# NAAKENAVAARA INTERGLACIAL — A TILL-COVERED PEAT DEPOSIT IN WESTERN FINNISH LAPLAND

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More than 100 till-covered organic deposits are currently known in the Finnish Lapland. All others, except Naakenavaara, are interpreted as having deposited during either the Early-Weichselian Peräpohjola/Maaselkä interstadial or the Eemian interglacial stage. At Naakenavaara, Kittilä, a 0.5—1.5 m peat deposit under till bed IV, was submitted to pollen and macrofossil studies.

Pollen analysis of the Naakenavaara peat deposit indicates a flora dominated by conifers: *Pinus*, *Picea*, possibly *Picea* Sect. *omorica* and, in the upper part of the deposit, *Larix*. *Bruckenthalia* type pollen and spores of *Osmunda* also occur. The pollen flora reflects the temperate climatic conditions of an interglacial stage.

Macrofossil analysis revealed four exotic taxa not found in Finland's present natural flora: *Aracites interglacialis*, *Larix* sp., *Abies* sp., and *Picea omorica*. The site was a wet mire with a sparse growth of *Pinus silvestris* and *Larix* sp., where the climate was more temperate than it is today. The main peat-forming plant was the extinct herb species *Aracites interglacialis*, whose inferred age is Holsteinian interglacial.

From the stratigraphic position and macrofossil content of the peat deposit, the Naakenavaara interglacial has been correlated with the Holsteinian interglacial, although it might be even older.

Key words: peat, till, stratigraphy, pollen diagrams, macrofossils, *Aracites interglacialis,* interglacial environment, Pleistocene Holsteinian, Naakenavaara, Kittilä, Finland.

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## Introduction

Naakenavaara, Kittilä, is located 130 km north of the Arctic Circle (see Fig. 4) in the extensive ice divide zone of Central Lapland. This was the central area of glaciation and thus the erosive and depositional action of the continental ice sheet has invariably been very weak (Penttilä 1963, Kujansuu 1967). Differing from each other in flow direction, six glacial stages, with corresponding till beds designated I—VI from youngest to oldest, have been established in this ice divide zone (Hirvas *et al.* 1976). The three youngest till beds are interpreted as having deposited during the Weichselian glaciation; the others are older (Fig. 1).

Till bed I was deposited during a deglaciation stage as a result of oscillation of the glacier margin or local glacial lobes. According to observations, there was only one subarctic interstage, the Peräpohjola/Maaselkä interstadial, in northern Finland during the Weichselian glaciation (Korpela 1969, Hirvas 1991). The interstadial sediments rest under till bed II. The pollen composition of the interstadial deposits is *Betula*-dominant and the proportion of NAP is considerable. The Peräpohjola/Maaselkä interstadial has been correlated with

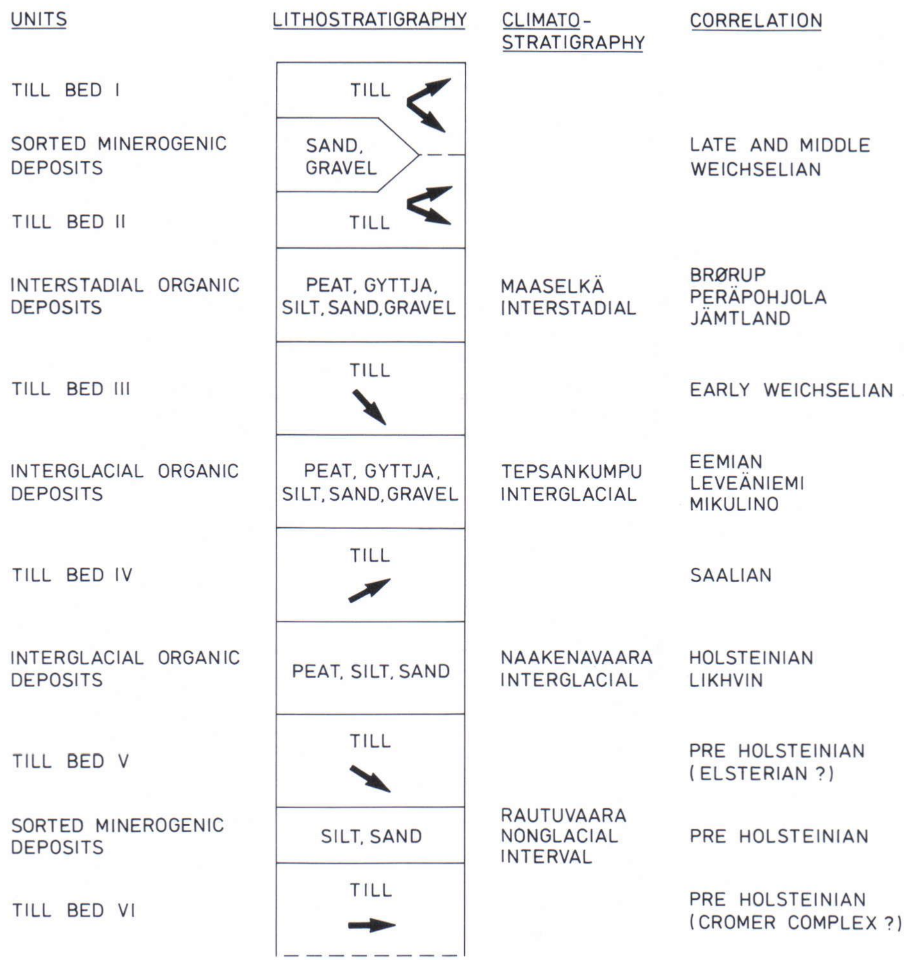



Fig. 1. The Pleistocene stratigraphy with its correlation in Finnish Lapland. The arrows indicate the average flow directions of the continental ice sheet in central Lapland during various stages. From Hirvas 1991; Fig. 74.

the Jämtland interstadial in Sweden and further with the Early-Weichselian Brørup interstadial in Denmark (e.g. Korpela 1969, Hirvas *et al.* 1981, Donner 1983, Hirvas and Nenonen 1987).

