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Danish Finds of Mammoth (*Mammuthus primigenius* (Blumenbach)) Stratigraphical position, dating and evidence of Late Pleistocene environment.

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KIM AARIS-SØRENSEN, KAJ STRAND PETERSEN AND
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Danmarks Geologiske Undersøgelse · København 1990

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Environmental Changes, Late Pleistocene,
Radiocarbon Datings, Terrestrial Mammals,
Catalogue, Denmark, Mammoth Steppe.

Vignette:
The Mammoth from the cave at Pindal in northern
Spain is mise-en-scène with a red heart.

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Kim Aaris-Sørensen,
Zoological Museum, Universitetsparken 15,
DK-2100 Copenhagen Ø, Denmark.
Kaj Strand Petersen,
Geological Survey of Denmark, Thoravej 8,
DK-2400 Copenhagen NW, Denmark.
Henrik Tauber
The C-14 laboratorium of Geol. Surv. of Denmark
and the National Museum
Nationalmuseet, Ny Vestergade 11,
DK-1471 Copenhagen K.
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Telefon: 64 44 16 83

To the former curator
at the Zoological Museum of
Copenhagen

Ulrik Møhl

this book is dedicated

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Abstract

A catalogue of all known remains of mammoth in Denmark is presented, comprising 125 finds. Half of the mammoth material is molars, which are morphologically referred to *Mammuthus primigenius* (Blumenbach), a third is tusk, and the rest is bone fragments. 14 specimens of mammoth have been C-14 dated. 13 samples have ages from older than 40 000 to ca 21 500 C-14 years B.P., and one sample gave an age of ca 13 200 C-14 years B.P. As the skeletal material is redeposited, these dates at the same time give maximum ages of the glacial deposits in which they are found.

On the basis of this evidence the glacial development during the Weichselian is reviewed. An ice free period from before 45 000 B.P. to around 20 000 years B.P. is indicated. A mammoth tusk from the Tirstrup sandur on Djursland, dated to 13240 +760/−690 B.P., marks an important stage in the ice retreat in Denmark, and shows that the mammoth re-immigrates after the maximum expansion of the Weichselian ice.

Remains of other Late Pleistocene vertebrates are also mentioned. On the basis of floral and faunal remains the environmental changes during the Late Pleistocene are then reconstructed. The ice free period in the Middle Weichselian was characterized by a steppe biome, which may appropriately be termed the mammoth steppe. This Weichselian environment seems to be incomparable to any environment known today.

Introduction

In the Northern countries the most numerous finds of mammoth, *Mammuthus primigenius* (Blumenbach), are found within the Danish area redeposited in glaciogenic deposits. Catalogues of the Danish mammoths have been published in the first half of the century (Aagaard 1896, Winge 1904, Nordmann 1905, 1921, 1942 & 1944), the last publication enumerating 67 finds of elephants of which 62 have turned out to be of mammoths. In their work on mammoth finds from southern Sweden, Berglund *et al.* (1976: 186) show the distribution of the finds in the North. Here the Danish part is based on an unpublished list by U. Møhl containing about 85 finds. The present paper presents an up-to-date catalogue with 125 Danish mammoths. By way of comparison only 9 finds of mammoth bones, molars or tusks have been recorded in Finland (Donner *et al.* 1979), 18 finds in Norway – all located in Gudbrandsdalen and its southerly continuation (Heintz *et al.* 1979), and finally ca 22 in Sweden of which half has been found in Scania (Persson 1961, Liljegren 1975, Berglund *et al.* 1976 and Lundqvist & Pleijel 1976).

Fourteen of the Danish finds have been radiocarbon dated, and the dates are used as a stratigraphical and chronological tool in reconstructing the paleoenvironment of the Late Pleistocene. As pointed out by Berglund *et al.* (*op. cit.*) the redeposited mammoth remains may, if dated, give maximum ages of the investigated deposits, and therefore may throw light on the ice movements in southern Scandinavia during the last glaciation and indicate the distribution of the last ice cover in time and space.

Material

None of the Danish mammoth remains are found *in situ* but all redeposited in till beds or meltwater deposits of Weichselian (and in a few cases probably Saalian) age. However, short transportation is supposed at least in the case of one of the Rosmos specimens (Cat.no. 23) embedded in sandur deposits and with no signs of glacial transportation in contrast to the other find of a molar in the Rosmos area, which was embedded in till material occurring as icecontact sediment (Cat.nr. 24). Generally the remains are highly fragmentated and the transportation is verified by clear signs of polishing and glacial striation (Fig. 1 & 2).

Around half of the remains are molar teeth or fragments of molars (53%), about a third are tusk fragments (37%) and only a tenth represents bone fragments of the mammoth skeleton itself.

Thus, the typical Danish mammoth find is discovered in a gravelpit. It is an almost complete molar with superficial fractures and broken, eroded roots or a fragment of a tusk, broken at both ends with a length of ca 50 cm along the outside curve and a diameter of 10 cm. The surface of the tusk fragment is weathered and brittle while the inner part is well preserved and dense (Fig. 3).

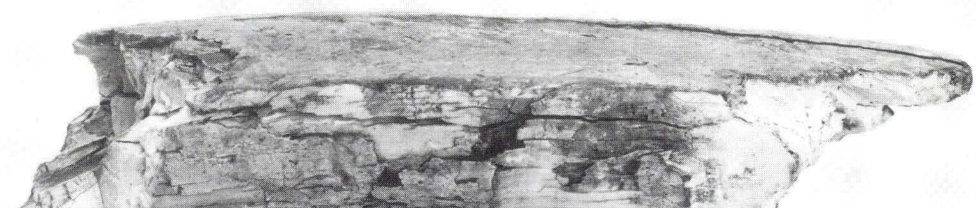

Fig. 1. Fragment of a mammoth tusk 34 cm long found in a gravel pit at Kiskelund, southern Jutland near the Main Stationary Line (Cat.No. 55). The tusk has been C-14 dated to 31 840 +1010/−870 B.P. (K-3696). Note the glacial abrasion surface revealing the conelike structure of the dentine. (Photo: G. Brovad).

Fig. 2. Fragment of mammoth pelvis (ilium, *36 cm) with glacial striations found in till west of the Main Stationary Line at Sdr. Omme (Cat.No. 35). Date infinite (K-4188). (Photo: G. Brovad). Scale: 7 cm.*

Fig. 3. Cross section (greatest diameter: 7 cm) of mammoth tusk found in gravel pit at Lovtrup Vestermark (Cat.No. 52). Apart from some cracks the section reveals a well preserved ivory structure. (Photo: G. Brovad). Scale: 1 cm.

Identification

Morphological characters of molars provide a reliable basis for identification of species within Elephantidae. In the *Mammuthus* lineage the molar width decreased, the number of plates increased, the enamel became thinner and the crown height increased during the evolution from Early Pliocene to Early Holocene, and during the dispersal from Africa to Eurasia and North America (Maglio 1973, Kurtén & Andersen 1980) (Fig. 4). This gradual change in molar characters makes a separation of distinct taxa difficult. In Europe the line has been arbitrarily divided into a *M. meridionalis* stage of Middle Pliocene and Early Pleistocene, a *M. armeniacus* stage of Middle Pleistocene and a *M. primigenius* stage of Late Pleistocene.

The woolly mammoth, *Mammuthus primigenius* (Blumenbach), represents the most advanced stage in this progression with molars characterized by a very high number of extremely thin and closely spaced plates, the lamellar frequency being 7 to 12 for M1 to M3, crown height 50 to 150 per cent greater than width and the enamel very thin, 1 to 2 mm (Maglio 1973: 60). The numerous enamel ridges made the molars excellent "millstones" and show one of the fine adaptations of the woolly mammoth to life on the late Pleistocene steppetundra. Here it fed on tough, dry, siliceous plants, mainly grasses, sedges, shrubs and the lower branches of some trees, but also on herbs and even mosses, as shown by examination of the gastrointestinal contents of plant remains in frozen mammoth carcasses in Siberia (Ukraintseva 1985).

In Table 1 the revised diagnosis for *Mammuthus primigenius* (cf. Maglio 1973) re-

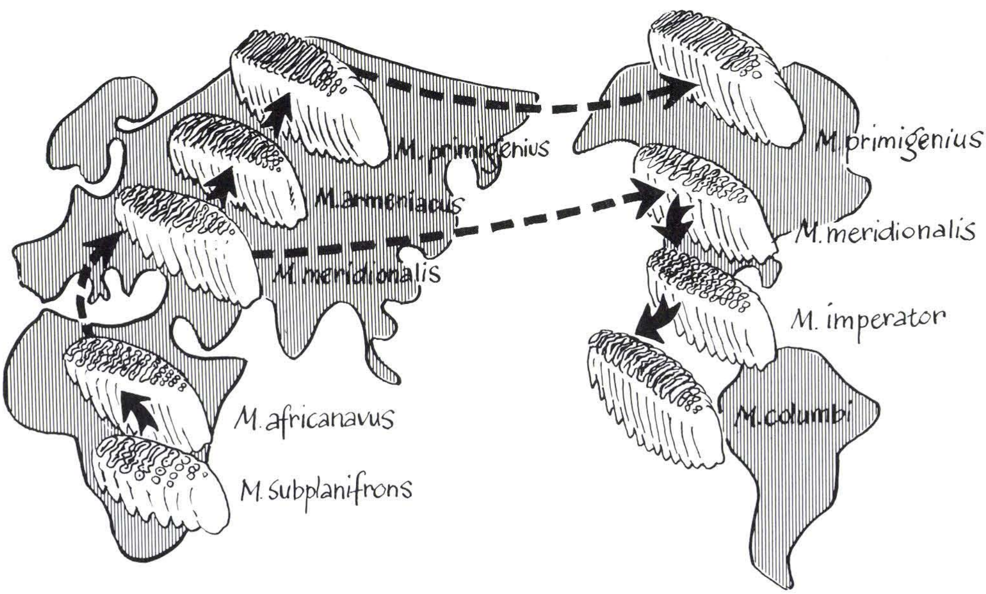

Fig. 4. Dispersal and evolution of Mammuthus. *(Drawing: J. Olesen, after Maglio 1973).*

	P Plate number	L Length, mm	W Width, mm	H Height, mm	LF Lamellar Frequency (Plates per 10 cm)	ET Enamel Thickness, mm	HI $\frac{H \times 100}{W}$ Hypsodonty Index
M^3	20–27	226.0–285.0	68.0–113.0	135.0–188.5	6.5–11.1	1.3–2.0	164.6–211.8
M_3	20–25	207.0–320.2	65.0–100.0	123.0–184.1	6.8–10.2	1.3–2.0	137.8–189.2
M^2	15–16	154.0–172.0	64.0– 80.0	127.0–151.0	9.4–11.5	1.0–1.3	198.4–228.8
M_2	15–16	147.0–185.0	43.0– 85.0	100.0–136.0	7.6–11.4	1.0–2.0	159.8–232.6
M^1	12–14	122.0–154.5	48.0– 76.0	99.0–123.5	10.3–11.0	1.0–1.4	206.3–208.3
M_1	12–15	124.0–146.0	41.0– 76.9	69.0–104.0	7.7–11.0	1.0–1.7	168.3–192.5
dm^4	10–13	102.0–121.0	37.0– 57.9	60.0– 84.0	8.2–16.0	1.0–1.5	141.3–189.2
dm_4	10–11	98.0–105.0	37.0	65.0– 70.0	11.4–11.5	1.0	189.2

Table 1. Summary measurements, observed range, for all molars of *Mammuthus primigenius*. After Maglio (1973:61).

garding molar characters is listed and can be compared with the corresponding measurements of the Danish mammoth molar teeth in Table 2. All the Danish specimens complete enough to be measured fall within the range of variability of *M. primigenius* and no occurrence of earlier *Mammuthus* forms has been recognized in the Danish material so far. This corresponds very well with the Late Pleistocene date which should be expected from the stratigraphical position of most of the finds. As mentioned earlier the vast majority were found in Weichselian deposits but a few found outside the Main Stationary Line and at the same time deeply embedded in till were supposed to date to Saalian or Early and Early Middle Weichselian (Cat.no. 26, 30, 35 and 47). One of these – the Sdr.Omme specimen, no. 35 – has been C-14 dated yielding an infinite age of >39.500 B.P. in conformity to the supposed stratigraphical position.

