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A reconstruction of the landscape of the mammoth site near Orvelte, the Netherlands

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Skeleton bones of woolly mammoths and a woolly rhinoceros were found *in situ* nearby Orvelte (the Netherlands) in the upper coarse of a former brook valley in 1991. A bone fragment and deposits were 14C dated to 44,000-47,000 yBP. Paleobotanical research included the analysis of both pollen and plant macroremains. A total of 64 vascular plants and 20 mosses could be identified on the basis of macrofossils. Together with the pollen analysis, an extensive record became available for the reconstruction of the former landscape. Many vascular plant species are indicative of both open water and bordering marshy areas. Also most of the mosses originate from this aquatic to wet environment. Outside this valley, on the moist to dry plateau, an almost treeless vegetation dominated by the dwarf birch (*Betula nana*) was present. That we are still dealing with a heterogeneous landscape on the plateau is, for example, illustrated by the presence of both calcicolous species, such as *Carex caryophyllea*, *Scabiosa columbaria* and *Homalothecium* cf. *lutescens*, and of others which are calcifuge, such as *Rumex acetosella*. Low temperatures are not only evidenced by the low percentage of tree pollen, but also by the presence of glacial species: *Betula nana*, *Ranunculus hyperboreus*, *Carex chordorrhiza* and *Potamogeton vaginatus* and *P. filiformis*. Nevertheless, it is striking that most plant species that once witnessed the mammoths and woolly rhinos in the Netherlands, are still part of the present vegetation.

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INTRODUCTION

Judging by the quantity of skeleton parts of mammoths which is retrieved, the Netherlands can be considered as a country with a very rich mammoth archive. Unfortunately, most of these parts originate from the bottom of the North Sea, from where they are recovered by means of trawlnets. In this way, bones and teeth are isolated from their context and obstruct a more comprehensive research. This situation changed, when in spring 1991 skeleton bones of some woolly mammoths [*Mammuthus primigenius* (BLUMENBACH, 1799)] and a woolly rhinoceros [*Coelodonta antiquitatis* (BLUMENBACH, 1799)] were found *in situ* nearby Orvelte in the northern part of the Netherlands (52°50'52"N - 6°41'33"E). Additionally, three unidentified rib fragments with traces of gnawing were found. The bones were recovered from a depth of four metres, during ground-work in connection with the construction of a gas pipeline. Traces of human beings (*Homo neanderthalensis*), such as bones or tools, were not found.

A total of almost 100 mammoth fragments was retrieved, including a complete mandible with two molars (Fig. 1), and belonging to three or possibly four individuals. One individual died at the age of 3-6 years, its sex could not be determined. The others are adult individuals and have an estimated age of 25-30 years (male) and 45-50 years (female). Mol & Van Kolfschoten (1993) have published a description of the mammal bones. One fragment of a mammoth bone was 14C dated to 46,800 +1500/-1250 yBP (GrN-18780), which coincides with the Moershoofd Interstadial Complex, being the warmest period during the cold Pleniglacial. This date is in accordance with two other dates obtained from gyttja (GrN-18915: 44,200 +3500/-2400 yBP) and peat (GrN-18916: 44,600 +1900/-1500 yBP) that was collected from almost the same level. These dates indicate that all animals must have died at about the same geological time period. The Orvelte site offered a unique opportunity for a thorough study of the mammal bones as well as the accompanying fauna, the flora and the geological setting. The team included experts in archaeology, geology, mammals, insects, mites and plants. In this article, the results of both pollen analysis and the analysis of botanical macroremains will be presented. These results have been published previously in Dutch (Cappers *et al*. 1993; Cappers & Van Zanten 1993). In this article, also the results of the other disciplines will be discussed briefly, including the results of the geological survey carried out by J.H.A. Bosch published in Cappers *et al*. (1993).