The interglacial deposits overlain by till bed III have been correlated with the Leveäniemi interglacial deposit in northern Sweden and further with Eemian deposits (e.g. Lundqvist 1971, Hirvas *et al.* 1981). The organic interglacial deposits are mainly *Pinus*-dominant in pollen composition.

The sediments of the ice-free interstages encountered under the till beds predating bed III are minerogenic at all sites except Naakenavaara, Kittilä, where peat has been encountered under till bed IV. The present paper describes the lithostratigraphy and biostratigraphy of the Naakenavaara site. The pollen and macrofossil results are correlated with the bio- and climmatostratigraphy of continental Europe.

## Lithostratigraphy

The till-covered peat deposit at Naakenavaara (67°42'N, 25°07'N) was found by the Geochemistry Department of the Geological Survey of Finland in the course of systematic till boring in 1974. To establish the stratigraphic position of the peat deposit and to take an undisturbed set of samples, the deposit was exposed with a tractor excavator in spring 1976 and with a more efficient crawler excavator again in spring 1984, when several test pits were excavated.

The Naakenavaara peat deposit, which is 1.5 m at its thickest, is located *in situ* beneath the depth of 6.5 m. The stratigraphy of the discovery site is shown in Fig. 2. At the ground surface there is a layer about 0.5 m thick of recent peat. This is underlain by about one metre of greyish brown, loosely packed silty till (clay content 7%) with small amounts of pebbles and well-developed fissile structure in places: till bed II. Till bed II is underlain by about 30 cm of varved silt interpreted as glacial lake sediment; it does not contain pollen or diatoms. Under the silt there is 1—2 m of massive fine sandy till which is more tightly packed and richer in bigger stones than till bed II (clay content 2 %): till bed III. The upper part of till bed III is grey and the lower part brown in colour. Till bed III is underlain by till bed IV, which is the thickest till unit in the stratigraphic column. The contact between till beds III and IV is sharp (a typical erosional contact) and gently undulating. Bed IV is yellowish brown massive sandy till, and the few pebbles are small in size (clay content 6 %). It contains abundant sand lenticles and ribbons, which probably derive from the sorted sediments under the till bed. Between till bed IV and the peat deposit there are thin (10—30 cm) layers of sand and laminated silt (Fig. 2).

The contact between till bed IV and the sand is sharp and erosional. In the near-by test pits the peat deposit is from 0.5 to 1.5 m thick, and is underlain by 1—2 m of glaciofluvial gravel and sand. In some bedrock depressions under the gravel and sand there is a thin layer of till, probably a remnant of a still older till bed (Hirvas 1991).

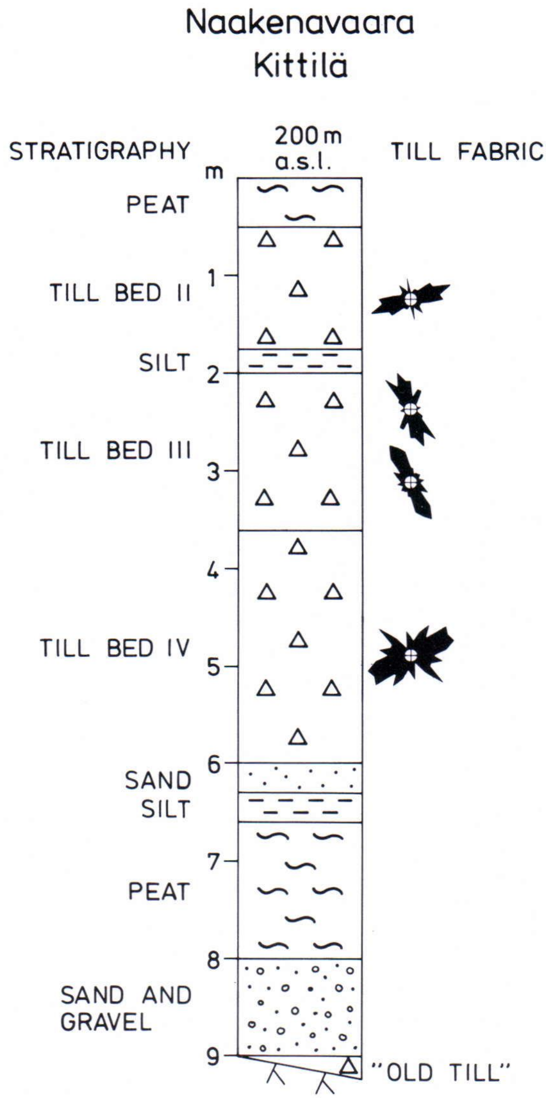



Fig. 2. Stratigraphy and fabric analyses of the Naakenavaara sequence at Kittilä. From Hirvas 1991; Fig. 65.

## The Naakenavaara peat

The peat contains well preserved twigs and even fragments of tree trunks, and abundant ribbons about 3—5 cm wide of the remains of a herbaceous plant that could not be identified. Microscopic analysis of the peat mass implied that the tissues identifiable were predominantly Bryidae mosses although *Sphagnum* spp. were also present; tissues of the above herbaceous plant existed as some tiny fragments. The peat type was determined as peat mainly formed by the unknown herbaceous plant intermingled with pieces of wood and remains of mosses (Bryidae).