The tusks of the *Mammuthus* are long, strongly curved, and spirally twisted to such a degree that it can be recognized even on the relatively short fragments which make up the Danish material. As the tusks are found in the same stratigraphical position as the molars and these are classified unambiguously to the *primigenius* stage, it seems most likely that even the tusks represent this advanced stage.

The few bones of the postcranial skeleton (12 fragments of vertebrae, costae, scapulae, pelvis and long bones) included in the catalogue have not been identified to *M. primigenius* on morphological but merely on stratigraphical grounds. It cannot be excluded that some of them might belong to *Elephas namadicus* (former *E. antiquus*), the straighttusked elephant. This species is known from five discoveries in Denmark: one from southwest Funen near Assens, three from southeast Jutland near Kolding, and one from the southeastern part of Jutland, Broagerland. They are all supposed to date to the Eemian interglacial. At least one of them was found *in situ* in limnic deposits of Eemian age (loc.: Ejstrup; Nordmann 1921, 1942 & 1944) and another one below a cliff with exposed Eemian layers (loc.: Stensigmose Strand; Raben 1916, Lehmann 1917, Wolff 1919, Nordmann 1921, 1942 & 1944) but two of them, two molars, were found redeposited in glaciofluvial layers of Weichselian age (loc.: Uglebjerg; Nordmann 1930 & 1944, Milthers 1940; and loc.: Seest; unpublished) (the fifth discovery at loc. Harte is not yet fully explained). With this in mind, it cannot be ruled out that perhaps some of the bone fragments which eludes a closer morphological identification within Elephantidae might belong to *E. namadicus* and not to *M. primigenius*. Consid-

		P	L	W	H	LF	ET	HI
		Plate number	Length, mm	Width, mm	Height, mm	Lamellar Frequency (Plates per 10 cm)	Enamel Thickness, mm	$\frac{H \times 100}{W}$ Hypsodonty Index
2. Lønstrup	M_1	×11	134	60	90 e+	11	1.6	
5. Hellum	M_3						1.9	
6. Lundebjerg 1	M_2	× 8+	152	84	75 +	7		
10. Lundebjerg 4	M^2	×10+	130	77	73 +	8	1.2	
13. Guldager Hede	molar fragm.						1.9	
16. Fuglsø	M_3*	× 9+	150	67	40 +	7	1.8	
24. Rosmos 2	M^3	×14+	200	92	98 +	7	2.0	
36. Sæbberup By	M_3*△	12	180	43	19 +	7	1.4	
39. Vejle	M^3, back half			86^{X}	144^{X}	11	1.6	167
43. Snoghøj	M_3	×17+	250	75^{max} 63^{VIII}	116^{VIII}	10	1.6	184
49. Fredsted	M^3 fragm.			85	100 +	9	1.8	
51. Brøde, Løjt Kirkeby	M_2	×14	160	70^{max} 55^{II}	95^{II}	10	1.5	173
53. Høgebjerg	M^3 fragm.			75	120 +	11	1.9	
59. Åsum 1	M^3	× 5+	152	72^{max} 70^{IX}	134^{IX}	10	1.5	191
63. Rønninge 2	M_3	×12+	200	83	74 +	8	1.8	
73. Hesselø	M^3	16+	210e	80e	125 e+	9	1.8	
74. Hornbæk	M_3 fragm.			78e	103 +	10	1.8	
80. Hedehusene 1	M2	×11+	134	72	98 +	10	1.4	
83. Hedehusene 2	M^3 fragm.			75^{VII}	125^{VII}	10	1.9	167
95. Tåstrup Valby	M^3	20+	260	84^{max} 75^{X}	150^{X}	10	1.8	200
106. Greve	dm_4	10+	102	59	46 +	11e	1.8	
109. Slagelse	M_1	×13	127	71	80 +	11	1.4	
110. Gisselfeld	M1?*	× 7+	60	71	25 +	12e	1.4	
114. Næstved 2	M1	9+	111	60	58 +	8	1.4	
116. Mogenstrup Ås	M_3		250	100				
122. Femø	upper molar			62e	106 +	10e	1.3	
123. Slotshøj, Stege Nor	M^1	10+	107	65	50 +	10	1.4	

Table. 2. Measurements of molars of Danish *Mammuthus primigenius*. Metrical procedure after Maglio (1973:11–13).
Signs and abbreviations: × in front of plate number (P) indicates the presence of significant folds that are not counted as full plates. + after plate number indicates that the original number was greater. Roman numerals after the width (W) and height (H) indicate on which plate the value was taken – counted from behind. + after the height indicates that the value represents maximum preserved height. e stands for estimated values. * designates that the molar is extremely worn, and △ means Det.: Soergel, Freiburg 1940.

ering the numerous finds of mammoth teeth the latter classification, however, seems more plausible.

In previous publications dealing with Danish mammoths two finds of tusks of the recent Indian elephant, *Elephas maximus*, have erroneously been included. Both were found at the coast of Nissum Fjord and were supposed to have been washed out of some very old deposits. The first one was found in 1856 and named Nissum Fjord or Bøvling Enge (Aagaard 1896, Winge 1904, Nordmann 1905, 1942 & 1944) and the second one in 1909 and named Bjerghuse, Nissum Fjord (Nordmann 1921, 1942 & 1944). They are both kept in the collection of the Zoological Museum, Copenhagen, and one of them (the 1856 specimen) has been C-14 dated to 290 ± 70 B.P. corresponding to 1590 AD in calendar years (K-3701). The date confirmed the suspicion that the tusks derived from a ship stranded on the west coast of Jutland – a counterpart to the finds of several tusks of walrus from Rubjerg Knude previously believed to be true arctic elements of a Late Weichselian fauna but later C 14 dated to the 15th century (Møhl 1974).

Age and sex

Out of a total of 66, only 37 of the Danish mammoth molars are so complete that their exact position in the eruption sequence can be inferred. The majority of these molars are M3's representing individuals older than 45 years (Table 3 & Fig. 5). Measurements of greatest diameter and circumference of the tusk fragments have been obtained in 29 cases. Although the majority of these measurements cannot be assigned to a fixed position on the tusk, they do give a hint of the overall size (Table 4 & Fig. 5). The presentation of these dental measurements could be seen as a first vague contribution to a demographic study of the *Mammuthus* in Denmark, but so far, the statistical samples are much too small and, as it will be shown later, derives from a very long span of time. The many M3's are probably primarily due to the fact that the biggest molars are the easiest discovered. Accepting this, one would further expect a dominance of fragments of the bigger tusks. It is therefore interesting to see that the tusk sample consists mainly of smaller, slender specimens which according to information given in the literature (e.g., Pfizenmayer 1926, Osborn 1942, Kubiak & Zakrzewska 1974, and others) have values within the range of va-

	Age class	n	%
dm2-dm4	0–10 years	4	11.0
M1	10–25 years	5	13.5
M2	25–45 years	5	13.5
M3	> 45 years	23	62.0

Table 3. Molars of Danish *Mammuthus primigenius* and their corresponding approximate age groups. Age criteria after Guenther (1955) and Laws (1966)

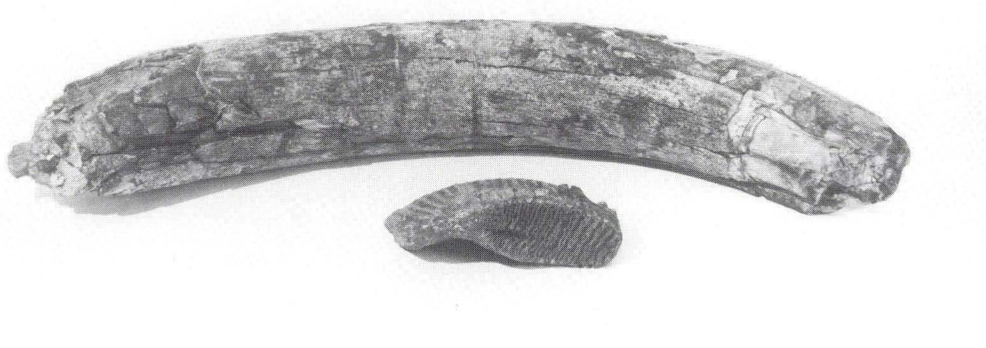

Fig. 5. Molar (M_3) and tusk of mammoths found in gravel pits respectively at Snoghøj and Hedehusene (Cat. No. 43 and 94). The tusk represents the biggest specimen found in Denmark measuring 126 cm along the outside curve and having a diameter of 17 cm. (Photo: G. Brovad).

	Length along outside curve	Greatest diameter	Greatest circumference
4. Kirkeholt	236		
7+8. Lundebjerg 2	906	90	270
15. Hadsund	800	75^{800}	230^{800}
23. Rosmos 1	790	83	254
31. Fyle Mose	440		
34. Sønder Kollemorten	350		260
45. Seest	380	76	225
52. Lovtrup Vestermark	400	70	225
55. Kiskelund	330	100	
56. Strib	340	100	
57. Staurby Skov	330	100	285
60. Åsum	600	80^{600}	240^{600}
62. Rønninge 1	400	70	245
68. Østrupgaard	540	118	350
71. Gammel Nyby	400	65	
76. Uggeløse	770	65	200
77. Farum Sten- og Grusgrav	305		310
82. Kallerup Gårde 2	300		
87. Hedehusene 4	490	100	310
88. Hedehusene 5	260		
89. Hedehusene 6	480	80	250
91. Hedehusene 8	570	95	275
92. Hedehusene 9	610	147	440
94. Hedehusene 11a	1260	172	520
Hedehusene 11b	250	120	370
96. Vodroffsvej	500	62^{500}	190^{500}
99. Jukkerup Vænge	400	68	215
100. Brorfelde 1	160	52	
101. Brorfelde 2	400	69	210
102. Ny Stengård, Hvalsø	340	65	200
103. Stengårdens Grusgrav 1	450		
104. Stengårdens Grusgrav 2	590	99	300
105. Darup	765		304
108. Regnemark	515	90	270
113. Næstved 1	500	73	230
117. Mogenstrup	500		
119. Stenskoven	445	83	255
120. Stenskov Grusgrav	495	148	450
121. Hastrup	450	107^{400}	330^{400}
124. Kongsnæs Strand	390		235
125. Saxkøbing	270		

Table 4. Measurements of tusks of Danish *Mammuthus primigenius,* in mm. The superscript indicates the distance from the tip at which the value was taken.

