RADIOCARBON DATES OF MAMMOTH FINDS IN FINLAND COMPARED WITH RADIOCARBON DATES OF WEICHSELIAN AND EEMIAN DEPOSITS

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In Finnish Lapland the Weichselian Peräpohjola Interstadial can be separated from the Eemian Interglacial with the help of the tree pollen composition of organic deposits between tills. In southern Finland the redeposited organic matter is either interstadial or interglacial. All organic deposits are too old to be dated with conventional radiocarbon methods. The three radiocarbon ages of mammoth finds, 15500 ± 200, 25200 ± 500 and > 43000, and an earlier date of $34300 \begin{smallmatrix} +2000 \\ -1450 \end{smallmatrix}$ of a reindeer antler, suggest that large parts of Finland were ice-free in Middle Weichselian time, a time from which no remains of organic deposits have been found. The youngest date does not agree with the deglaciation chronology.

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Introduction

Nine finds of mammoth bones, molars or tusks have been recorded in Finland, most of them from till or glaciofluvial sediments and therefore clearly redeposited (Donner 1965, Berglund et al. 1976). Two, however, are from clays formed during or after the deglaciation but are also in a secondary position and possibly washed out from glacial drift. One find, the pieces of humerus found in Herttoniemi, Helsinki, has earlier been dated but the age 9030 ± 165 B.P. (Tx-127, Pearson et al. 1965) was considered to be only a younger limit to the true age (see also Berglund et al. 1976). This find, and two others, were dated in 1978 at the Radiocarbon Dating Laboratory of the University of Helsinki. As these finds are Weichselian or older, their ages have to be compared with similar radiocarbon ages of stratigraphically known organic deposits. Only in this way can an attempt be made to determine where the dated mammoth finds belong chronologically and stratigraphically. A summary is therefore first given of the stratigraphy and dating of Weichselian and Eemian deposits in Finland.

Weichselian and Eemian stratigraphy and its dating

Finnish Lapland is the area in Finland where the Quaternary stratigraphy is best known and where several tills with underlying organic deposits have been traced and correlated, first through the work by Korpela (1969) and Ilvonen (1973) and later through the more extensive studies by Hirvas et al. (1976, 1977). Their stratigraphical division of the Pleistocene and the tree pollen assemblages of the organic deposits is shown in Table I together with the tree pollen assemblages of the Holocene lake sediments and peats, as earlier summarised by Donner (1971) and Hyvärinen (1976). Lapland was deglaciated in the beginning of the Flandrian (for division see Mangerud et al. 1974). The Flandrian tree pollen diagrams have lowermost a Birch Zone, with 80—90 % *Betula* in addition to *Pinus,* replaced higher up by a Pine Zone, dominated by *Pinus* but with a strong representation of *Betula* and in addition some *Alnus.* The age of the lower boundary of the Pine Zone varies between about 8400 B.P. in the southern parts of Lapland and about 7500 B.P. in the northern parts. In the uppermost parts of the pollen diagrams there is a Pine-spruce Zone, in which the curve for *Picea* seldom reaches values above 10 %.