The peat is poorly humified. Its high calorific value (22.4 MJ/kg for dry peat and 10.0 MJ/kg for peat with a 50 % moisture content) and high sulphur content (0.58 % of dry weight) (Mäkilä, oral comm.) also suggest that the herbaceous plant was the dominant peat-forming agent. At most of the levels of the deposit the ash content of the peat is 3—7 % (Fig. 3). On the basis of the water content of the peat, Mäkilä (oral comm.) has estimated preliminarily that the peat deposit in the ancient bog was about three times thicker than the present deposit. The infinite radiocarbon age of >48 700 yr BP (Su-510) was obtained from the peat.

## Pollen analysis

Pollen analysis were made at 5-cm intervals from the test pit, where the peat deposit was 1 m thick (6.6—7.6 m), but the basal part (7.4—7.6 m) could not be sampled because of ground water inflush. The samples, in which the relative density of pollen was very low, were boiled in 10 % KOH, sieved and washed in distilled water. The slides were mounted in glycerine, and a total of 500 arboreal pollen grains were counted per slide. The pollen grains were very well preserved. Any material that did not pass the sieve was studied for tissue. The sums from which the percentages of pollen grains and spores were calculated are given in the diagram (Fig. 3).

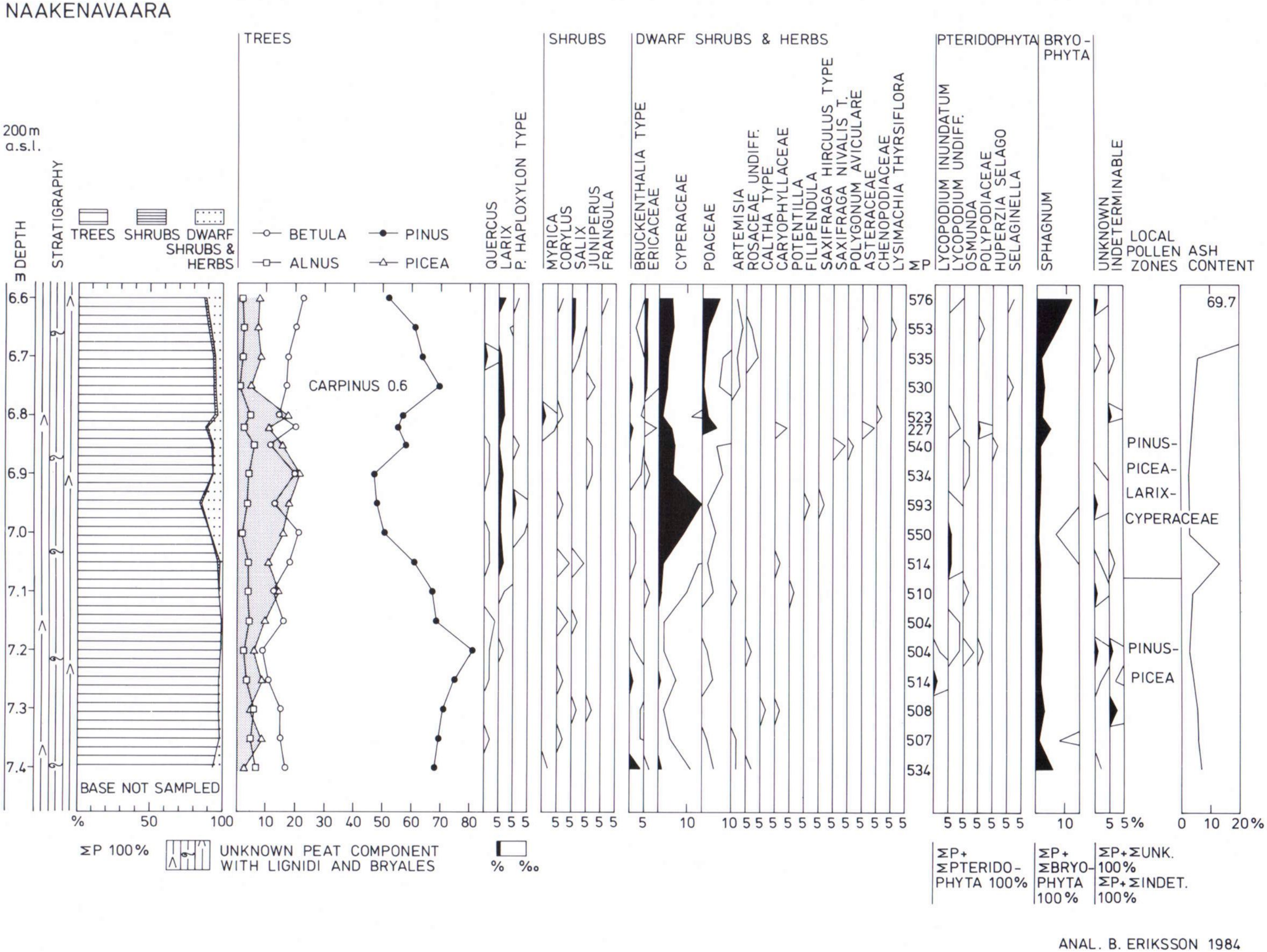
The pollen stratigraphy of the deposit has been discussed briefly earlier (Hirvas and Eriksson 1988) and an arboreal pollen diagram has been published (Hirvas 1991). *Pinus* pollen constitute a clear, up to 80 %, maximum in the whole deposit. The abundance of *Betula* and *Picea* pollen varies within the range 10—20 %. Among the *Picea* pollen are some of the *P. omorica* type. The even curve of *Alnus* pollen remains below 10 %. Several pollen spectra include random grains of *Quercus* and *Corylus*. The continuous curve of *Larix* pollen begins at a depth of 7.1 m, being at its highest, 2.4 %, in the uppermost sample. *Myrica* pollen grains are occasionally encountered in the deposit. The pollen of *Bruckenthalia* type (cf. Menke 1976) form an almost continuous, low curve. As the grains of *Bruckenthalia* type pollen encountered in interglacial and interstadial deposits in Finland are smaller and more rounded than those of the present *B. spiculifolia*, they probably represent some other species. It was not possible to identify any pollen grains that might have been associated with *Aracites interglacialis*, a plant which occurs very abundant as macrofossils. Spores of *Osmunda* are present occasionally. The amount of *Sphagnum* spores is very low compared to the high frequency of its tissues. Two local pollen assemblage zones can be recognized from the diagram: *Pinus-Picea* and *Pinus-Picea-Larix*-Cyperaceae zones (Fig. 3).