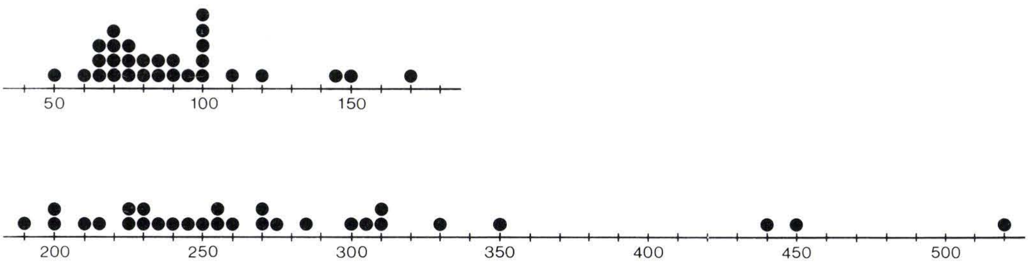

Fig. 6. Measurements of tusks of Danish Mammuthus primigenius.

riation for adult females with a mean diameter of 82 mm and a mean circumference of 256 mm. Only three specimens (catalogue no. 92, 94a and 120) fall within the main variation of adult males having corresponding mean values of 155 mm and 470 mm (Fig. 6). As an ontogenetical ageing of the individual tusks is not possible, it cannot, however, be excluded that the "female sample" is a mixture of adult females and juvenile males.

Catalogue

Abbreviations: DMG = Djursland Museum, Grenå; FS = Fyns Stiftsmuseum, Odense; GM = Geologisk Museum, Copenhagen; HM = Horsens Museum; HNS = Herlufsholm Naturhistoriske Samling, Næstved; KMR = Kulturhistorisk Museum, Randers; LM = Langelands Museum, Rudkøbing; MHM = Morslands Historiske Museum, Nykøbing M.; MM = Middelfart Museum; MMG = Midtsønderjyllands Museum, Gram Slot; NMA = Naturhistorisk Museum, Århus; RM = Roskilde Museum; SAM = Svendborg Amts Museum, Svendborg; SZM = Svendborg Zoologisk Museum; VHM = Vendsyssel Historiske Museum, Hjørring; ZM = Zoologisk Museum, Copenhagen.

Catalogue numbers 1–125 are mapped on Fig. 7 from northern to southeastern Denmark respectively.

1. Tornby Strand, 1907. Upper (milk?) molar. GM. (Nordmann 1921, 1942 & 1944).
2. Lønstrup, 1887. A lower left molar (M_1) found on the beach, rounded by water. ZM.
   (Winge 1904); (Nordmann 1905, 1942 & 1944 under the locality: Stensnæs).
3. Stenhøj, 1965. Proximal part of a rib. ZM.
4. Kirkeholt, 1967. Very badly preserved tusk fragment. VHM.
5. Hellum, 1976. Lower third molar fragment (M_3). VHM.
6. Lundebjerg 1, 1926. Lower second molar (M_2). VHM.
   C-14 date: 32,460 ± $^{970}_{870}$ B.P. (K-4190).
   (Nordmann, 1942).

7+8. Lundebjerg 2, 1931. A 90 cm long tusk fragment, as well as a collection of smaller fragments probably belonging to the former. ZM.
   Radiocarbon dating has been tried but the collagen fraction was too small (0.6%) (K-3700).
   (Nordmann 1942).

9. Lundebjerg 3, 1950. Fragment of long bone. ZM.
10. Lundebjerg 4, 1950. A second upper molar (M^2). ZM.
11. Sønder Dråby, 1958. Molar fragment, probably M_3. MHM.
12. Thyborøn Strand, 1978. One complete plate of a molar and two halves – rounded by water and found on the beach. In private possession.
13. Guldager Hede, 1896. Fragment of very badly preserved molar. ZM.
   (Winge 1899 & 1904); (Nordmann 1942 & 1944).
14. Rævedal, 1917. Three very badly preserved fragments of a tusk. GM.
   (Nordmann 1921, 1942 & 1944).
15. Hadsund, 1950. The outermost 80 cm of a tusk. According to the finder the tip itself was present at the discovery but broke off and disappeared during the two years the tusk was lying in a workmen's shed. ZM.
   C-14 date: 25,110 ± 440 B.P. (K-3699).
16. Fuglsø, 1972. A heavily worn third lower molar (M_3). KMR.

17+18. Sønder-Onsild, 19??. Very badly preserved fragments of one, possibly two, tusks. ZM.
Radiocarbon dating has been tried but the collagen fraction was too small (0.3%) (K-3695).

19. Fjaltring, 1920. Fragment of third upper or lower molar, found on the beach and strongly rounded by water. ZM.
(Nordmann 1942 & 1944).

20. Langå, 1910. Fragment of 6th or 7th cervical vertebra. ZM.
(Nordmann 1921, 1942 & 1944).

21. Kolindsund, 19??. A third lower molar (M_3). DMG.
(Nordmann 1942).

22. Balle, Djursland, 1959. Molar fragment. NMA.

23. Rosmos 1, 1934. Tusk fragment. ZM.

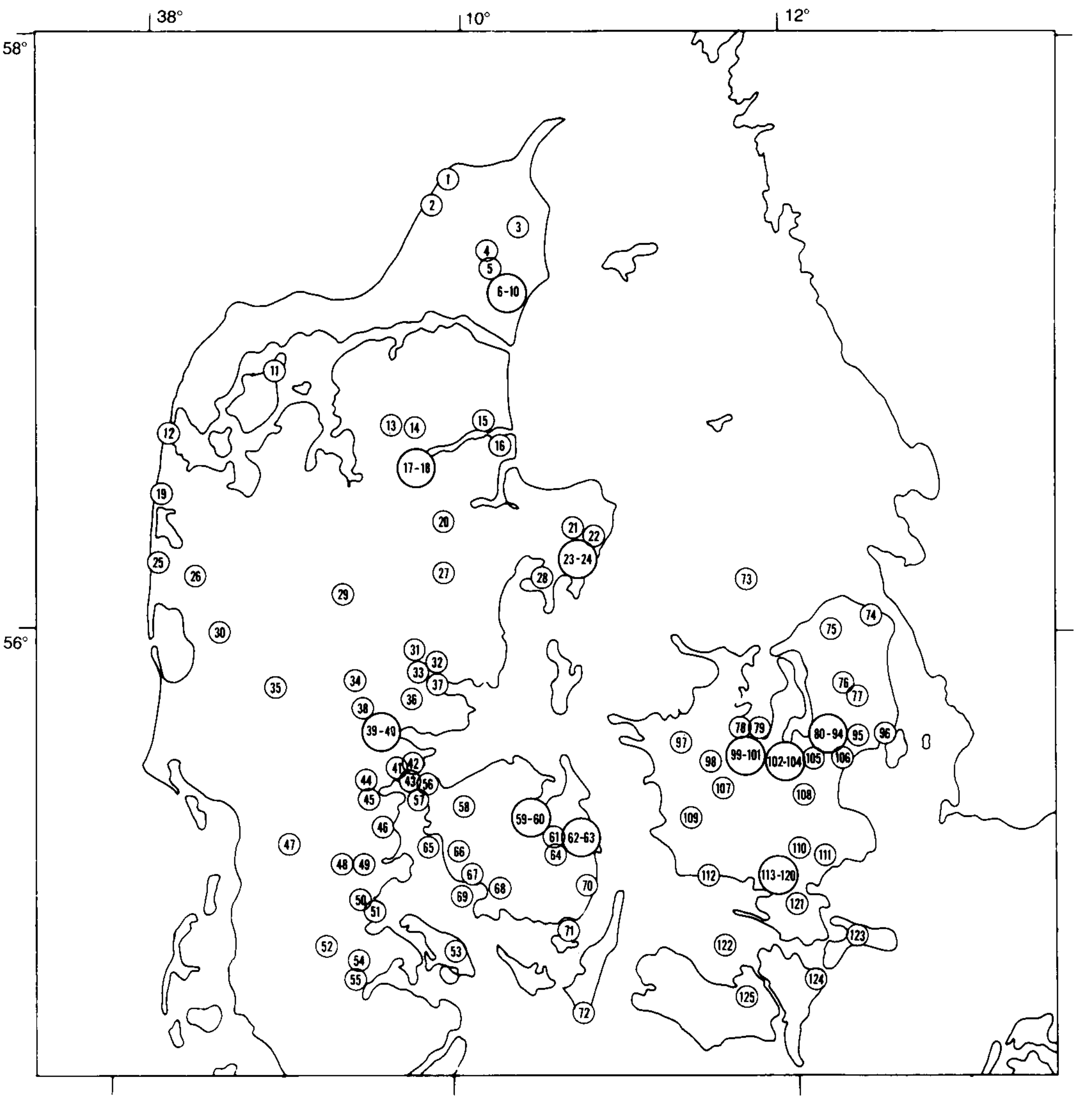

Fig. 7. Map showing the distribution of Danish mammoth finds.

C-14 date: $13{,}240 \pm {}^{760}_{690}$ B.P. (K-3697).
(Nordmann 1942 & 1944).

24. Rosmos 2, 1982. A third upper molar (M^3). ZM.
C-14 date: >39,600 B.P. (2 σ) (K-4587).
25. Vedersø Strand, 1980. A single plate of a molar found on the beach. NMA.
26. Torsted, 1872. A rib. ZM.
27. Voldby, Hammel, 1954. A molar. NMA.
28. Rolsøgård, Knebel Vig, 1963. Molar fragment. ZM.
29. Bording, 198l. A molar. NMA.
30. Sædding, 1873. Molar fragment. ZM.
(Winge 1904); (Nordmann 1905, 1942 & 1944).
31. Fyle Mose, 1976. Tusk fragment. NMA.
32. Højballegård, Hansted, 1933. Upper third molar (M^3) in an early stage of wear. ZM.
(Nordmann 1942 & 1944).
33. Vinten, 1961. A molar. NMA.
34. Sønder Kollemorten, 1880. Tusk fragment. GM.
C-14 date: >37,900 B.P. (2 σ) (K-4191).
(Nordmann 1921, 1942 & 1944).
35. Sønder Omme, 1850. Fragment of pelvis (*ilium*). ZM.
C-14 date: >39,500 B.P. (2 σ) (K-4188).
(Steenstrup 185l); (Aagaard 1896); (Winge 1904); (Nordmann 1905, 1942 & 1944).
36. Sæbberup By, 1932. Heavily worn lower third molar (M_3). ZM.
(Nordmann 1942 & 1944).
37. Nim, Horsens, 19??. Tusk fragment. In private possession.
38. Jelling, 1861. Fragment of distal epiphysis of a femur. ZM.
(Winge 1904); (Nordmann 1905, 1942 & 1944).
39. Vejle, 1863. The back half of a third upper molar (M^3). ZM.
(Aagaard 1896); (Winge 1904); (Nordmann 1905, 1942 & 1944).
40. Lillegrundet Hulvej, Vejle, 1909. A fragment of a lower molar (M_2 or M_3). In private possession.
(Nordmann 1921, 1942 & 1944).
41. Børup Sand, 1941. A molar, two fragments of probably the same atlas, and a fragment of ilium. ZM.
(Nordmann 1942 & 1944).
42. Erritsø, 1932. A molar. In private possession.
(Nordmann 1942 & 1944).
43. Snoghøj, 1930. A lower third molar (M_3). ZM.
(Jørgensen 1940) (Nordmann 1942 & 1944).
44. Stenvad Mølle, 1900. Seven plates of an upper molar. GM.
(Steenstrup 1901); (Winge 1904); (Nordmann 1905, 1942 & 1944).
45. Seest, 1954. Tusk fragment. ZM. Radiocarbon dating has been tried but the collagen fraction of the tusk turned out to be too small (K-4189).
46. Hejlsminde, 1899. Seven plates of a molar. ZM.
(Nordmann 1905, 1942 & 1944).
47. Fole, 1874. Heavily fragmented molar, most of the crown broken off. ZM.
(Aagaard 1896); (Winge 1904); (Nordmann 1905, 1942 & 1944).
48. Vojens, 1922. Seven plates of a small molar (dm4?). ZM.
(Nordmann 1942 & 1944).
49. Fredsted, 1850. Fragment of an upper third molar (M^3). ZM.
(Steenstrup 1851); (Aagaard 1896); (Winge 1904); (Nordmann 1905, 1942 & 1944).
50. Genner Østermark, 1961. Distal epiphysis of a right ulna. NMA.
51. Brøde, Løjt Kirkeby, 1910. A lower second molar (M_2). ZM.
(Nordmann 1942 & 1944).

