm). In the development of the forest vegetation the next important pollen-analytical guide level is the spread of spruce *(Picea),* which is reflected at 50 cm depth *(Sphagnum-Carex* peat).

Pollen of CIP were noted throughout the sediment core and show small maxima at 250—210, 185, 150 and 40—30 cm. CIP are represented by *Juniperus, Artemisia,* Chenopodiaceae, Compositae, *Plantago, Pteridium* and *Rumex.*

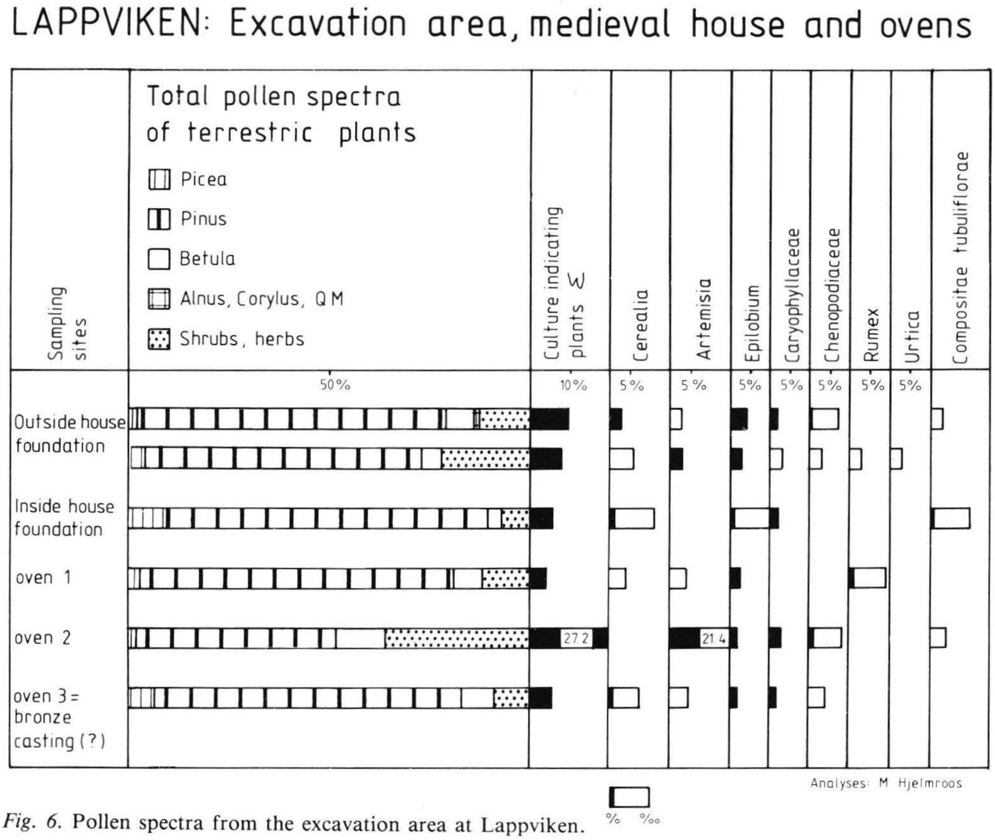


*Fig. 6.* Pollen spectra from the excavation area at Lappviken.

Five radiocarbon datings were made, giving the following results (Table 2): The rise of the *Alnus*-curve 8 695 ± 180 B.P. Maxima for CIP 7 495 ± 205, 6 345 ± 165 and 6 695 ± 165 B.P. *Sphagnum-Carex* peat formed after the immigration of *Picea* 2 825 ± 130 B.P.

Gyttja deposited in the Byskeälven after the immigration of alder was dated 8 065 ± 220 B.P. (Miller 1980).

## Discussion

Palaeoecological studies of the vegetational history, and human influence on the vegetation in northern Sweden were carried out by Fries (1962), Königsson (1970), Huttunen and Tolonen (1972), Engelmark (1976, 1978, 1979), Miller and Robertsson (1979).

In northern Finland investigations were made on material from Kuusamo, the Tornio River valley, Pohjanmaa and Österbotten (Hicks 1976, Hjelmroos 1978, Reynaud and Hjelmroos 1980, Vuorela 1982). Vorren performed pollen-analytical studies to trace the first agricultural phase in northern Norway (Vorren 1975, 1983). Palaeoecological studies of prehistoric life and conditions were summarized by Tolonen in connection with a symposium on the history of Northern Scandinavia (Tolonen 1980). These investigations mostly comprise material from coastal areas situated at rather low