During deposition of the peat, coniferous forests with pine and spruce and probably some species of the *Picea omorika* group were dominant. Later, when the upper part of the peat deposited, larch, too grew in the area. Birch was probably most abundant on fell tops. Royal fern, *Osmunda*, occurred in the field layer of wetlands. Larch and royal fern have not grown naturally in Finland during the Holocene period. The Naakenavaara vegetation also included a representative of the genus *Bruckenthalia* (Ericaceae). The only current species of the genus, *B. spiculifolia,* is a calcifuge and grows in forests and subalpine meadows on the Balkan peninsula and in mountains of Rumania. The vegetation thus implies that the peat was deposited during the temperate substage of an interglacial (Fig. 3).

### *Discussion of the pollen stratigraphy*

Although most of them are very shallow, several tens of deposits found in Finnish Lapland are interpreted as having been formed during an interglacial on the basis of their lithostratigraphy and

Fig. 3. Pollen diagram from the peat deposit at the Naakenavaara site.


NAAKENAVAARA
200 m a.s.l.
DEPTH m
STRATIGRAPHY
TREES
SHRUBS
DWARF SHRUBS & HERBS
BETULA
ALNUS
PINUS
PICEA
CARPINUS 0.6
QUERCUS
LARIX
P. HAPLOXYLON TYPE
MYRICA
CORYLUS
SALIX
JUNIPERUS
FRANGULA
BRUCKENTHALIA TYPE
ERICACEAE
CYPERACEAE
POACEAE
ARTEMISIA
ROSACEAE UNDIFF.
CALTHA TYPE
CARYOPHYLLACEAE
POTENTILLA
FILIPENDULA
SAXIFRAGA HIRCULUS TYPE
SAXIFRAGA NIVALIS T.
POLYGONUM AVICULARE
ASTERACEAE
CHENOPODIACEAE
LYSIMACHIA THYRSIFLORA
ΣP
PTERIDOPHYTA
LYCOPODIUM INUNDATUM
LYCOPODIUM UNDIFF.
OSMUNDA
POLYPODIACEAE
HUPERZIA SELAGO
SELAGINELLA
BRYOPHYTA
SPHAGNUM
UNKNOWN
INDETERMINABLE
LOCAL POLLEN ZONES
ASH CONTENT
69.7
PINUS-PICEA-LARIX-CYPERACEAE
PINUS-PICEA
BASE NOT SAMPLED
ΣP 100%
UNKNOWN PEAT COMPONENT WITH LIGNIDI AND BRYALES
% ‰
ΣP+ ΣPTERIDOPHYTA 100%
ΣP+ ΣBRYOPHYTA 100%
ΣP+ΣUNK. 100%
ΣP+ΣINDET. 100%
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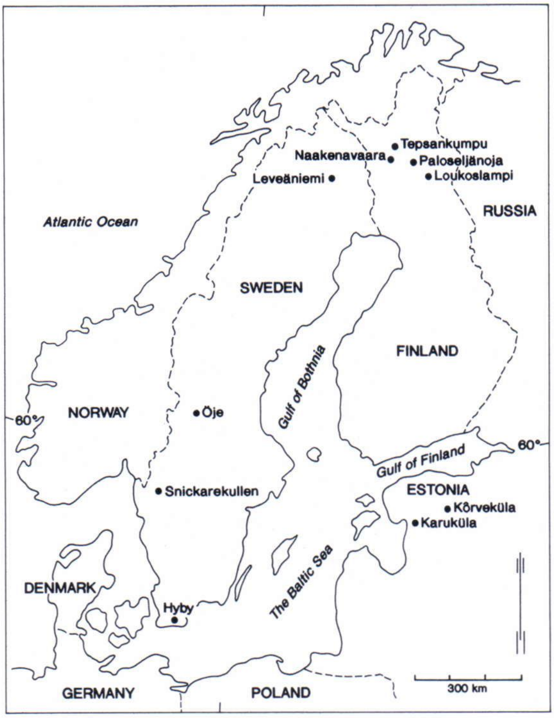


Fig. 4. The map showing the localities discussed in connection with pollen analysis.

pollen stratigraphy (Eriksson 1982, Mäkinen 1982, cf. Hirvas 1991). Two of them in particular, Tepsankumpu and Paloseljänoja (Fig. 4), have pollen diagrams showing a distinct succession of interglacial vegetation development. Both series exhibit a pollen assemblage zone (c) with *Picea* pollen values of about 10—20 %. The zone is devoid of *Larix* pollen, *Bruckenthalia*-type pollen and *Osmunda* spores, which are encountered in many of the other *Picea* zones of the pollen series in Lapland, e.g. Loukoslampi (Fig.4) (Hirvas 1991; pollen diagram Fig. 59). The gyttja deposits at Tepsankumpu and Paloseljänoja were most probably formed during the Eemian interglacial stage. An almost complete Eemian pollen succession reported from Leveäniemi (Fig. 4) in Swedish Lapland has a *Picea-Pinus* zone (Robertsson 1971, Fig. 4:1, zone c) comparable to the Tepsankumpu and Paloseljänoja *Picea* zones (Hirvas 1991, Figs. 56 and 57, zones c).