52. Lovtrup Vestermark, 1982. Tusk fragment. MMG, cast at ZM.
53. Høgebjerg, 1948. A fragmented upper third molar (M^3). ZM.
54. Fladbjerg, 1953. Fragment of ilium. ZM.
55. Kiskelund, 1976. Tusk fragment with glacial abrasion surface. MMG, cast at ZM.
C-14 date: 31,840 ± $^{1010}_{870}$ B.P. (K-3696).
56. Strib, 1952. Tusk fragment. ZM.
57. Staurby Skov, 1935. Tusk fragment. MM.
(Nordmann 1942 & 1944).
58. Fjeldsted, 1934. A molar fragment. MM.
(Nordmann 1942 & 1944).
59. Åsum 1, 1869. An upper third molar (M^3). ZM.
(Aagaard 1896); (Winge 1904); (Nordmann 1905, 1942 & 1944).
60. Åsum 2, 1936. 60 cm of the outermost part of a tusk broken approximately 10 cm from the very tip. ZM.
(Jørgensen 1940); (Nordmann 1942 & 1944).
61. Davinde, 1949. Lower part of a scapula. FS, cast at ZM.
62. Rønninge 1, 1852. Tusk fragment. ZM.
C-14 date: 28,120 ± $^{760}_{680}$ B.P. (K-3808).
(Aagaard 1896); (Winge 1904); (Nordmann 1905, 1942 & 1944).
63. Rønninge 2, 1953. A lower third molar (M_3). ZM.
64. Tarup, 1971. Tusk fragment. GM.
65. Baagø, 1933. A molar fragment. In private possession.
(Nordmann 1942 & 1944).
66. Turup, 1932. A molar fragment. In private possession.
(Nordmann 1942 & 1944).
67. Fyn, the southwestern part, 1863. Eight plates of the rear and unworn part of (probably) an upper third M^3. Found on the beach and slightly rolled by water. ZM.
(Aagaard 1896); (Winge 1904); (Nordmann 1905); (Milthers 1940).
68. Østrupgaard, 1885. Tusk fragment. ZM.
C-14 date: 25,480 ± $^{560}_{520}$ B.P. (K-3809).
(Aagaard 1896, under the locality: Hvedholm); (Winge 1904); (Nordmann 1905, 1942 & 1944); (Milthers 1940).
69. Helnæs, 1948. A molar fragment. In private possession.
70. Hesselager, 1938. A (second upper) molar. SZM.
(Nordmann 1942 & 1944).
71. Gammel Nyby, 1929. Tusk fragment. SAM.
(Nordmann 1942 & 1944).
72. Kjels Nor, 1920. A molar fragment. LM.
(Nordmann 1921, 1942 & 1944).
73. Hesselø, 1942. A badly preserved, third upper molar (M^3). ZM.
(Nordmann 1942 & 1944).
74. Hornbæk, 1858. Fragment consisting of 12 plates of a lower third molar (M_3). Badly preserved, found on the beach. ZM.
(Winge 1904); (Nordmann 1905, 1942 & 1944).
75. Nejlinge, 1927. A small fragment of a milk molar. ZM.
(Nordmann 1942 & 1944).
76. Uggeløse, 1961. Tusk fragment. ZM.
77. Farum Sten- og Grusgrav, 1975. Tusk fragment. In private possession.
78. Holbæk, 1933. A right ulna. ZM. Radiocarbon dating was attempted as an experiment although the collagen fraction was very small (1.2 % of sample weight) and the collagen had an untypical appearance. The sample material in addition contained large amounts of impuri-

ties (28 % of sample weight). The subrecent age found (2840 +/− 150 B.P.) shows that the separated carbon compounds from the specimen was not the original collagen.
(Nordmann 1942 & 1944).

79. Bredetved, 1934. Molar fragment. ZM.
(Nordmann 1942 & 1944).

80. Hedehusene 1, 1904. A second molar (M2), heavily rounded and rolled by water. ZM.
(Grönwall 1904).

81. Kallerup Gårde 1, 1913. Some small fragments of a tusk. GM.
(Nordmann 1921, 1942 & 1944).

82. Kallerup Gårde 2, 1913. An upper molar with 14 plates (probably M^3) and some badly preserved fragments of probably three different tusks. In private possession.
(Nordmann 1921, 1942 & 1944).

83. Hedehusene 2, 1921. Fragment of an upper third molar. ZM.
(Nordmann 1921, 1942 & 1944, under the locality: Nymølle).

84+85. Kallerup Gårde 3, 1921. Four very badly preserved fragments of a tusk. GM.
(Nordmann 1921, 1942 & 1944).

86. Hedehusene 3, 1928. Fragment of an upper molar. GM.
(Nordmann 1942 & 1944).

87. Hedehusene 4, 1964. Tusk fragment. In private possession, cast at ZM.

88. Hedehusene 5, 1965. Fragment of outermost layer of tusk. In private possession.

89. Hedehusene 6, 1965. Tusk fragment. In private possession, cast at ZM.

90. Hedehusene 7, 1966. Molar fragment. RM.

91. Hedehusene 8, 1966. Tusk fragment. In private possession.

92. Hedehusene 9, 1968. Tusk fragment. ZM.

93. Hedehusene 10, 1969. A very badly preserved molar. ZM.

94. Hedehusene 11, 1970. A very big (126 cm long) and a rather small (25 cm) fragment of a tusk. ZM.

95. Tåstrup Valby, end of 19th century. An upper third molar. ZM.
(Winge 1904); (Nordmann 1942 & 1944).

96. Vodroffsvej, 1914. 50 cm of the outermost part of a tusk but missing the tip itself. ZM.
(Nordmann 1921, 1942 & 1944).

97. Svebølle, 1911. A molar. GM.
(Nordmann 1921, 1942 & 1944).

98. Skellingsted, Tømmerup, 1927. A molar fragment. ZM.
(Nordmann 1942 & 1944).

99. Jukkerup Vænge, 1963. Tusk fragment. In private possession, cast at ZM.

100. Brorfelde 1, 19??. Tusk fragment. In private possession.

101. Brorfelde 2, 19??. Tusk fragment. ZM.
C-14 dates:
$38{,}000 \pm ^{1400}_{1200}$ B.P. (T-2275A)
$46{,}300 \pm ^{3200}_{2300}$ B.P. (T-2275B)
$42{,}000 \pm ^{1500}_{1300}$ B.P. (T-2275C)
$43{,}100 \pm ^{1500}_{1300}$ B.P. (T-2275D)
(Selsing 1982).

102. Ny Stengård, Hvalsø, 1937. Tusk fragment. ZM.
C-14 date: $25{,}760 \pm ^{840}_{770}$ B.P. (K-3805)

103. Stengårdens Grusgrav 1, 1979. Tusk fragment. RM.

104. Stengårdens Grusgrav 2, 1983. Tusk fragment. ZM.
C-14 date: 27,810 ± 610 B.P. (K-4192).

105. Darup, 1970. Tusk fragment. In private possession.

106. Greve, 1900. The last milk molar, dm_4. ZM.
(Winge 1904); (Nordmann 1905, 1942 & 1944).

107. Munke Bjergby, 1916. Tusk fragment. ZM.

C1–14 date: 24,190 ± 420 B.P. (K-3806).
(Nordmann 1921, 1942 & 1944).

108. Regnemark, 1933. Tusk fragment. ZM.
(Nordmann 1942 & 1944).

109. Slagelse, 1902. A lower first molar (M_1). ZM.
(Winge 1904); (Nordmann 1905, 1942 & 1944).

110. Gisselfeld, 1857. Heavily worn molar (7 plates ofM1?). ZM.
(Aagaard 1896); (Winge 1904); (Nordmann 1905, 1942 & 1944).

111. Faxe Kalkbrud, 1890. A molar. GM.
(Aagaard 1896); (Winge 1904); (Nordmann 1905, 1942& 1944).

112. Glænø, 1896. A lower third molar. GM.
(Aagaard 1896); (Winge 1904); (Nordmann 1942 &1944).

113. Næstved 1, 1869. Tusk fragment. ZM.
(Aagaard 1896); (Winge 1904); (Nordmann 1942 &1944).

114. Næstved 2, 1903. A first molar (M1). ZM.

115. Næstved, Apotekerhaven, 1917. A badly preserved and heavily fragmented molar. HNS.
(Nordmann 1942 & 1944).

116. Mogenstrup Ås, 1938. A lower third molar. NM.
(Nordmann 1942 & 1944).

117. Mogenstrup, 1947. Tusk fragment. HNS.

118. Myrup Banke, 1973. Fragment of pelvis (*ischium dextra*). ZM.
C-14 date: 21,530 ± 430 B.P. (K-3703).
(Krüger 1976).

119. Stenskoven, 1976. Tusk fragment. In private possession.
(Krüger 1976).

120. Stenskov Grusgrav, 1980. Tusk fragment. ZM.

121. Hastrup, 1934. Tip of tusk with wear facet. ZM.
(Nordmann 1942 & 1944, under the locality: Beldringe).

122. Femø, 1928. A fragment of an upper molar. ZM.

123. Slotshøj, Stege Nor, 1953. An upper first molar(M^1). ZM.

124. Kongsnæs Strand, 1910. Tusk fragment. GM.
(Nordmann 1921, 1942 & 1944).

125. Saxkøbing, 1934. Fragment of outermost layer of tusk.
C-14 date: 29,570 $\pm^{950}_{870}$ B.P. (K-3807).
(Nordmann 1942 & 1944).

Radiocarbon dating of mammoth finds in Denmark

Methods

Mammoth finds are generally so old that reliable C-14 dates can only be obtained if great care is taken to avoid any kind of contamination with extraneous carbon. This requirement is especially acute, if the specimens have been exposed to various types of preservatives prior to dating, as is often the case. A rigorous pretreatment was therefore applied to all samples of mammoth submitted for dating.

Among the 125 finds of bones, molars or tusks of mammoth from Denmark, 21 specimens were selected for C-14 dating. A broad geographical scatter of the dated samples was aimed at, in order to enhance the ensuing stratigraphical information. However, consideration also had to be taken to the state of preservation and to the amount of sample available. 19 of the specimens were expected to be of a glacial age, whereas 2 were chosen because they were suspected to represent recent elephants although they had previously been published and/or exhibited in museums as true mammoths (K-3701 Nissum Fjord see also p. 12, and K-3702 Langeland). The C-14 dates for these two specimens also showed ages of only a few hundred years.