# LAPPVIKEN: Sikträskmyran

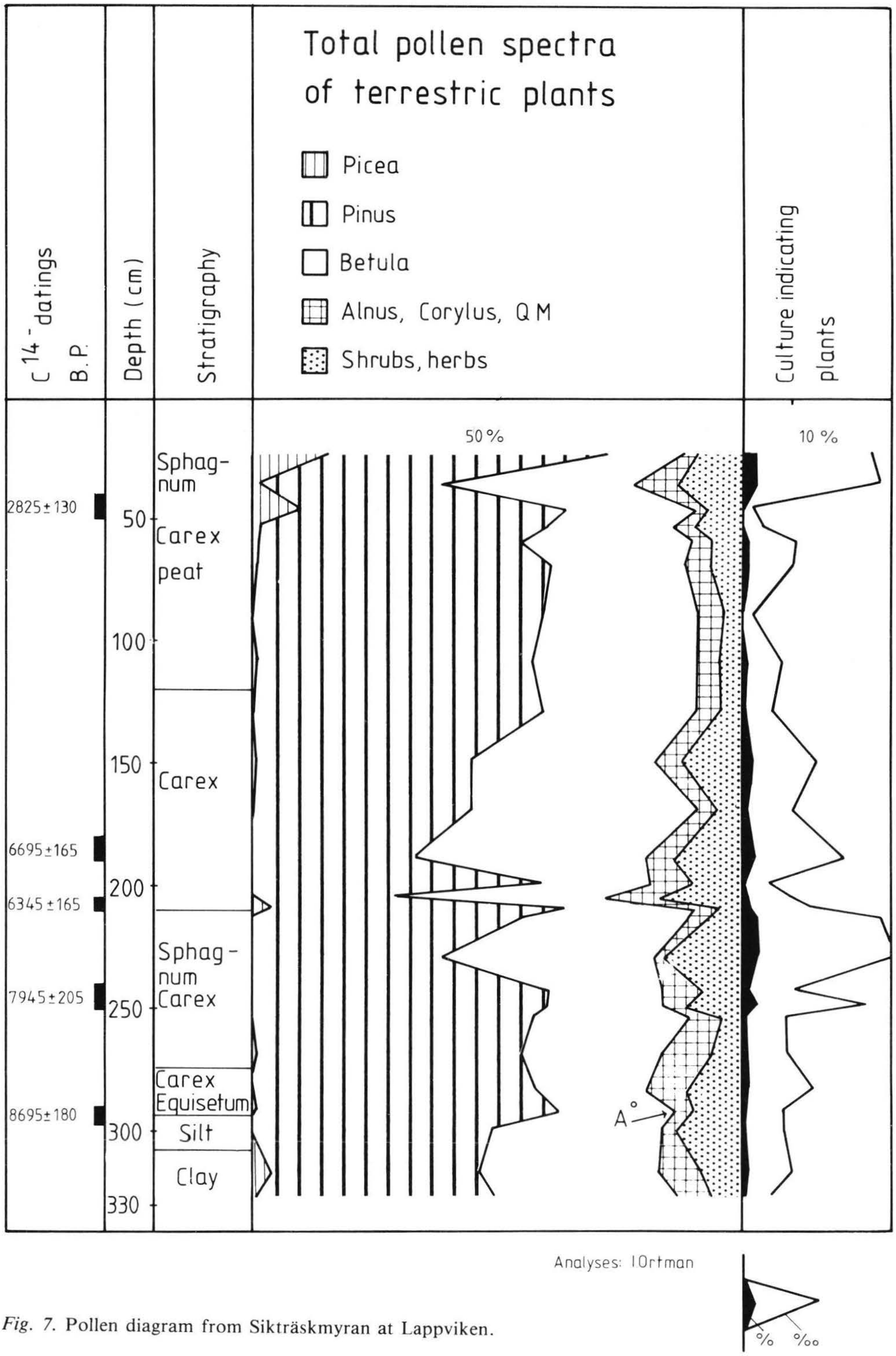


*Fig. 7.* Pollen diagram from Sikträskmyran at Lappviken.

altitudes, often below the Litorina limit. The occupation of the land took place during the end of Atlantic times and later. Traces of Mesolithic dwelling sites and human impact in the inland areas of northernmost Scandinavia are so far rare (Hicks 1976, Reynaud and Hjelmroos 1980). The Mesolithic fishers and hunters caused only slight changes in the natural vegetation. Clearing of the forest around the dwelling sites was probably very limited and changes of the flora of minor importance.

In southern Scandinavia palaeoecological studies have shown that traces of Mesolithic cultures are rather insignificant (Berglund 1969, Iversen 1973, Andersen et al. 1983). Before the introduction of agriculture, human influence might be indicated by the appearance of apophytes, which are plants occurring in the natural vegetation but favoured by culture.