The tills in Table I are numbered according to the division by Hirvas et al. (1976, 1977). The uppermost till, I, is mainly an ablation till. The second till, II, represents a lodgement till as do the older tills, III—IV, included in Table I. Between tills II and III there are sometimes stratified sands and silts, often flood sediments in valleys, occasionally with thin layers of peat, or alternatively remains of organic material are found in the basal parts of the upper till (II). The tree pollen composition is dominated by *Betula,* with small amounts of *Pinus.* Other tree pollen occur only irregularly. This interval is the Weichselian Peräpohjola Interstadial identified by Korpela (1969). Below till III there are similar sediments as in the interstadial above, but in addition pure lake sediments and peats, the best site being at Sokli (Ilvonen 1972). At Kurujoki (Hirvas et al. 1976, 1977) peats, with a tree pollen composition dominated by *Pinus,* and with *Betula, Alnus, Corylus* and *Picea,* are higher up replaced by floodplain sediments with peat, with a *Betula*-dominated tree pollen composition. The sediments below till III have, on the basis of their pollen content, been placed in the Eemian (Ilvonen 1972, Hirvas et al. 1976, 1977). Below these there are three till beds, of which only till IV is included in Table I. It can thus be seen that the tree pollen composition of the Peräpohjola Interstadial is similar to the upper part of the Eemian (as well as the lower part of the Flandrian) and that they are separated only on the basis of the till beds. In addition, the purely organic Eemian sediments represent only a part of the whole interglacial vegetational sequence. No complete interglacial or interstadial deposit has so far been recorded below tills in Finnish Lapland, but, on the other hand, the stratigraphical division in Table I is supported by a number of sites. In Swedish Lapland, however, a more complete Eemian sequence has been found at Leveäniemi (Lundqvist 1971). All organic interglacial or interstadial deposits in Finland are, as seen above, dominated by tree pollen and therefore represent times with woodlands. No pollen floras dominated by non-tree pollen from times with a herb vegetation have been found.

Table 1. Stratigraphy and tree pollen assemblages in Finnish Lapland.

			Stratigraphy	*Tree pollen assemblages*
Holocene Flandrian			Peat & mud	Pine-spruce
				Pine ∼ 8000 B.P.
				Birch ∼ 9500 B.P.
			I Ablation till	
Pleistocene	Weichselian		II Till	
		Peräpohjola Interstadial	Sand & silt with peat	Birch
			III Till	
	Eemian		Sand & silt with peat	Birch
			Peat & mud	Pine
			IV Till	

In addition to the interglacial or interstadial sites in Finnish Lapland, of which those with radiocarbon dates are shown in Fig. 1, there are some sites further south in Finland with either organic material in till, or charcoal in till-covered sand, which have been assumed to represent redeposited interstadial organic material and which have also been dated (see Fig. 1). All radiocarbon dates from the above-mentioned sites are listed in Table II, with references and a mention of the dated material. The sites from Lapland are grouped into interstadial and interglacial (Eemian) according to the stratigraphical position of the dated sediments as well as their pollen content. The origin of the organic material dated from southern Finland is less certain but is, as mentioned above, assumed to be interstadial. The same grouping as in Table II was used in Fig. 2, in which the radio-carbon ages are compared with one another, and with the

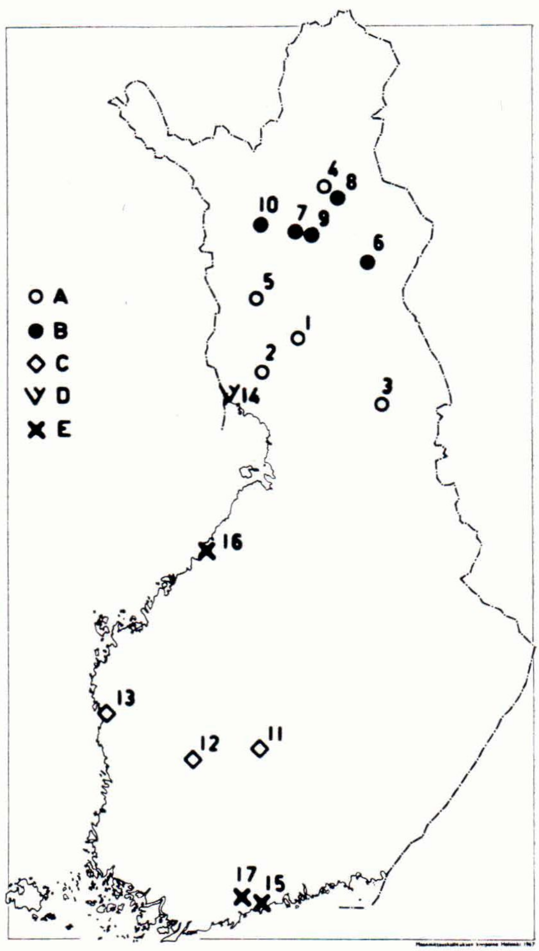

Fig. 1. Map of sites with radiocarbon dates of: A, Peräpohjola Interstadial; B, Eemian Interglacial; C, redeposited interstadial (?) material; D, reindeer antler and E, mammoth.