The dating of 4 of the glacial specimens was given up, either because the collagen content was considered too low for a reliable dating, or because the specimen had been so extensively treated with preservatives that a safe recovery of the original collagen was not considered possible (K-3595 Sdr. Onsild, Cat.no. 17+18, K-3698 Hedehusene 11, Cat.no. 94, K-3700 Lundebjerg 2, Cat.no. 7+8, and K-4189 Seest, Cat.no. 45). One further sample (K-3695 Holbæk, Cat.no. 78) was doubtful for the same reasons, and the separated collagen had an untypical appearance. Also the C-13 content of the separated "collagen" was untypical. The sample material thus was very suspicious, but a dating was attempted as an experiment to check on contamination. Although striation, presumably of glacial origin, was detected on the surface of this specimen, a C-14 dating gave a subrecent age, thus indicating that the purification had not been successful. Only 14 glacial specimens were, therefore, left.

Five of the tusk samples had been treated with various types of surface lacquer. These layers were removed mechanically, and the material for dating was taken from the uncontaminated interior parts. Samples were crushed to a size < 0.5 mm, and the collagen was separated as a gelatine by the method of Longin (1971), with additional NAOH extraction for humic matter when the colour indicated a possibility for contamination of this kind. The amount of collagen recovered from the specimens depends on the state of preservation and varied from 0.3% to 30.7% of the dry sample weight. However, only if the collagen fraction obtained in this way amounted to more than 1% of the sample weight and in addition had a collagen like gelatinous appearance was the sample accepted for further processing and dating. These conditions were imposed in order to minimize the risk of contamination with extraneous carbon.

Separated collagen was then combusted to carbon dioxide, which was purified and counted in a proportional gas counter. A small portion of the carbon dioxide was used for assay of the C-13 content. This is expressed as δ C-13 values, i.e. as the per mil deviations from the isotope ratio in the PDB-standard. The δ C-13 values were used for a correction for isotopic fractionation. Such corrections make all C-14 dates of terrestrial materials directly comparable, irrespective of diets, biochemical components, individual isotopic scatter, etc. (Tauber 1981).

Dates for the mammoths are expressed in conventional C-14 years B.P., and are reported in the list below. Three of the samples gave infinite ages on the 2σ level. A number of the samples were too small to produce enough carbon dioxide for a normal filling of the counter and were supplemented with inactive carbon dioxide to the standardized pressure. This is indicated as "undersized" in the sample descriptions. Undersized samples give rise to a somewhat larger statistical error in the dating result, or to a lower age limit in the case of infinite ages, but the addition of a known amount of inactive carbon dioxide does not otherwise influence the reliability of the result.

In the geological discussion of the finds (p. 33), thermoluminescence (TL) dates of glacial deposits are also applied. In comparing such dates with the C-14 dates below, it should be remembered that TL dates and uncalibrated C-14 dates are not directly comparable. TL dates, if properly corrected for all external effects, represent absolute ages throughout the whole dating range, whereas C-14 dates can only be precisely calibrated back to about 9000 B.P. For ages older than that C-14 dates are stated in conventional C-14 years, which deviate systematically from solar years. At about 10000 B.P. a conventional C-14 date thus may be about a 1000 years younger than a corresponding TL age, and this difference may increase to perhaps 2000 years at 40000 B.P. In this estimate it is also taken into account that conventional C-14 ages are calculated on the basis of the Libby halflife, which is 3% too small and thus tend to underrate the absolute age of samples correspondingly.

List of C-14 dates

K-4190	Molar of mammoth, Lundebjerg 1. Sample taken from interior part of molar. Collagen recovered: 5.8% of sample weight. Cat.no. 6. $\delta^{13}C = -20.2\%$.	$32460 \pm {}^{970}_{870}$ B.P.
K-3700	Tusk of mammoth, Lundebjerg 2. Collagen recovered: 0.6% of sample weight. Sample too small for a safe dating. Cat.no. 7+8.	
K-3699	Tusk of mammoth, Hadsund. Collagen recovered: 9.0% of sample weight. Cat.no. 15. $\delta^{13} = -19.5\%$.	25110 ± 440 B.P.
K-3695	Tusk of mammoth, Sdr. Onsild. Collagen recovered: 0.3% of sample weight. Sample too small for a safe dating. Cat.no. 17+18.	

K-3697	Tusk of mammoth, Rosmos 1. No traces of glacial striation. Collagen recovered: 1.3% of sample weight. Collagen had a proper gelatinous appearance. Undersized: 12.8% of normal filling. Cat.no. 23. $\delta^{13}C = -21.1\%$.	$13240 \pm {}^{760}_{690}$ B.P.
K-4587	Molar of mammoth, Rosmos 2. Sample cut out of interior part of molar. Collagen recovered: 4.5% of sample-weight. Cat.no. 24. $\delta^{13}C = -21.1\%$.	> 39600 B.P.
K-4191	Tusk of mammoth, Sønder Kollemorten. Sample taken from interior of tusk. Collagen recovered: 23.5% of-sample weight. Cat.no. 34. $\delta^{13}C = -20.2\ \%$.	> 37900 B.P.
K-4188	Bone of mammoth, Sønder Omme. Sawed out of inner part of fragment of pelvis, which had striation marks on the surface. Collagen recovered: 1.9% of sample weight. Undersized: 29.4% of normal filling. Cat.no. 35. $\delta^{13}C = -20.4\%$.	> 39500 B.P.
K-4189	Tusk of mammoth, Seest. Collagen recovered: 1.1% of sample weight. Sample too small for a safe dating. Cat.no. 45.	
K-3696	Tusk of mammoth, Kiskelund. Surface treated with shellac, which was removed before dating. Collagen recovered: 8.7% of sample weight. Cat.no. 55. $\delta^{13}C = -20.5\%$.	$31840 \pm {}^{1010}_{870}$ B.P.
K-3808	Tusk of mammoth, Rønninge 1. Collagen recovered: 15.9% of sample weight. Cat.no. 62. $\delta^{13}C = -19.5\%$.	$28120 \pm {}^{760}_{680}$ B.P.
K-3809	Tusk of mammoth, Østrupgård. Surface partly treated with glue, which was removed before dating. Collagen recovered: 6.2% of sample weight. Cat.no. 68. $\delta^{13}C = -20.4\%$.	$25480 \pm {}^{560}_{520}$ B.P.
K-3698	Tusk of mammoth, Hedehusene. Tusk had been boiled in "Mobilwax 2305". Wax constituted more than 30% of sample weight. Dating abandoned. Cat.no. 94.	
K-3805	Tusk of mammoth, Ny Stengaard. Surface treated with lucite, which was removed before dating. Collagen recovered: 4.2% of sample weight. Undersized: 55.1% of normal filling. Cat.no. 102. $\delta^{13}C = -21.2\%$.	$26270 \pm {}^{1440}_{1240}$ B.P. $25520 \pm {}^{920}_{830}$ B.P. av. $25760 \pm {}^{840}_{770}$ B.P.

K-4192	Tusk of mammoth, Stengårdens Grusgrav 2. Collagen recovered: 17.2% of sample weight. Cat.no. 104. $\delta^{13}C = -20.0‰$.	27810 ± 610 B.P.
K-3806	Tusk of mammoth, Munke Bjergby. Surface partly treated with glue,which was removed before dating. Collagen recovered: 3.9% of sample weight. Undersized: 81.7% of normal filling. Cat.no. 107. $\delta^{13}C = -20.9‰$.	24190 ± 420 B.P.
K-3703	Bone of mammoth, Myrup Banke. Collagen recovered: 3.0% of sample weight. Undersized: 77.8% of normal filling. Cat.no. 118. $\delta^{13}C = -20.8‰$.	21530 ± 430 B.P.
K-3807	Tusk of mammoth, Saxkøbing. Surface partly treated with glue, which was removed before dating. Collagen recovered: 15.3% of sample weight. Cat.no. 125. $\delta^{13}C = -19.6‰$.	29570 ± $^{950}_{870}$ B.P.
K-3701	Tusk of elephant, Nissum Fjord 1856. Previously published together with a corresponding find from 1909 as *Mammuthus primigenius* – see p. 12. Collagen recovered: 30.7% of sample weight. $\delta^{13}C = -19.3‰$.	290 ± 70 B.P.
K-3702	Bone of elephant, dredged out of the sea 10 km S of Langeland. Previously identified and exhibited as *Mammuthus primigenius*. Surface treated with stearine and camphor, which was extracted with ether and acetone before dating. Collagen recovered: 19.7% of sample weight. $\delta^{13}C = -17.2‰$.	200 ± 50 B.P.

Discussion of results

As mentioned earlier, at least one of the three finds with an infinite date (the Sdr. Omme specimen, no. 35) found deeply embedded in till outside the Main Stationary Line, might date back as far as Saalian. With infinite ages older than 38–40 000 B.P. however, they might all belong to Early Weichselian or at least to Early Middle Weichselian. In addition to this a sample of a mammoth tusk (Brorfelde, Cat. no. 101) has previously been dated at the Trondheim Radiocarbon Laboratory (Selsing 1982) to an age of 44300 +/– 1400/1200 B.P., thus representing the oldest finite date from the Danish mammoth material.

The majority of the dated mammoths ranges between ca 32 000 and 22 000 B.P. corresponding to an ice free Middle Weichselian stage antedating the main ice advance which reached Denmark around 20 000 B.P. After this Main Glaciation the mammoth apparently re-immigrated into Denmark from its more southern or eastern refugia as suggested by the youngest date of ca. 13 000 B.P. on the Rosmos 1 specimen (Cat. no. 23).

The general pattern in the Danish dates corresponds very well to the radiocarbon-dated records of mammoth from the rest of Norden (Berglund *et al.* 1976; Donner *et al.* 1979 and Heintz *et al.* 1979) and from England (Lister in print). Especially the eight dates on four tusks from South Sweden are very similar to the Danish and "indicate that several mammoth finds may derive from an ice free phase about 40 000–20 000 years B.P., which can be correlated with the Middle Weichselian interstadial complex preceding the main glaciation" (Berglund *et al.* 1976: 187). Add to this, that the youngest Swedish date on the Lockarp specimen corresponds to the youngest Danish with a value of ca 13 000 years B.P.. As pointed out by Berglund *et al.* (op. cit.) this is of the greatest importance since it throws light on the deglaciation chronology of southernmost Sweden – and you could add: throws light on the re-immigration of the mammoth after the main ice advance.

For southern England Lister (in print) has been able to show a much similar chronological distribution of dates through an extensive list of 20 mammoth dates from 10 localities. He presents 7 dates in the 35–40 000 years interval, but because these results are so close to the limit of effective radiocarbon dating, he prefers to regard them as undivided Early to Middle Devensian. From the interval between 35–18 000 years only 3 dates are available. The author is more inclined to interpret the small number as a result of insufficient sampling than as a rare occurrence of the mammoth in Britain at the time. The youngest of the three dates on 18 000 has to be treated with caution because of a very low collagen content. The interval between 18–13 000 demonstrates a hiatus in mammoth occurrence very similar to that of southern Scandinavia and it is followed by 9 dates from the 13–12 000 years interval. Six of these very young dates derive from two of the four mammoth skeletons found in 1986 in a small kettlehole at Norton Farm Pit, Condover (Coope & Lister 1987) – a remarkable discovery which proved that the mammoth returned to Britain after the main ice advance.

In northern and central Europe no dates of mammoth are younger than 12 000 B.P.. Stuart (in print) has summarized all available information on the extinction of the species in Eurasia and North America and he concludes, that *Mammuthus primigenius* was extinct in Europe by 12 000 B.P. but survived another 1–2000 years in Siberia and North America with the last known population apparently surviving to ca 10 000 B.P. in north central Siberia.