Figure 1 Mandible *in situ* of one of the Orvelte woolly mammoths, partly damaged by an excavator. [photo: GIA, Groninger Instituut voor Archeologie]

MATERIAL AND METHOD

A soil sample of some 30 litres was collected for the analysis of botanical macroremains close to the almost complete mammoth mandible. The soil has been washed through a stack of sieves of meshes 2.0 mm, 1.0 mm, 0.5 mm and 0.2 mm. Sieve residues were sorted out under a dissecting microscope. Only plant remains of charophytes and vascular plants were quantified. For the pollen analysis, the sediment was sampled over a length of 260 cm in one of the profiles of the trench. Subsamples of c. 1 ml were prepared according to standard procedures described by Faegri & Iversen (1975). Pollen of aquatic plants, spores and algae were excluded from the pollen sum.

RESULTS

Thanks to the deep position of the samples, the soil was saturated with water and waterlogging consequently very well preserved plant remains. The analysis of the botanical macroremains yielded 84 taxa, of which 70% could be identified to the level of species. They represent charophytes or stoneworts (Characeae), mosses (Bryophyta) and vascular plants (Tracheophyta) (Tables 1 and 2). The pollen diagram represents ten spectra (Fig. 2).

Table 1 Charophytes and vascular plants from Orvelte.

species	amount
Alopecurus aequalis	1
Armeria maritima	4
Betula nana	28
Bidens tripartita	1
Callitriche	9
Caltha palustris	3
Carex caryophyllea	24
Carex chordorrhiza	189
Carex panicea	25
Carex rostrata	3341
Carex cf. *trinervis*	420
Carex subg. *Carex*	38
Carex subg. *Vignea*	41
Characeae	6
Cicuta virosa	327
Cirsium	1
Dianthus	2
Eleocharis palustris	24
Empetrum nigrum	11
Epilobium palustre	1
Eriophorum angustifolium	1
Hippuris vulgaris	20
Juncus bufonius	1
Luzula	2
Menyanthes trifoliata	123
Montia fontana	15
Myriophyllum spicatum	16
Pedicularis palustris	5
Poa	6
Polygonum aviculare	6
Potamogeton	74
Potamogeton cf. *acutifolius*	1
Potamogeton alpinus	235
Potamogeton filiformis	25
Potamogeton gramineus	7
Potamogeton mucronatus	374
Potamogeton natans	60
Potamogeton obtusifolius	19
Potamogeton perfoliatus	9
Potamogeton praelongus	3
Potamogeton vaginatus	8
Potentilla anserina	5
Potentilla palustris	181
Ranunculus acris/repens	12
Ranunculus flammula	14
Ranunculus hyperboreus	87
Ranunculus subg. *Batrachium*	36
Rhinanthus	11
Rorippa palustris	2
Rumex	1
Rumex acetosella	1
Rumex maritimus	22
Sagittaria sagittifolia	3
Salix	37
Scabiosa columbaria	1
Scleranthus	2
Senecio congestus	11
Sparganium	14
Stellaria palustris	14
Thalictrum cf. *minus*	3
Trifolium	1
Valeriana officinalis	6
Viola	1
Zannichellia palustris	49

INTERPRETATION

A geological survey of the site proper and the analysis of nine additional corings in the near surrounding revealed that the bones of the woolly mammoths and the rhino were found in the upper course of a former brook valley. During the melting of the Saalian ice, brook valleys in the northern part of the Netherlands became very wide. The brook valley at the location of the Orvelte site widened out to about 1 km. During the warmer Eemian, the brook valleys were largely filled up. As a result of climatic changes during the Weichselian, the brook valleys were again subjected to scouring, but during this period they were broadened to a lesser extent. The bones from Orvelte are dated to the Moershoofd Interstadial Complex and during this relatively warm period the valley west of the site was enlarged to a large lake, measuring up to several hundreds of metres. The sediments from the corings show that boulder clay was still within reach of plant roots and may have provided them with a substantial amount of lime. Also seepage of calcareous water may have been a source, although it might have been only a local phenomenon because Orvelte is located on the most elevated part of the ice-pushed ridge in the province of Drenthe. The absence of pingos and ice wedges is indicative of a relatively warm period and the absence of permafrost.