Some apophytes are also shore plants e.g. *Artemisia,* Chenopodiaceae and *Urtica.* As Mesolithic dwellings were often situated beside the sea, lakes and rivers, the changes of the pollen flora indicated by the presence of these apophytes are not unambiguous. The occurrence of pollen of Chenopodiaceae and *Urtica* together with Caryophyllaceae on inland sites indicate ruderal communities with supply of nitrogen by man and/or animals. Grazing reindeer flocks may cause patches of worn-out open ground, which favours the apophytes (Vorren 1983).

Another group of plants increases in burnt areas e.g. *Betula, Epilobium angustifolium, Pteridium aquilinum* and *Melampyrum pratense.* Fire used by man as a tool for clearing can be distinguished from natural forest fires if the said plants occur together with pollen of other culture-indicating plants (Vuorela 1970).

Clearings in the forest caused by fire or cutting result in a regeneration of trees, of which *Betula, Alnus, Populus* and *Corylus* invade most quickly (Iversen 1941). A maximum for *Betula,* the tree demanding most light, gives a hint of open vegetation, sometimes caused by human impact on the forest. An intentional improvement of grazing areas for hunted animals could be an explanation of vegetational changes around a dwelling site (Vuorela 1982).

Evidence of human presence and interference with the vegetation at Garaselet can be adduced by means of the pollen-analytical results as follows.

The composition of the pollen flora in the minerogenic sediments from the excavation area at Garaselviken (Fig. 4) comprises three different types, all characterized by sparse occurrence of CIP (0.3—3.0 %). The deposition of the lowermost humus layers in section V (59—64 cm depth) and the test pit (70—73 cm) does not seem to be related to human activities. The pollen flora is dominated by trees and only single pollen grains of *Artemisia* were noted. Herbs are represented by very low values (2—5 %).

In sections V and VI human activities are reflected in the composition of the pollen flora at 40—30 cm (uppermost silty humus layer with charcoal). Pollen of CIP are present (about 3 %), mainly *Artemisia* and *Juniperus* togethet with increasing values of *Betula.* The radiocarbon dating of charcoal in section VI (about 3 000 B.P.) indicates that the late Neolithic — early Bronze Age occupation may have caused the vegetational changes. The same age was achieved by dating the humus layer at 47—36 cm in section V (Table 1).

The pollen diagram of the gyttja sediments from the Byskeälven at Garaselviken (Fig. 5) contains indications of human activities on different occasions. Radiocarbon datings are in progress but no results are yet available. The increase of CIP and a maximum for *Betula* at 140—120 cm is contemporary with the final spread of *Picea.* A correlation with the upper humus layers in sections V (36—47 cm) and VI (36—40 cm) is plausible.

At Lappviken the entire holocene vegetational development is registered in the pollen diagram from Sikträskmyran (Fig. 7). The organic sedimentation started shortly after the deglaciation of the area (Minell 1979). The immigration of alder *(Alnus)* was dated about 8 700 B.P. The CIP-curve in the lowermost part of the diagram probably represents pioneer plants. Increasing frequencies of CIP, herbs and *Betula,* together with decreasing values of *Alnus, Corylus* and *QM* above 250 cm, may be reflexions of human impact radiocarbon dated to about 8 000, 6 500 and 3 000 B.P. The upper part of the peat sequence is very compressed (50 cm corresponds to 3 000 years) and radiocarbon datings from such a low depth are not reliable. For this reason the younger periods of human activity in the Lappviken area are not datable in Sikträskmyran. The reversed ages of the peat at 210—205 and 190—180 cm, about 6 400 and 6 700 B.P. may be caused by erosion with deposition of older organic material in the peat. The erosion process could be a result of damage to the vegetation cover caused by human activities, e.g. forest clearance and dwelling construction, or by forest fire.

In the samples from the excavation area at Lappviken pollen of CIP occur frequently. Cerealia is present together with apophytes and ruderal plants. High values of *Epilobium* and Caryophyllaceae show the presence of open mineral soils. Ruderal plants favoured by nitrogenous substratum are represented by e.g. Chenopodiaceae and *Urtica.* Radiocarbon datings carried out on charcoal give ages from 4 500 to 800 B.P., indicating occupation from the Middle Neolithic to Medieval times.

The studies of gyttja sediments from the Byskeälven at Lappviken are now in progress. The sedimentary sequence consisting of gyttja and clay gyttja has a thickness of 5.4 m and is underlain by silty clay. The prospects of continuous sedimentation with registration of the different settlement periods from the Mesolithic to the Middle Ages are very promising. In this case correlations between culture layers from the excavation areas, and the indications of human impact in the peat of the mires and in the gyttja from the bays of Garaselet will be possible.

The Garaselet project is an excellent example of interdisciplinary studies on collaboration between archaeologists and geologists. The main aim is the reconstruction of the palaeoenvironmental development. The interaction of climatic changes and human impact by settlement can be traced in the sediments by biostratigraphical studies, radiocarbon dated and correlated with the ages of the culture layers which represent the periods of occupation.

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