Other Late Pleistocene remains of terrestrial mammals

Bones, tusks and molars of mammoths are among the most numerous remains of terrestrial mammals in Danish Late Pleistocene deposits – but they are not the only ones. The few finds of straighttusked elephants have already been mentioned but other species can be added (Table 5 & Figs 8, 9 and 10).

Found *in situ* in Eemian deposits are *Cervus elaphus, Dama dama, Bison priscus* and as mentioned *Elephas namadicus*. The following species are found redeposited by the Weichselian ice side by side with the mammoths: *Cervus elaphus, Dama dama, Megaloceros giganteus, Rangifer tarandus, Saiga tatarica, Ovibos moschatus, Bison priscus, Coelodonta antiquitatis, Dicerorhinus kirchbergensis and Elephas namadicus*. This is obviously a faunal mixing caused by the geological processes, but although only the mammoths have been dated it seems reasonable to divide the species as proposed in Table 5. In this division, *Cervus, Dama, Dicerorhinus* and *Elephas* are supposed to relate to the Eemian interglacial and *Rangifer, Saiga, Ovibos, Coelodonta* and *Mammuthus* to the Middle Weichselian glacial time. *Megaloceros* and *Bison* might belong to both periods.

Some of these finds have been treated earlier by e.g., Nordmann (1905 & 1944), Degerbøl (1932, 1933, & 1952), and Degerbøl & Iversen (1945) but with a prevailing tendency to place most of them in the last interglacial. This was done e.g. in the treatment of a find of a saiga antelope near Ringe, Funen (Degerbøl 1932: 176) and this and similar argumentations were a natural consequence of the view held on the Weichselian glaciation of that time which left no space and time for a mammalian megafauna in Denmark.

			Redeposited by the Weichselian Ice and with a supposed	
	No of finds	Eem, *in situ*	Eemian origin	Middle Weichselian origin
Cervus elaphus	7	X	X	
Dama dama	10	X	X	
Megaloceros giganteus	4		X -----------	----------- X
Rangifer tarandus	6			X
Saiga tatarica	1			X
Ovibos moschatus	2			X
Bison priscus	10	X	X -----------	----------- X
Coelodonta antiquitatis	1–2 5			X
Dicerorhinus kirchbergensis	1–3		X	
Elephas namadicus	5	X	X	
Mammuthus primigenius	125			X

Table 5. Late Pleistocene remains of terrestrial mammals – stratigraphical position and supposed age.

	Cervus elaphus	Dama dama	Megaloceros giganteus	Rangifer tarandus	Saiga tatarica	Ovibos moschatus	Bison priscus	Coelodonta antiquitatis	Dicerorhinus kirchbergensis	Elephas namadicus
1 Gedsig				X						
2 Lundbjerg				X						
3 Svenstrup			X							
4 Hørup	X									
5 Romalt						X				
6 Hollerup	X	X								
7 Pindsminde							X			
8 Søby								X		
9 Hylke				X						
10 Egtved		X					X			
11 Ejstrup		X								X
12 Harte										X
13 Seest	X	X	X				X	X	X	X
14 Grønninghoved							X			
15 Gram			X							
16 Højrup								X		
17 Arnitslund							X			
18 Stensigmose										X
19 Lysabild							X			
20 Favrskov							X			
21 Uglebjerg										X
22 Åsum							X			
23 Rågelund	X	X								
24 Ringe					X					
25 Bannebjerg						X				
26 Lundtofte							X			
27 Vetterslev				X						

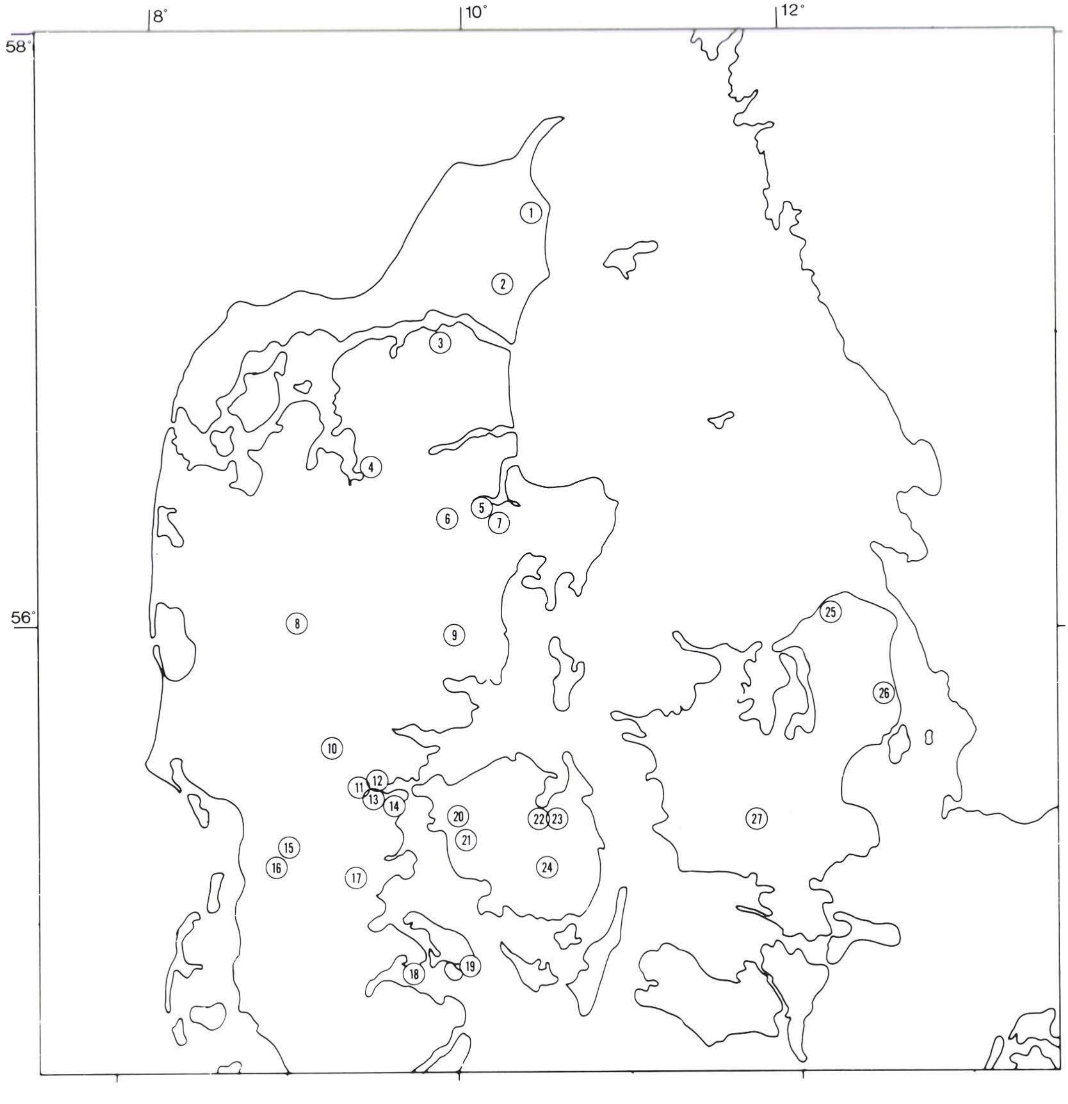

Fig. 8. Late Pleistocene mammal localities in Denmark.

Fig. 9. Cranial fragment of muskox, Ovibos moschatus, *with the two broad horncore bases pointing forward. Found in till near Bannebjerg, northern Zealand (Fig. 8 No. 25). (Photo: G. Brovad).*

Fig. 10. Left part of skull and horncore of saiga antelope, Saiga tatarica, *found near Ringe, Funen (Fig. 8 No. 24). (Photo: G. Brovad)*

Glacial stages during the Weichselian

Datings of vertebrate remains, especially of mammoths as presented in this paper and shown graphically in Fig. 11, indicate that during the Middle Weichselian huge land areas in southern Scandinavia were open to a fauna of big mammals. A similar view is presented by Donner *et al.* (1979) for large parts of Finland in Middle Weichselian time. At the same time the Kattegat area and northern Jutland were covered by the sea which formed an extensive palaeo-Kattegat (Petersen 1985, Fig. 4, Bahnson *et al.* 1974). This has implications both for a reconstruction of environmental conditions, which is attempted in the next chapter, and for the understanding of the glacial development during the Weichselian.

The time span represented by faunal remains treated in this paper covers most of an interglacial/glacial cycle, including the Eemian and the Weichselian. The Weichselian is divided into Early, Middle, and Late Weichselian. The limits between these subunits vary among different authors. According to Mangerud *et al.* (1974) the age boundary between Middle and Late Weichselian is set to 13 000 C-14 years B.P. Other workers use a division between Middle and Late Weichselian at around 25 000 B.P. Such a boundary has no biological bearing within the Northern countries (Andersen 1979 a). The present authors, therefore, adhere to a division at 13 000 B.P., although this chronostratigraphic subdivision applies only to Northern Europe (Andersen & Rasmussen 1980). This division is also followed by Houmark-Nielsen (1987) in his Pleistocene stratigraphy and glacial history of the central part of Denmark.

During the Eemian, the sea covered the present western Baltic area (Madsen *et al.* 1908), whereas the occurrence of a sea in northern Jutland has been very much debated, as the stratigraphic position of the marine sequence demonstrated by the classical Skærumhede well (Jessen *et al.* 1910) has been in doubt. The environmental conditions during the Eemian and the transition to the last glaciation are reflected in the freshwater deposits in Jutland and Northwest Germany (Jessen & Milthers 1928).

In the Early Weichselian no ice cover reached western Denmark although the limit between the Eemian and the Weichselian is distinguished by a large decrease of temperature (Andersen 1961).

Modern marine records from the northern part of Denmark have revealed a continuous sequence from the Eemian into the Middle Weichselian as demonstrated by the new Skærumhede well (Bahnson *et al.* 1974). These deposits indicate that no ice cover was established until Late Middle Weichselian in northern Jutland. However, within this marine sequence a drop till has been recognized with a stone composition pointing to a southern/Baltic origin. Such an Early Middle Weichselian drop till has been referred to a Baltic ice advance – the so called Old Baltic Ice (Petersen & Kronborg 1990). On the basis of new investigations of the marine sequence in Vendsyssel, Lykke Andersen (1987) places this drop till sequence stratigraphically in the stadial before the Moershoofd interstadial *i.e.* in the Early Middle Weichselian. The till deposits from such an ice advance have been located in southern Denmark as pointed out by Petersen (1984a and 1985).