Table 2. Radiocarbon ages used in Figure 2. The list gives for each site used the laboratory number for dated sample, age B.P., site with reference(s) to paper(s) in which it was described and material dated.

Site no.	Lab.no.	Radiocarbon age B.P.	Site	Dated material
Lapland, Peräpohjola Interstadial:				
1.	I-1139	> 28 000	Permantokoski (Korpela 1969)	Peat
	K-722	> 35 000	— » —	Peat
	GrN-4543	> 42 700	— » —	Peat
2.	I-1138	> 30 000	Ossauskoski (Korpela 1969)	Organic matter in flood sediment
3.	GrN-4491	45 400 ± 2 000	Taivalkoski, Kostonniska (Korpela 1969)	Peat
4.	Su-153	42 000 ± 2 000	Vuotso (Kujansuu 1972, Heikkinen et al. 1974)	Fragments of wood and charcoal from soil horizon
5.	Su-236	> 42 300	Marrasjärvi (Kujansuu 1975, Heikkinen 1975, Heikkinen & Äikää 1977)	Organic matter in till
	Su-237	> 48 000	— » —	Organic matter in till
	Su-263	> 54 000	— » —	Organic matter in till, humic acids
	(3 other ages, Su-264, Su-265 & Su-266 are not included, see comments by Heikkinen 1975 and Heikkinen and Äikää 1977)			
Lapland, Eemian Interglacial:				
6.	Birm-279	$32\,830^{+1\,460}_{-1\,240}$	Sokli (Ilvonen 1973, Shotton & Williams 1973)	Diatom mud
	Birm-278	> 39 400	— » —	Diatom mud
	Hel-147	> 45 000	— » —	Peat
	Hel-349	> 45 000	— » —	Peat
	Hel-348	$46\,100^{+9\,000}_{-4\,000}$	— » — (see comment in text)	Peat
7.	Su-311	> 55 000	Pyssyselkä (Tanskanen 1975, Heikkinen & Äikää 1977)	Peat
	Su-312	> 55 000	— » —	Peat
8.	Su-508	> 50 000	Kurujoki (Hirvas et al. 1976, 1977, Heikkinen & Äikää 1977)	Peat
	Su-509	> 50 000	— » —	Peat
9.	Su-513		Postoaapa 2 (Hirvas et al. 1976, 1977, Heikkinen & Äikää 1977)	Mud
10.	Su-510	> 50 000	Naakenavaara (Hirvas et al. 1976, 1977, Heikkinen & Äikää 1977)	Peat

Table 2, continued

Southern Finland, redeposited interstadial (?) material:				
11.	Su-493	> 37 000	Kerkkolankangas, Jämsänkoski (Heikkinen & Äikää 1977)	Organic matter in till, humic acids
	Su-492	> 45 000	— » —	Organic matter in till, humic acids
	Su-504	> 45 000	— » —	Organic matter in till
12.	Su-494	> 37 000	Honkalanmäki, Kuru (Heikkinen & Äikää 1977)	Organic matter in till, humic acids
	Su-495	> 45 000	— » —	Organic matter in till, humic acids
13.	Su-541	> 37 000	Risåsen, Kristiinankaupunki (Heikkinen & Äikää 1977)	Charcoal in sand
	Su-573	> 50 000	— » —	Charcoal in sand
Bones:				
14.	Hel-254	$34\,300 \begin{smallmatrix} +\,2\,000 \\ -\,1\,450 \end{smallmatrix}$	Tornio (Siivonen 1975)	Reindeer antler in gravel
15.	Hel-1074	15 500 ± 200	Herttoniemi, Helsinki*	Humerus of mammoth between clay and sand
16.	Hel-1075	25 200 ± 500	Lohtaja (find described by Okko 1949)	Femur of mammoth in clay
17.	Hel-1076	> 43 000	Espoo (find described by Metzger 1925)	Molar of mammoth in till