The Holsteinian vegetational succession has been described on the basis of palynological investigations by many workers, e.g. Szafer 1954 (Poland), Andersen 1965 (Denmark), Hallik 1960, Menke 1968, Menke and Behre 1973, Meyer 1974, Mäller 1974 (Germany), Liivrand 1984, 1991 (Estonia), Mojski 1985 (Poland) and Dassow 1987 (Germany). *Picea* and *Alnus* were early components of the Holsteinian flora, and dominantly coniferous forests had a wide spread during the interglacial. Pollen data from the Karuküla dislocated organogenic deposits and Kôrveküla (Fig. 4) lacustrine deposits in Estonia (Liivrand 1984, 1991) indicate the dominance of conifers, *Picea*, *Pinus* and *Larix*, and the high abundance of *Alnus*. After the climatic optimum, *Abies* and some spruce of the *omorika* group were included in conifers.

Deposits attributed to the Holsteinian interglacial have been encountered in Sweden at Hyby (Fig. 4) (Miller 1977), Snickarekullen (Fig. 4) (Miller 1986) and Öje (Fig. 4), in central Sweden (Robertsson 1988, Garcia Ambrosiani 1992). Only one pollen assemblage zone, *Picea-Pinus-Larix*, could be distinguished in the sediments at Öje (Robertsson 1988). In the light of macrofossil analysis, Garcia Ambrosiani (1992) has interpreted the Öje sediments as Holsteinian or possibly Eemian in age.

The pollen assemblage of the Naakenavaara peat can be correlated with several of the *Picea* zones of the series assigned to the Eemian interglacial in Lapland. However, it should be remembered that, in the Holsteinian stage, conifers were also predominant in the forests south of the Gulf of Finland, and that the vegetation also included *Larix* and *Osmunda*. In Lapland, coniferous forests probably dominated during the temperate substage of both the Eemian and Holsteinian interglacials, making interpretation of the fragmentary pollen series in this area ambiguous, particularly if the arboreal flora included *Larix* during both interglacials. The pollen studies imply that the peat at Naakenavaara deposited either during a temperate substage of the Holsteinian interglacial or during the Eemian interglacial after spruce had become common in the area.

## Macrofossil analysis

When the Naakenavaara section was opened in the year 1984 a research team collected several profiles and separate samples. Also samples of wood, cones, seeds and insects were collected in the field from the exposed peat layers. In the laboratory, one profile has been sampled (c. 5 cm each) and washed for macroscopic plant analyses, the same profile as for pollen (Fig. 3). Some other macrofossil samples from other profiles, and several separate samples (3 dl each) have also been inspected and treated by conventional $HNO_3$ method (e.g. West 1968).

The results of the plant macrofossil analyses (by M. Aalto), are listed in Table 1 (nomenclature follows that of Flora Europaea, Tutin *et al.* 1964—80).

Table 1. Plant macrofossils of Naakenavaara organic deposit.

| | |
|---|---|
| TREES: | type of remains: |
| *Abies* sp. | needles |
| *Betula pendula* | fruit scales, nutlets |
| *Larix* sp. | a cone, needles |
| *Picea abies* | needles |
| *Picea omorika* | needles |
| *Pinus sylvestris* | cones, seeds, needles, wood |
| | |
| DWARF-SHRUBS: | |
| *Andromeda polifolia* | seeds |
| *Arctosstaphylos alpina* | endocarps |
| *Arctostaphylos uva-ursi* | endocarps |
| *Calluna vulgaris* | seeds |
| *Chamaedaphne calyculata* | seeds |
| *Empetrum nigrum* | endocarps |
| *Vaccinium* spp. | seeds |
| | |
| MIRE PLANTS: | |
| Herbs | |
| *Aracites interglacialis* | seeds, rhizomes (?) |
| *Carex lasiocarpa* | utricles with nutlets |
| *Carex globularis* | utricles with nutlets |
| *Carex* spp. | nutlets |
| *Cicuta virosa* | fruits |
| *Eleocharis palustris* | nutlets |
| *Eriophorum scheuchzeri* | nutlets |
| *Menyanthes trifoliata* | seeds |
| *Potentilla palustris* | seeds |
| *Sparganium hyperboreum* | endocarps |
| *Ranunculus* sp. | nutlets |
| *Rumex* sp. | nutlets |
| *Triglochin palustris* | fruits |
| | |
| Mosses | |
| SPHAGNIDAE: | |
| *Sphagnum* spp. | leaves |
| BRYIDAE: | |
| *Calliergon* spp. | shoots, leaves |
| *Drepanocladus* spp. | shoots, leaves |
| *Scorpidium* sp. | shoots, leaves |

### *Comments on some exotic plants in the plant macrofossil list*

*Aracites interglacialis* Wieliczk (Table 1)