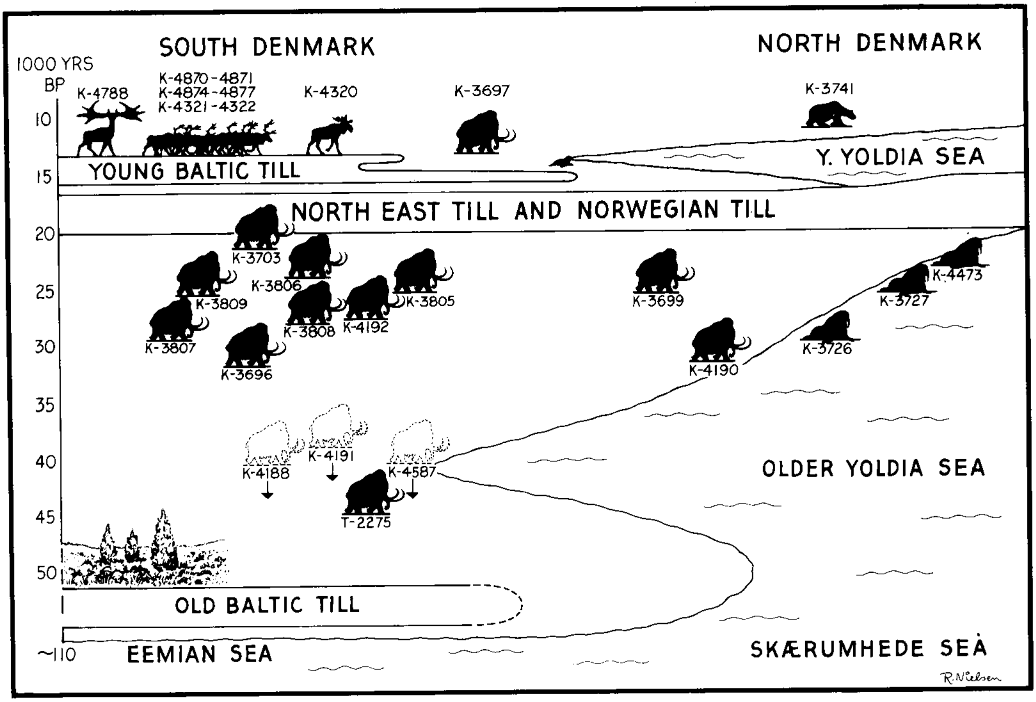

Fig. 11. Land/sea distribution and till formations during the Weichselian seen in a N-S oriented section of central Denmark. The mise en place *of the dated animal remains is shown by the animals "standing" on their actual dates. The infinite dates are given by arrows pointing back in time. The late glacial ringed seal,* Phoca hispida, *placed in the southernmost part of the Younger Yoldia Sea and originally found in the Nivå Clay awaits a more accurate dating through a work by Lagerlund and Houmark-Nielsen in prep. The landscape with* Juniperus *around 50 000 B.P. refers to Kolstrup and Havemann (1984:128).*
It is seen that from northern Denmark there is a continous marine record from the Eemian up to the glacial advance from the north and north east around 20 000 B.P. A new Arctic sea develops (the Younger Yoldia sea) around 15 000 B.P. while a Young Baltic till is deposited in southern Denmark. From around 50 000 B.P. to 20 000 B.P. southern Denmark was part of the mammoth steppe. (Drawing: R. Nielsen, based on Petersen 1984a Fig. 2).

The duration of this Old Baltic ice advance is not known, but it seems to be part of the glaciation in northern Scandinavia during the cold isotope stage 4 (Mangerud 1990). TL datings also point to glacial advance in Poland within the Vistula area during this stage (Drozdowsky & Fedorowicz 1987).

The final advance of the icecap reaching the Main Stationary Line (Ussing 1903 and 1907), was initiated by the glaciers from Norway followed by the northeast ice (from central Sweden) ending up with the Young Baltic ice advance from southeast (through the Baltic Sea depression) forming the East Jutlandic Borderzone (Harder 1908) as demonstrated in Pedersen *et al.* (1988).

The duration of this Late Middle Weichselian ice advance is well known by way of C-14 datings of marine strata and TL datings of the outwash sediments. The outwash sediments for the advancing glaciers in Denmark have been dated to around 20 000 B.P. and the last ice cover in Denmark (from southeast) between 14 000 – 13 000 B.P. (Petersen 1984a).

During the last 1 000 years of ice cover in southern Denmark around 14 000 B.P. an arctic sea in northern Jutland reached its highest limit (Petersen 1984b) and most probably formed a new bay as the palaeo-Kattegat reaching as far south as the Øresund region (Petersen 1985 Fig. 6).

The latest phase of the glaciation in Denmark has been described by Houmark-Nielsen & Lagerlund (1987) from northeastern Zealand. The deposits have been named the Helsingør diamicton, and these deposits from drifted and grounded icebergs are overlaying the clay deposits from the southeastern part of the Younger Yoldia Clay.

Considering the views of Houmark-Nielsen (1987) on the Main Weichselian glaciation there seem to be agreements with the present authors on the formation of the Main Stationary Line in Late Middle Weichselian around 20 000 B.P. But there are contrasting views on the formation period of the Old Baltic ice advance, which in the present paper is considered an ice advance during the Early Middle Weichselian. However, Houmark-Nielsen (1988 & 1989) expresses a similar point of view based on new investigations of a locality on Møn (Klintholm) and admits a Baltic ice advance during the Karmoy-Ristinge-Göteborg I stadial at about 60 000 B.P.

The environmental changes during the Late Pleistocene

The Eemian

From the Eemian there are many records both of lacustrine and marine deposits.

The vegetation is known from pollen analyses of lake deposits and is described in 7 pollen zones (Andersen 1965). The Eemian vegetation is characterized by an early development of the climax forest. According to Andersen (1965) *Quercus* had its culmination before *Corylus* which is the opposite of what happened during the Holocene. The climate was warm and oceanic and according to the study of marine molluscs (Nordmann 1928) warmer than today. This is seen from the occurrence of species as: *Gastrana fragilis*, *Lucina divaricata*, *Mytilus lineatus*, *Syndesmya ovata* with a southern extension, and as pointed out by Nordmann (1928) the absence of pronounced nordic forms with a restricted extension.

The regression of the Eemian sea is found to occur before the pollen zones 6 and 7 representing the final part of the Eemian interglacial which was dominated by spruce and pine, respectively (Andersen 1979 b).

Remains of vertebrates from the marine Eemian deposits are few and random by-products from core sampling: a single bone of the porpoise, *Phocoena phocoena*, and the eider, *Somateria mollissima*, and bones and otoliths of fishes as *Gadus morhua*, *Thunnus thynnus* and *Eutrigla gurnardus*.

As mentioned earlier (p. 27 and table 5) several terrestrial mammals from the Eemian have been found represented by whole skeletons, greater parts of skeletons or as single bones. Actually one more species, the beaver, *Castor fiber*, can be added to the list based on finds in freshwater deposits of several branches and stems with the characteristic broad paired-incisor marks produced by beaver-gnawing. In these former beaverpond deposits we also find bones, scales and otoliths of fishes as *Esox lucius*, *Perca fluviatilis*, *Acerina cernua*, *Rutilus rutilus*, *Abramis brama* and *Alburnus alburnus*.

The Early Weichselian

During the Early Weichselian the vegetation development can be followed up to and including the Brørup interstadial with forest of *Betula* and *Pinus* during the Brørup, and *Betula nana*, *Juniperus* and herbaceous vegetation prevalent during the Rodebæk interstadial. The stadials are characterized by bare widespread solifluction areas (Andersen 1961).

In the marine environment the *Turritella terebra* communities are found. However, in the final part around the Chronozone Odderade? (Lykke-Andersen 1987 fig. 5) the change to the *Abra nitida* zone is found with molluscs as *Leda pernula* and *Bela incisula* which are also found in the *Turritella erosa* macrofossil zone at the Early Middle Weichselian. *Turritella erosa* is the cold counterpart of the *Turritella terebra* known from the Early Weichselian and the Eemian deposits.

The Middle Weichselian

From the Middle Weichselian an arctic sea is established in Denmark prevailing through chronozones Moershoofd, Hengelo and Denekamp (Lykke-Andersen 1987) with the characteristic macrofossil zones of *Turritella erosa*, *Balanus crenatus* and *Macroma calcaria* (Petersen in Bahnson *et al.* 1974 fig. 7).

A continuous record has not been obtained from the lacustrine deposits from Brørup and onwards into the Middle Weichselian. The sedimentation in the "long living" Solsø (western Jutland) was dominated by minerogen sedimentation and redeposited pollen (Andersen 1979b) so no information on the vegetation can be drawn from this unique deposit in Denmark. Furthermore the record from Scania in Sweden also comes to an end with the Brørup interstadial (Berglund & Lagerlund 1981). However, from northern Germany there is a record of 4 Weichselian interstadials, and according to Behre and Lade (1986): "Brørup and Odderade represent two great forested interstadials. Oerel and Glinde were treeless with shrub tundra and were parts of the early pleniglacial of the Weichselian. The Glinde may perhaps be placed at the beginning of the Moershoofd-complex". However according to Behre (1989) Oerel and Glinde are placed in the beginning of Pleni-Weichselian.

From Sejerø, in southern Kattegat, a pollen diagram has been obtained from a deposit of slightly organic, clayey sand and silt (Houmark-Nielsen and Kolstrup 1981 fig. 4). *Pinus, Salix* and *Betula* are found in very low percentages altogether not representing more than 10%. The rest of the pollen represents herbs i.e. Cyperaceae and Gramineae. The secondary pollen and spores are dominated by pre-Quaternary types. Two samples from this deposit have been dated by radiocarbon, giving ages around 36000 B.P., which shows that the deposits might be contemporaneous with Hengelo interstadial. This is where most of the present mammoth datings appear, and the great amount of Gramineae and Cyperaceae in the pollen diagram bear witness of a stable food basis for the mammoth.

Also from the profile at the Older *Yoldia* Clay (the Skærumhede sequence) of the Hirtshals coast cliff in northern Jutland (Lykke Andersen 1971) an organic freshwater layer intercalated between marine deposits has been studied by Odgaard (1982). From a pollen analysis Cyperaceae occurs in 35.4%. The deposit which belongs to the Moershoofd Interstadial complex (previously radiocarbon-dated to 47.300 B.P.) yields a treeless subarctic/low arctic flora dominated by herbs, dwarf shrubs and mosses. This corresponds to what was found at the Sejerø locality (Hengelo interstadial).

The climate was non-oceanic with July temperatures between 8 and 10°C. This is a little lower temperature than found during the Early Weichselian interstadials as demonstrated by Andersen (1961 Table 24).

According to Odgaard (1982) the flora at Hirtshals shows many similarities to the (redeposited) flora found by Hesselbo and Hartz in the synchronous layers of the Skærumhede deposits (Jessen *et al.* 1910).

Consequently the existence of a steppe biome during the Middle Weichselian is to be expected, in the interstadial periods. This makes Denmark a part of a vast Late Pleistocene steppetundra. Stretching from Europe over Asia to Beringia, this steppetundra is chronologically and spatially characterized by the woolly mammoth. Guthrie (e.g., 1982: 308) has therefore proposed the term *mammoth steppe* to replace steppetundra, tundrasteppe, arctic steppe, loess steppe, cold steppe and others, as he finds the mammoth and the other large mammal remains to be the best clue to the puzzle of the paleoenvironment of Late Pleistocene in the northern Holarctic.

The Danish fossil assemblage presented in Table 5 for the Middle Weichselian fits very well into this mammoth steppe fauna as it is described elsewhere (e.g., Kowalski 1967 & 1986, Vereshchagin & Baryshnikov 1982, Guthrie 1968 & 1982). The high diversity of mega-herbivores are reflected even in the relatively small Danish sample although some of the species are still missing, most conspicuously one of the indicators of the mammoth steppe, namely the horse, *Equus* sp.. The same applies to representatives of small and medium sized mammals which are first discovered in Danish Late Weichselian deposits (Aaris-Sørensen & Petersen 1984, Aaris-Sørensen 1988).