* An earlier age of 9 030 ± 165 (Tx-127, Pearson et al. 1965) has been considered to be too young (see Berglund et al. 1976). The removal of humus before the new dating may well explain the difference between the two ages. Plant remains stuck to the bone gave an age of 4 270 ± 100 B.P. (Hel-1073).

ages of an earlier dated reindeer antler and the three new datings of mammoth finds. There are only two finite radiocarbon dates of the Peräpohjola Interstadial, 45400 ± 2000 (GrN-4491) and 42000 ± 2000 (Su-143); the other dates are all given only as lower age limits. The lower limit for these dates depends on when the samples were dated and also on how each dating laboratory gives the results. Of the Eemian in Finnish Lapland there are also only two finite dates, $32830 \begin{smallmatrix} +\,1460 \\ -\,1240 \end{smallmatrix}$ (Birm-279) and $46100 \begin{smallmatrix} +\,9000 \\ -\,4000 \end{smallmatrix}$ (Hel-348), both from Sokli. According to the suggestions given by Stuiver and Polach (1977) the latter date has to be taken as an apparent age and as the activity is between 1 and 2 σ it should have been given as > 42500. The other dates are similar to those of the Peräpohjola Interstadial, and even from Sokli three other dates give lower limits varying between > 39400 and > 45000. Thus, even if the Peräpohjola Interstadial and Eemian deposits in most cases can be separated on the basis of their tree pollen assemblages, an age difference between these deposits cannot be demonstrated with the radiocarbon dates so far obtained. Further, most of the dates cannot give true ages for the deposits. If the deposits dated as interglacial are Eemian in age, then their age is according to organic terrestrial deposits at least > 70000 years old (van der Hammen et al. 1967, West 1977) or, according to the dat-