This plant genus is an extinct one, reported from Tertiary Neogene deposits and from Holstein interglacial sites (Fig. 5). The major part of Naakenavaara peat is composed of the remains of *Aracites* (Aalto and Hirvas 1987). Two kinds of fossils have been referred to in this species: the very numerous seeds as well as very numerous rhizomatous tubers. Other vegetative tissues of the plant (stems, leaves), do not have such distinguishing features. The mean size of seeds is 1.84 x 1.3 mm, the length varies more (1.5—2.1 mm), breath less (1.1—1,.4 mm). Form (Fig. 6) is ovoid, tapering towards the base (sometimes the base is rounded), and some seeds are asymmetrically cordical, slightly flattened. In the longitudinal section of the seed, there is a characteristic pear-shaped seed cavity. It opens with narrower cavity to the apex end of the seed, where a round hole is regularly seen. This feature of the seed is similar to *Hippuris* seeds, and consequently, the authors Reid and Reid (1915) placed these fossils in this family under the name *Hippuris globosa*, found from Pliocene of Holland. The Naakenavaara fossils agree well with the description and the pictures of Nikitin (1957) from *Aracites johnstrupii* (Hartz) Nikitin. Nikitin's descrition is from a Pliocene lignite bed in Krivobor-

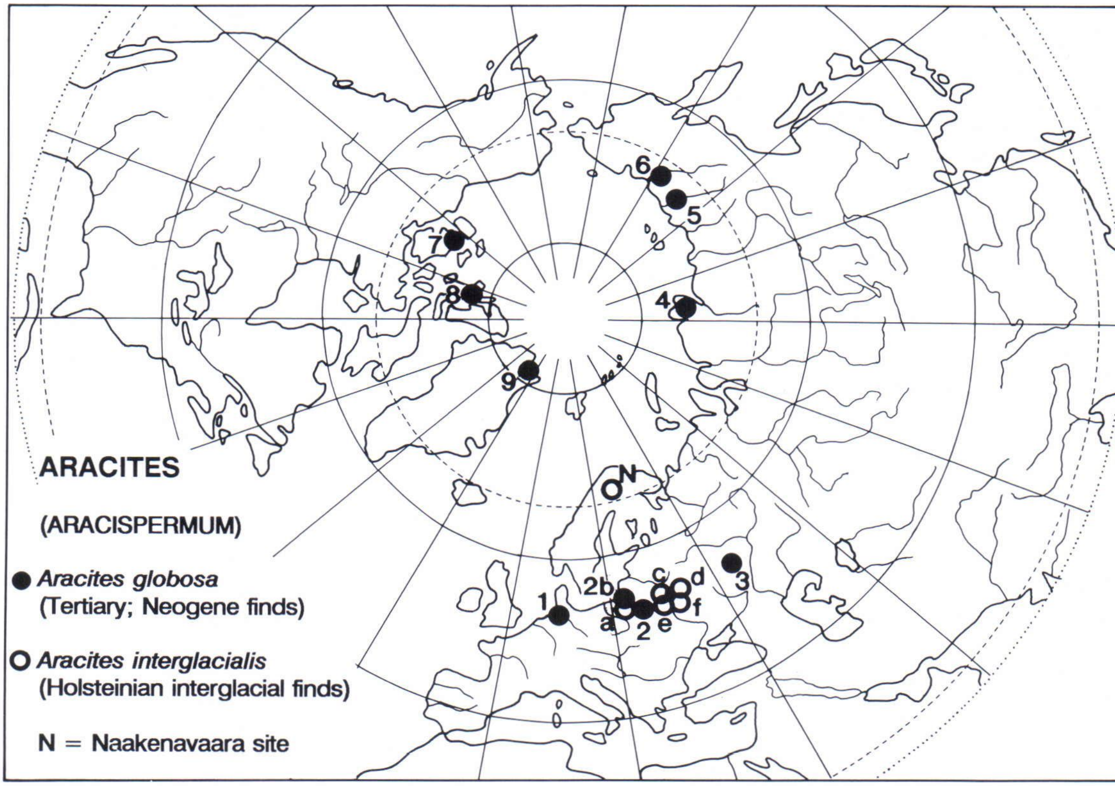


Fig. 5. Holsteinian Interglacial and Neogene finds of *Aracites interglacialis* Wieliczk and *Aracites globosa* (Reid & Reid) Bennike. Holsteinian Interglacial finds: a. from Poland, Stanowice (Sobolewska 1977), c—f. from Byelorussia, c. Ruba, Vitebsk Region, d. Gralevo, Vitebsk Region (Velichkevich 1977, 1982), e. Vily Villago, Mogilev Region, f. Zhidovschchizna, Grodno Region (Dorofeev 1960, 1963), N. from Finland, Naakenavaara, Western Lapland (Aalto et *al*. 1992). Tertiary (Neogene) finds: 1. Pliocene of Holland (Reid & Reid 1915), 2. Miocene of Poland, Stare Gliwice (Szafer 1961), 2 b. Pliocene of Poland (Lancuscka-Srodoniowa 1966), 3. Pliocene of Russia, Voronezkoj Oblasti (Nikitin 1957), 4. Neogene deposits of West Sibiria, Svero-Vostoka Oblasti (Nikitin 1979), 5.—6. Tertiary deposits of Northeast Siberia, Yana-Indigirka Lowland and Lower Aldan basin (Dorofeev 1963, 1972, Baranova 1978), 7.—8. Neogene deposits of Arctic Canada, Meighen Islands, Ballast Brooks (Matthews 1987, 1989). 9. Neogene of North Greenland, Kap København (Bennike 1990).

je, Voronezkoj Oblasti, a village in Russia. Those seeds are, however, somewhat smaller: 1.2—1.7 mm long and 0.9—1.2 mm in breath. One common feature, the dark secretory cells among parenchymatous tissue of the seed wall. On the bases of e.g this feature, Nikitin has placed this fossil in the family Araceae. Also the described ecology and the very numerous finds in certain, those of finds mire plants dominated layers are in agreement with Naakenavaara site (Table 1, explanations below).