The contemporaneous marine mammals are represented by three finds of walrus

(*Odobenus rosmarus* (L.)) dated to between 31 000 and 24 000 B.P. (Møhl 1985). Thus representing the youngest elements dated from the Older *Yoldia* sea fauna, before the Main Weichselian ice advance put an end to the paleo-Kattegat and reached the Main Stationary Line. The youngest date on the mammoth remains antedating the glaciation is 21 500 B.P..

Considering the sparse data one could conclude this review of the environment before the Main Weichselian ice advance by quoting Kolstrup (1983) from her work on Cover Sands in southern Jutland: "The pollen content of the organic layers in the cover sands in The Netherlands (Kolstrup 1980) and Denmark show that parts of the landscape were, at least periodically, covered by vegetation during the deposition of the sands... It is difficult to envisage the extension of vegetation during the coversand accumulation. It was probably much more extensive than the scattered findings in northwestern Europe suggest, but since the accumulation and preservation of organic material is dependant on a non-aerated, nonoxidized environment, organic remains have only become preserved in a few places with favourable conditions."

From the time of the Main Weichselian glaciation – Late Middle Weichselian, the non-glaciated area in Denmark beyond the Main Stationary Line gives no record of the vegetation. At Solsø where there still is a small remnant of the lake mentioned earlier, the uppermost clay (gyttja) corresponds to the beginning of the Postglacial, and the Allerød, the Bølling and any older interstadials are not differentiated (Andersen 1961 p. 76).

TL datings on frostwedge casts (Kolstrup and Mejdahl 1986) reveal palaeoenvironmental conditions where the plant cover may have been discontinuous and the soil surface layers unstable during the upper part of the Weichselian. TL datings of deflation surfaces from northern Jutland as studied by Jørgensen (1988) supplement the above mentioned picture of a harsh periglacial environment.

The marine record gives the first information on animal life after the Main Weichselian ice advance when northern Jutland was covered by the arctic sea. The Younger *Yoldia* sea reached the highest marine shoreline between 14 000 and 13 000 B.P. (Petersen 1984b fig. 1). This interval corresponds to the time of the Young Baltic ice lobe reaching Djursland and the southeastern part of Jutland. This is dated by the youngest mammoth find in Denmark embedded in the Tirstrup sandur (Cataloque Rosmos 23).

The Late Weichselian

From 13 000 B.P., the Late Weichselian, a temperate marine mollusc fauna occurs in shallow water deposits in Vendsyssel (Petersen 1984b). This supports the view of Andersen (1979a) that the Late Weichselian has been established even in the marine sequences.

Marine mammals represented in late glacial sediments in Vendsyssel include: one find of *Ursus maritimus* (Aaris-Sørensen & Petersen 1984) and several of *Phoca hispida* and the arctic/subarctic *Balaena mysticetus* and *Delphinapterus leucas* together with the cosmopolitan *Balaenoptera musculus*, *B. physalus* and *Orcinus orca* (Møhl 1971, Aaris-Sørensen 1988).

The terrestrial mammalian fauna of Late Weichselian Denmark as described in detail by Aaris-Sørensen (1988) shows a mixed "disharmonious" composition with species as *Desmana moschata*, *Lepus timidus*, *Spermophilus major*, *Castor fiber*, *Microtus agrestis*, *Canis lupus*, *Ursus arctos*, *Gulo gulo*, *Megaloceros giganteus*, *Alces alces*, *Rangifer tarandus*, and at the very end of the period *Bison bonasus*, *Bos primigenius* and *Equus ferus*. A similar mixture of elements from several biomes is evident in the late glacial flora (Iversen 1954), and makes the Late Weichselian environment incomparable with anything known today.

Acknowledgements

This study is mainly based on the collection of pleistocene mammals of the Zoological Museum University of Copenhagen (ZMUC) supplemented in 1980 with the corresponding collection of the Geological Survey of Denmark (DGU). We wish to thank the former curators of these collections and especially Ulrik Møhl (ZMUC) for placing important records on the Danish mammoth material at our disposal. We are also indebted to the curators of the Geological Museum University of Copenhagen and of all the local museums and to private persons who willingly lended out their mammoth material for our investigation. Thanks to Jeppe Møhl (ZMUC) for skillfully taking C-14 samples without destroying the exhibition value of the specimens and to Knud Rosenlund for solving tricky problems with documents and filings and for drawing the maps showing mammoth and other pleistocene mammal localities. Finally we direct our sincere thanks to C.R. Harington (National Museum of Natural Science, Ottawa) for having commented on the manuscript and revised the English and to S.Th. Andersen (DGU) for critically reviewing the paleobotanical data.

Dansk sammendrag

Artiklen præsenterer et katalog over alle kendte danske mammut lokaliteter omfattende ialt 125 fund.

Halvdelen af mammutmaterialet udgøres af molarer, og disse kan entydigt morfologisk henføres til *Mammuthus primigenius* (Blumenbach). En trediedel er fund af stødtænder og resten knoglefragmenter.

Fjorten af fundene er blevet C-14 dateret, hvorved de 13 opnåede aldre fra > 40 000 og frem til omkring 21 500 C-14 år B.P.

Et af fundene gav en alder på omkring 13 200 B.P., og dette stykke, en stødtand, fandtes indlejret i ekstramarginalt sand på Tirstrup hedeslette. Stødtanden er uden spor af istransport og får herved stor betydning, idet den daterer den østjyske israndslinje. De andre C-14 daterede stykker bærer til gengæld spor af istransport og/eller findes indlejret i moræneler og kan således afsløre maksimum aldre på de glaciale aflejringer, hvori de er fundet. På denne baggrund er den glaciale udvikling i Danmark under sidste nedisning beskrevet bl.a. med tilstedeværelsen af en isfri periode strækkende sig fra før 45 000 til omkring 20.000 B.P. efterfulgt af et isfremstød i Sen Mellem Weichsel af ganske kort varighed – 5 – 6 000 år (ca. 20 – 14 000 B.P.). Mammutstødtanden fra Tirstrup Hedeslette på Djursland dateret til 13 240 +760/−690 B.P. markerer som nævnt et vigtigt stadium i Weichsel-isens afsmeltning fra Danmark, men viser iøvrigt også, at mammutten genindvandrede til Danmark efter isens hovedudbredelse helt parallelt til forholdene i England og Skåne.

Rester af andre danske Sen Pleistocæne vertebrater, især pattedyr (f.eks. kronhjort, dådyr, kæmpehjort, rensdyr, saigaantilope, moskusokse, steppebison, uldhåret næsehorn, skovnæsehorn og skovelefant), præsenteres ligeledes, og i kombination med de øvrige kendte palæoøkologiske data gives en rekonstruktion af de miljømæssige ændringer igennem hele Sen Pleistocæn. Særlig markant i forhold til tidligere tiders opfattelse bliver den lange isfri periode i Mellem Weichsel. Her er det nu muligt sammen med mammutten at placere en lang række, ikke nærmere daterede, fund af store hovdyr, hvis tidligere placering i Eem har syntes økologisk ejendommelig. I og med man gør Danmark isfrit, bliver det samtidig til en lille del af en stor sammenhængende steppetundra, benævnt *mammutsteppen*, der strakte sig fra Europa over den nordlige del af Asien til det nordvestligste Nordamerika, idet en landbro over Beringsstrædet forenede det østligste Sibirien og Alaska i et fælles Beringia.

Mammutten er områdets og periodens karakterdyr *par excellence*. Foruden den er mammutsteppen først og fremmest præget af flokdannende hovdyr som uldhåret næsehorn, kæmpehjort, rensdyr, saiga antilope, steppebison, moskusokse og vildhest – og i det næste led i fødekæden af rovdyr som ulv, jærv, hyæne, sabelkat, hulebjørn og bjørn. I Beringia kan desuden tilføjes arter som kamel, yakokse, mastodont og vildfår. Det vil med andre ord sige, at man faktisk *har* mange af mammutsteppens karakterdyr blandt de danske istidsfund. Man mangler vildhesten, men må forvente at den og nogle af rovdyrene vil kunne føjes til den danske faunaliste.

Den mangfoldighed af græsædende hovdyr, som fundene dokumenterer, synes umiddelbart uforlignelig med det relativt "fattige" palæobotaniske billede, der foreligger. Dette kunne dog tilskrives det botaniske materiales ringe bevaringspotentiale, som gør det vanskeligt at rekonstruere et sammenhængende billede igennem dette lange tidsrum. En tentativ miljøbeskrivelse, der trods alt forsøger at sammenfatte de zoologiske og de botaniske fund, kunne være som følger:

Klimaet har været koldt, tørt og kontinentalt. Strenge frostgrader om vinteren; sommertemperaturer mellem 10 og 15 grader og så ringe nedbør, at store områder kunne blæses helt fri for sne om vinteren. Vegetationen var mosaikagtig og domineret af græsser og halvgræsser, men med et væld af urter især bynke, som mange steder voksede sig højere end den spredte busk- og kratvegetation af især pil, birk og ene. Denne mosaik af forskellige plantesamfund opstod som resultat af forskelle i mikroklima, jordbund, fugtighed, højde, orientering i forhold til solen osv., og netop i det mosaikagtige skal vi nok finde svaret på mammutsteppens bæreevne. En ensartet græssteppe ville ikke have kunnet huse de mange pattedyr. De mange plantesamfund gav mange økologiske nicher. De fleste af hovdyrene var hovedsagelig græssere. Enkelte levede dog især af blade, skud og kviste, men ingen af arterne var hundrede procent det ene eller det andet – jævnfør maveindhold bevaret i frosne kadavre. Dette sammenholdt med flokkenes mobilitet, hvor de forskellige bestande vandrede i mere eller mindre afstukne ruter året rundt, gav en maksimal udnyttelse af vegetationen og resulterede i en stor diversitet i pattedyrfaunaen.

Резюме

Данный каталог вцех избестных остаток мамонтов в Дании охватыбает 125 находок. Половина мамонтового материала коренные зубы, морфологически отнесенные к Mammuthus primigenius (Blumenbach), третья чацть бивни, остальное фрагменты кости. 14 зкземпляров мамонта были датированы методом с-14. 13 проб имеют геологические возрасты от старше 40 000 до около 21 500 с-14 лет до настоящего времени, одна проба дала возраст около 13 200 с-14 лет до настиоящего времени. Так как скелетный материал переотложенный, эти даты в то же время дают максимальные возпасты ледниковых месторождений, в которых они найдены.

На этой основе рассматривается ледниковое развирие во период Вейхсела. Отмечается свободен от леда период с раньше 45 000 лет до настоящего времени до около 20 000 лет до настоящего времени. Мамонтовый бивень зандра Тирструпа на Дюрсланде отнесея к 13240 +760/-690 до настоящего времени. Этот бивень отмечает важный этап в отступлении леда в Дании и показывает что мамонт снова иммигрирует после максимального распостранения Вейхселского леда.

Остатки других позвоночных животных верхнего Плейстоцена также упомянуты. На основе остаток флоры и фауны потом реконструированы изменения окружающей среды в период верхнего Плейстоцена. Свободный от леда период среднего Вейхсела охарактеризован степным биомом, который соответственно может быть назбан мамонтовой степью. Кажется, что эта окружающая среда Вейхсела несравнима с какой-либо известной сегодня окружающей средой.

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This book contains a catalogue of all known remains of mammoth in Denmark comprising 125 finds. 14 specimens of these mammoth finds have been C-14 dated. It appears that an ice-free period existed in Denmark from before 45.000 B.P. to a. 20.000 years B.P., and that the mammoth re-immigrates a. 14.000 years B.P. The ice-free period in the Middle Weichselian was characterized by a steppe biome, which is termed the mammoth steppe.

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