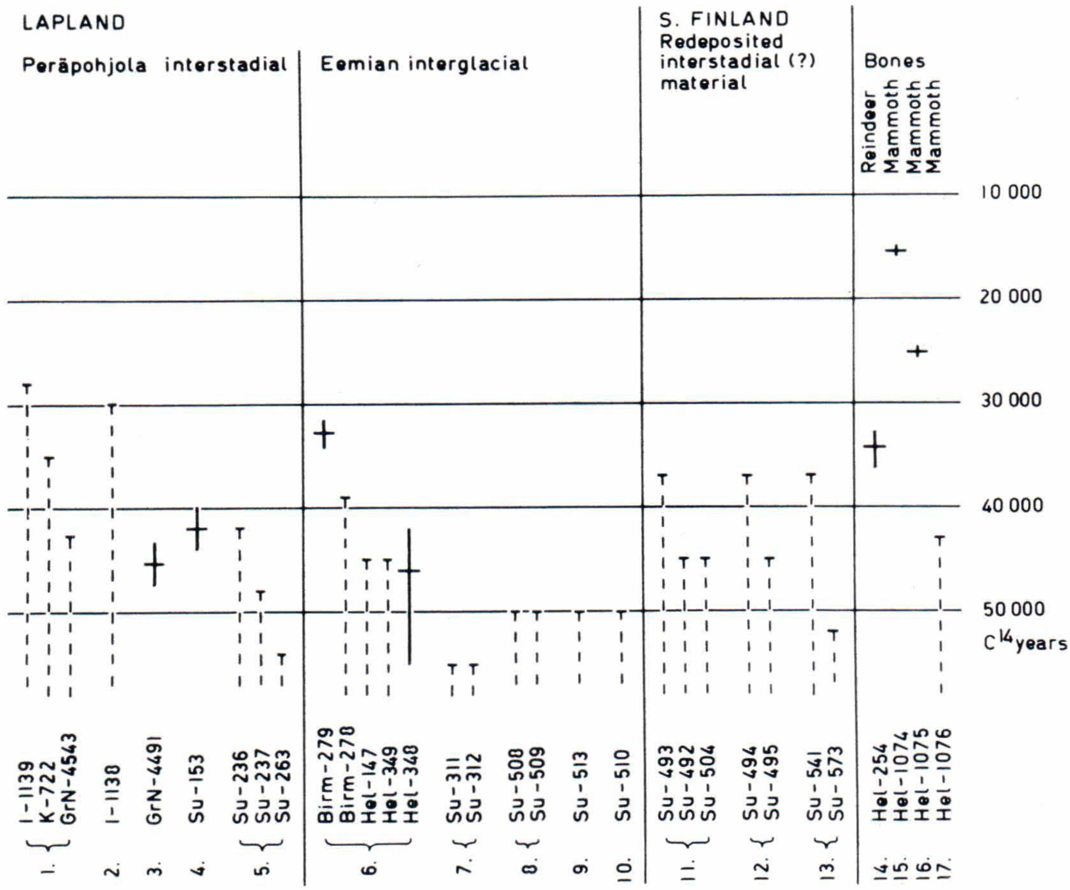

Fig. 2. Radiocarbon ages of interstadial and interglacial deposits or material compared with ages of reindeer and mammoth finds.

ing of marine cores in which Substage 5e is correlated with the Eemian, around 120000 years old (Shackleton 1969, Shackleton and Opdyke 1973). Both alternatives are beyond the dates shown in Fig. 2 for the Eemian. As the radiocarbon dates for the Peräpohjola Interstadial are similar to those for the Eemian it is not possible to determine how close the true age of the Peräpohjola Interstadial is to the dates shown in Fig. 2. An improvement of the radiocarbon dating method is likely to make a dating of this interstadial possible, as already indicated by, for instance, thermal diffusion isotopic enrichment of carbon-14 (Grootes 1978). The three sites in southern Finland (Fig. 1) with redeposited organic material are also included in Fig. 2. Their dates are similar to the above-mentioned dates from Lapland and the material may be interstadial, as concluded on the basis of their stratigraphical position, or be interglacial material, perhaps redeposited several times.

The relationship between the organic deposits and the tills in Finnish Lapland shows that the Peräpohjola Interstadial most likely represents only one interstadial, during which Lapland became ice-free and was covered with woodlands. It is the only Weichselian interstadial in Lapland and the radiocarbon ages show, even if they do not date the interstadial, that it most likely represents an Early Weichselian interstadial, equivalent to the Jämtland Interstadial in Sweden, correlated with the Brørup Interstadial (Lundqvist 1974) and thus also corresponding to the Chelford Interstadial in England (West 1977). The stratigraphy in Lapland further shows that Lapland was deglaciated in Early Flandrian, after the Posterior Glaciation of the Weichselian Glaciation according to Lundqvist (1974), with its maximum extension of the ice sheet at about 20000 B.P. (see also West 1977). During this glaciation only one lodgement till, II, was formed, but it is covered by an ablation till, I. Whether or not the Weichselian glaciation of Lapland and southern Finland was interrupted by younger interstadials cannot be determined on the basis of the present stratigraphical evidence.

The dating and description of the mammoth finds

The three dated mammoth finds are listed in Table II and the sites shown in Fig. 2. In dating the two bones and the molar the combined method, as described by Berglund et al. (1976) in dating mammoth finds in South Sweden, was used when extracting the collagen. Special attention was paid to the removal of humus.

The molar of mammoth from Espoo west of Helsinki is a right upper molar, probably M^2 (Fig. 3). It is heavily worn and the roots are well developed. The total length as preserved is about 140 mm, but since the front end is worn down to the roots and the hind end is broken, the original length may have been 160 mm. Along an occlusal face about 120 mm in length, 10 plates are present, giving a length-lamellar quotient (Guenther 1954) of about 12. The original number of plates was somewhat higher. The width of the specimen is 71 mm but certainly was greater in the unworn tooth. These data suggest that the specimen is a small to medium-sized M^2, rather than M^1. The molar from Espoo, with an age of $>$ 43000 (Hel-1076), was found in till. Its radiocarbon age