In Cambridge, at the Botany School's reference collections, the Naakenavaara specimens were compared to fossil material collected from Byelorussian interglacial deposits of Holsteinian age. Fig. 6 illustrates how the Naakenavaara fossil (1), can be compared to those collected from (2) Ruba (Velichevich 1977), and from (3) Gralevo (Velichevich 1980), Vitebsk Region in Byelonissia. As the seeds are in close agreement, it was quite impossible to distinguish them as being of different origins. Until further notice, the present author has placed the Naakenavaara fossils in the species *Aracites interglacialis* Wieliczk, following


Fig. 6. Three seeds of *Aracites interglacialis* Wieliczk from three different deposits of Holsteinian interglacial age. Localities: 1. Naakenavaara, Finnish Lapland (coll. M. Aalto 1984), 2. Byelorussia, Ruba, Vitebsk Region (coll. Velichevich 1977), 3. Byelorussia, Gralevo, Vitebsk Region (coll. Velichevich 1980).

Velichevich (1977). Bennike (1990) has taken an attitude towards both the interglacial and Neogene *Aracites* finds by placing them in the same taxon *A. globosa*, in Central Europe, and ranging circumpolarly from North Siberia, American Arctic Islands, Greenland to Naakenavaara, Finnish Lapland. He also deals with the complicated information of the taxa *Aracites*, *Aracispermum* and allies (see the referat is in his paper pp. 63—64). He has placed both Neogene and interglacial as morphologically similar fossils under the name *Aracites globosa* (Reid & Reid) Bennike, though he recognizes that the Neogene fossils are usually smaller. It is possible, however, to distinguish the Neogene and Holstein Interglacial taxa as two separate species. This can be botanically argued, for example, by looking at the Polish finds (Fig. 5), those of Miocene (site 2) from Slascu (Szafer 1961, described as *Hippuris globosa)*, and Holsteinian (site a) from Stanowice (Sobolevska 1977, described as *Aracispermum johnstrupii*). Though geographically close to each other, they are measured in time scale, at tens of millions of years distance from each other. During such time, the original species have certainly changed, so that crossing one criterion of a taxon is not possible. It has been shown, (e.g. Friis 1985), that the form group of fossils, found from Danish Tertiary deposits and called *Carpolitus Johnstrupii* by Hartz (1909), belongs to the species of the family *Myrica*. They differ in that they easily split into two halves (Hartz 1909, p. 276, pl. 3, Figs. 11—13, Friis 1985), a feature unknown to *Aracites* fossils. The name has been confusingly adapted to *Aracites johnstrupii* Hartz by Nikitin (1957).

*Picea omorika* (Pancic) Purkyne (Table 1)

Two whole needles and fragments of several others related to Serbian spruce were found from the middle of the profile (6.80—6.90 m, Fig. 3 and Table 1). The leaves are identical to the recent *P. omorika* leaves when compared to the material received from the arboretum of the Botanical garden, at the University of Helsinki. The epistomatic needles are characteristic with their rounded, shortly acuminate leaf apex and broad, rather flat leaves (c. 1.5—2.0 mm wide). The stomata occur only on the upper side of the leaf, arranged densely up to 10—12 longitudinal rows. The fossil leaves were somewhat shorter (1.2—1.3 cm) than the recent ones (up to 2 cm), but yet they fit to the informed measurements (1—2 cm, e.g. Farjon 1990). Macrofossils and pollen of *Picea omorikoides* Web., an extinct taxon, have been reported: from some Polish Holsteinian interglacial deposits (Sobolewska 1956, Sródon 1960, 1962, 1967), from Holsteinian of Netherlands (Zagwijn 1978), from Holstein (Lichvin) of Russia and Byelorussia (Velichevich 1982), from Holstein of Estonia (Liivrand 1984) and from Brørup interstadial deposits (Andersen 1961, Zagwijn 1961, Sobolewska *et al.* 1964). According to some opinions, they might have been referred to the same or a closely related taxon, such as the recent *Picea omorika* (Zagwijn 1978). In addition, *P. omorika* -type pollen were found from the Naakenavaara deposit.

*Abies* sp. (Table 1)

Two fragments of leaves (a typically twisted leaf base and a middle part of a needle), referred to the genus *Abies*, were found from the same level as Serbian spruce (6.80—6.90 m). The leaves were broader than recent *A. sibirica* leaves. In addition to Serbian spruce, also *A. alba* and *A. fraseri* have been reported from Polish Holsteinian deposits (e.g. Sobolewska 1956). No closer determination to species level has not yet been found.

*Larix* sp. (Table 1)

One small, very worn cone (1.8 x 1.2 cm) of larch was picked from the field with exposed peat, and several fragments of leaves were found in the sequence. Larch does not belong to the present flora of Finland: the nearest natural occurrences are those of *L. sibirica*, the range of which extends east of the Moscow region (37° E, Hultén and Fries 1986). However, its cones are usually wider (2.0—4.5 cm long); the measuremets of the fossil cone are in closer agreement to those of Polish larch (*L. decidua* ssp. *polonaica*, 1.5—2. 0 cm x 1.0 cm; Hämet-Ahti *et al.* 1989). There is also an other interglacial *Larix* find from Vuotso, Lapland: a tree trunk of c. 8 meters long, the supposed age of which is Eemian Interglacial (Mäkinen 1982).

*Macroscopic plant finds and the local palaeoenvironment (Table 1)*

There was no clear plant succession in the peat sequence as to plant assemblage. *Aracites* seeds were numerous, uncountable ( >100) in all 17 samples, except at the top of the peat profile (6.6—6.7 m, cf. Fig. 3), where only a few seeds were found. In respect to these seeds, only few other species were found in the peat samples. The rather short list of plant finds (Table 1) indicate the poorness of species at the habitat. The accumulation speed must have been rapid (cf. the pollen concentration). In its poorness of species and speed of growth, the Naakenavaara peat resembles oligotrophic *Sphagnum* peats.