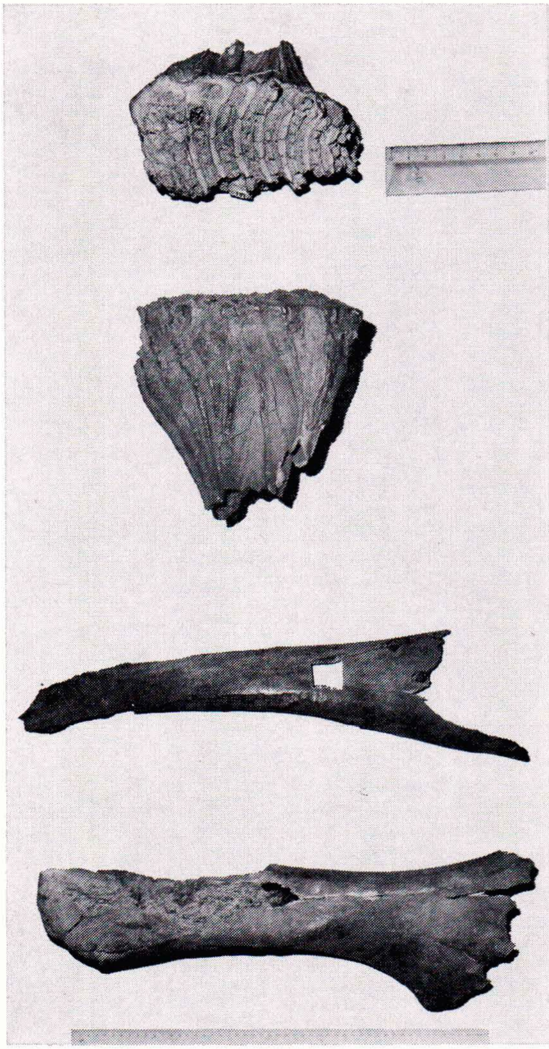

Fig. 3. Photographs from top to bottom: First and second, molar from Espoo; third, femur from Lohtaja and fourth, humerus from Herttoniemi. Photographs are not in the same scale.

is similar to the interstadial and interglacial finds in Lapland and to the presumably interstadial organic material in till or underneath till in southern Finland (Fig. 2). This molar therefore possibly comes from the Early Weichselian Peräpohjola Interstadial, but could also be Eemian.

The two fragments from Lohtaja represent the posterior face of the left femur (Fig. 3). The length of the preserved part is 71 cm. This specimen, and that from Herttoniemi described below, were compared with their homologues in a mounted skeleton of *Elephas maximus* L. in the Museum of Zoology, University of Helsinki. The skeleton belonged to an almost adult animal in which, however, the proximal epiphyse of the humerus, and both epiphyses of the femur, were not yet completely fused. Its shoulder height as mounted is about 225 cm. The Lohtaja femur compares very closely with that in the elephant skeleton and the indication is that it was only very slightly larger. The length of the *E. maximus* femur is 90 cm and the mammoth femur may have measured approximately 92 cm. As the ends are missing, the stage of epiphyse fusion cannot be determined. The femur of mammoth from Lohtaja, with an age of 25200 ± 500 (Hel-1075), was found near the present sea-level in a grey clay covered by 1 m of sand. According to Okko (1949) two femora have been found in the clay, one in 1924 and another, now dated, in 1930, which would indicate that the bones, even if they are in a secondary position, may not have been transported far. The finite date of the Lohtaja femur shows it to be younger than the Peräpohjola Interstadial. Even if there are no finds of organic matter from this time the Lohtaja find may show that Finland was ice-free before the maximum extension of the ice at about 20000 years B.P. during the long Middle Weichselian phase between 40000—35000 B.P. and 25000—20000 B.P., corresponding to an ice-free phase in southern Sweden, the Göta Älv Interstadial, and southern Norway (Lundqvist 1974, Berglund et al. 1976) and also corresponding to the time of the Hengelo and Denekamp interstadials in the Netherlands and the long Middle Devensian time with tundra in England (West 1977). The find in gravel of an antler of tundra reindeer type, with a radiocarbon age of 34300 $^{+2000}_{-1450}$ (Hel-254), from Tornio in northern Finland (Figs 1 and 2, Table II), supports the conclusion about a Middle Weichselian ice-free time. Thus, even if there is no stratigraphical evidence of interstadials of this age, as mentioned above, the mammoth find at Lohtaja and the reindeer antler from Tornio both show that there was probably no ice in most parts of Finland at this time. The radiocarbon ages are otherwise difficult to explain.

The right humerus from Herttoniemi in Helsinki is a fragment with ends missing (Fig. 3). However, the proximal end includes part of the epiphyse which is partially fused with the diaphyse, showing that the animal was a young adult. The length of the fragment is 59 cm. Comparison with the *E. maximus* humerus, which has a length of 72 cm, shows that the mammoth humerus was only slightly longer, probably about 75 cm. It would thus pertain to an animal of the same size as the femur from Lohtaja. Both bones are much smaller than Siberian specimens of *Mammuthus primigenius* in the collections of the Museum of Zoology. The skeletal shoulder height of the Lohtaja and Herttoniemi mammoths may be estimated at about 230—235 cm. The humerus of mammoth from Herttoniemi, with an age of 15500 ± 200 (Hel-1074), was found between clay and sand under a bog (Table II). The dated bonetissue was badly preserved compared with the Lohtaja femur. In contrast to all other radiocarbon dates listed in Table II the date of the humerus from Herttoniemi cannot be fitted into the general scheme of glacial events. The date of 15500 ± 200 would mean that the ice retreated beyond the south coast of Finland already before this time, and not some time between 12000 and 11000 B.P. as indicated by the varve chronology and radiocarbon dates of Late Weichselian and Early Flandrian deposits (see Donner 1978). Further, the southern coast was submerged at the time of deglaciation and emerged in Late Flandrian time. Other datings of mammoth have shown that it survived in Europe until Late Weichselian time (Berglund et al. 1976) and it is possible that the Herttoniemi find also is from this time, but conclusions about its exact age cannot yet be drawn because of the conflict with the deglaciation chronology. The Herttoniemi find in any case differs from the two other mammoth finds dated, which are both older than the last main Weichselian advance of the ice about 20000 years ago.

Conclusions

Summarizing the conclusions from the previous discussion, it can be seen that the stratigraphical evidence from Finnish Lapland, combined with evidence based on the tree pollen composition of organic deposits between tills, separates the Eemian Interglacial from the Peräpohjola Interstadial. The radiocarbon dates of this interstadial as well as its pollen composition suggests that it is Early Weichselian in age and that it corresponds to the Jämtland Interstadial in Sweden and the Brørup Interstadial further south. Redeposited interstadial and interglacial organic matter in southern Finland support the evidence from Lapland. All of the above-mentioned deposits were, however, too old to be dated with currently used conventional radiocarbon methods.

Of the dated mammoth finds the molar from Espoo, found in till, most likely comes from deposits of the Peräpohjola Interstadial, or possibly from older deposits, but the femur from Lohtaja, found in clay, is younger. This find, and the earlier dated reindeer antler from Tornio, found in gravel, suggest that large parts of Finland were ice-free in Middle Weichselian time, between 40000—35000 B.P. and 25000—20000 B.P., at the same time as the southern parts of Sweden and Norway were ice-free. It would thus have been a comparatively long period of time with a cold climate, most likely with a tundra vegetation, from which no remains of organic deposits have been found. Numerous sites in Finland, however, have sands and gravels underneath till and some of these may be younger than the Peräpohjola Interstadial, from the above-mentioned ice-free time. The Late Weichselian date for the Herttoniemi humerus is problematic because it would mean that the south coast of Finland became ice-free already at about 15500 B.P. and not at about 12000—11000 B.P., as concluded on the basis of the varve chronology and the vegetational history. The Herttoniemi find is in any case probably younger than the last glaciation of Finland, with its maximum extent at about 20000 B.P.

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