The plant list (Table 1) is composed of two different elements as to their ecological requirements: plants of wet mire habitat (all herbs listed), and plants of dry heath or hummock habitat (all the dwarf-shrubs, some trees). This mixture of two quite different localities can be explained by the palaeoenvironment of the site. The landscape relief is, at present, smoothened by several overlien tills (Fig. 2), but at the beginning of peat accumulation, 8 meters deeper, the landscape relief evidently offered slopes surrounding the small mire depression. Slopes might have served growth locality to trees such as *Picea omorika* and *P. abies* and some *Abies* species as well as the dwarf-shrubs *Arctostaphylos uva-ursi*, *A. alpina*, *Calluna vulgaris*, *Empetrum nigrum*, *Vaccinum* spp., all off wich are species of typical heath environment. Moreover, the mire itself has evidently grown sparsely pine and some larch, and the bearberries, heather, crowberry as well as *Andromeda polifolia* and *Vaccinium* species might have also grown on their hummocks. The frequent occurence of such a strictly dry habit plant as endocarps of *Arctostaphylos uva-ursi* in almost all peat samples might reflect the annual influx of material from the surrounding slopes to the mire. The mire itself has been rather wet, at least temporarily flooded, as indicated by narrow sandbands in the sediment. It has been densely covered by *Aracites* shoots and rhizomes. Together with the species grew such wet habitat plants as *Menyanthes trifoliata* (frequent), *Sparganium hyperboreum*, *Cicuta virosa*, *Eleocharis palustris*, *Eriophorum scheuchzeri* and *Triglochin palustris*. This plant composition, together with the frequent occurrence of mosses (*Scorpidium*, *Drepanocladus*, *Calliergon* species), indicates rather good trophy of the site, at least a mesotrophic mire type. The identified sedge species *Carex globularis* and *Carex lasiocarpa* are of poor habitat nature and might have grown on hummocks as well.

In the plant list (Table 1), there are some indications of northern level the Naakenavaara site, such as *Arctostaphylos alpina*, *Sparganium hyperboreum* and *Eriophorum scheuchzeri*. The latter two are typical circumpolar plants, an arctic-montane type (Hultén 1962, 1971a) having a more or less wide southern distribution in the Alps or other southern mountains. In Scandinavia, their area outside the mountains is north of latitudes 64.—66. (Hultén 1971b). Here, these species are not indications of »cold climate», rather they characterize only the northern situation of the site.

The exotics listed above are indicators of more southern vegetational zones. *Picea omorika,* for of example indicates hemiboreal- temperate zones on the bases of its present range in Serbia, Jugoslavia where it grows on north facing mountain slopes between 800—1600 m elevations. It occurs there together with *Picea abies, Abies alba* and *Pinus nigra*. The climate is »cool montane, with moderately warm and dry summers and snowy winters» (Farjon 1990, p. 237). This plart characterized as Tertiary relict can be grown in Finland up to Arctic circle, and it thrives well in the polluted town millieus of Southern Finland (Hämet-Ahti *et al.* 1989) and otherwise in the Central Europe lowlands.

On the basis of *Aracites interglacialis* and *Picea omorika,* the climate at the time of peat accumulation might have been similar to the recent vegetational zones of continental hemiboreal to northern temperate zones. It might be, perhaps, correlated to Polish coniferous assemblage zones of Holsteinian age (cf. Sobolevska 1956). The situation, however, north of Arctic circle, links it to the circumpolar Arcto-Tertiary flora elements, to which *Aracites* species and also coniferous trees belong (see Fig. 5). Naakenavaara organic deposit is on the bases of stratigraphical and pollen evidence the most probably of the Holsteinian age, but on the bases of macrofossils the deposit might be of Neogene age as well.

## Summary

The Naakenavaara peat deposit is covered by three till beds (II—IV) deposited during different glacial stages. Till bed IV has been deposited most probably during the Saalian glaciation. The peat deposit analysed is trought to have been three meters thick, but is now compressed to one meter. From the pollen and macrofossil analyses no clear succession or zonation was shown.

The Naakenavaara site was a forested mire when the peat deposited, as it is today. Areas that are currently depressions were already depressions a long time ago. The general features of the basement topography have hardly changed at all during the last three, if not more, glaciations, particularly in the ice divide zone of central Lapland.

In terms of dominant trees, the pollen diagram of Naakenavaara peat deposit is very similar to that of many Eemian interglacial deposits in northern Finland. On the other hand, the pollen diagrams of the Holsteinian interglacial in northern Europe are also characterized by conifers and poorly developed zonation of the forests. Therefore, dating or discriminating between the interglacial deposits in northern Finland merely on the basis of pollen stratigraphy, is uncertain.

Macrofossil determinations have, however, brought to light exotic plant species. The presence of *Aracites interglacialis* and *Picea omorika* indicate, that at the time peat was depositing, the climate was warmer and more continental than it is at present. The seeds of *Aracites interglacialis*, which the Naakenavaara peat contains abundantly, have been encountered in European Quaternary deposits, only in those of Holsteinian interglacial on the one hand, and in Tertiary Neogene deposits on the other.

The pollen evidence of Naakenavaara peat deposit clearly reflects interglacial climatic conditions. On the basis of the stratigraphical position and macrofossil content, of the peat deposit the Naakenavaara interglacial has been correlated with the Holsteinian interglacial. Alternatively, it is possible that the Naakenavaara interglacial is even older.

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