Located at the edge of a large lake, the site was favourable for trapping plant macroremains and pollen. This is expressed in the large number of seeds and fruits and high pollen sums according to Pleniglacial standards. Although these taxa will certainly not represent the complete flora of the surroundings, their assemblage can still be considered as a considerably rich archive of the Dutch flora of the Moershoofd Interstadial Complex. The fact that such a rich record could be retrieved, is attributed to the availability of a bulk sample, whereas most palaeobotanical studies dealing with this period depend on small subsamples from corings.

Table 2 Mosses from Orvelte (amount: 1 = single leaf or branch; 2 = several leaves and/or branches).

species	amount
cf. *Amblystegium riparium*	1
cf. *Amblystegium varium*	2
Atrichum undulatum	1
Bryum pseudotriquetrum	2
Calliergon cordifolium	2
Calliergon giganteum	2
Calliergonella cuspidata	2
Campylium cf. *stellatum*	1
Climacium dendroides	2
Drepanocladus aduncus	2
Homalothecium cf. *lutescens*	2
Hylocomium splendens	2
cf. *Hypnum cupressiforme*	1
Philonotis fontana	2
Plagiomnium cf. *ellipticum*	2
Polytrichum commune	2
Rhytidium rugosum	2
Scorpidium revolvens	2
Sphagnum	1
Thuidium delicatulum/philibertii	2

Wind and water can transport seeds and fruits over considerable distances, even when their shape is not primarily adapted to these dispersal agencies (Cappers 1993). This is especially true in running water with considerable rates of flow and in powerful winds, which are not hampered by a vegetation with a high profile. This is illustrated very well by the composition of the soil sample from Orvelte, which not only contains seeds and fruits of local plants, but also a variety of plant remains from the surrounding plateau. It is even this latter group of plant remains that also includes other particles than diaspores: flower parts of clover (*Trifolium*), knawel (*Scleranthus*) and thrift [*Armeria maritima* (MILLER) WILLD.], leaf fragments and buds of willow (*Salix*) and female cone scales of dwarf birch (*Betula nana* L.). It may be assumed, therefore, that the plant macroremains that were retrieved from the Orvelte sample are quite representative for both the local vegetation and the more regional vegetation cover. On the other hand, the ecology of the species does indicate that we are dealing with a patchy vegetation pattern.

Many plants are indicative of surface water and represent open water, riparian vegetation and marshland. From the water plants, only mare's-tail (*Hippuris vulgaris* L.), bogbean (*Menyanthes trifoliata* L.) and arrowhead (*Sagittaria sagittifolia* L.) are clearly visible above the waterlevel. Water-crowfoots (*Ranunculus* subg. *Batrachium*), spiked water milfoil (*Myriophyllum spicatum* L.) and several pondweed species (*Potamogeton* spp.) are submerged waterplants with only their inflorences rising above the water surface. Other species are completely submerged, such as horned pondweed (*Zannichellia palustris* L.) and several algae. Their macroscopic female gametangia (oogonia) and *Spyrogyra*, *Pediastrum boryanum*, *P. duplex*, *P. kawraiskyi*, and *P. granulatum* represent the stoneworts (Characeae) by their microscopic spores. It is striking that the pondweeds are represented by so much species. Even today, this genus, which comprises some 80-90 species, is well represented in the Netherlands with 18 species. The presence of some seeds from long-stalked pondweed (*Potamogeton praelongus* WULFEN) indicates that the lake must have been several metres deep. Although part of the above mentioned waterplants can sustain some flow, none of these plants is indicative of running water. Moreover, arrowhead will not start flowering in running water.

Riparian plants are also well represented. This is especially true for bottle sedge (*Carex rostrata* Stokes), three-nerved (?) sedge (*Carex* cf. *trinervis* DEGL.), cowbane (*Cicuta virosa* L.) and marsh cinquefoil [*Potentilla palustris* (L.) SCOP.]. The most dominant species is bottle sedge. The dispersal unit of sedges consists of a fruit, which is surrounded by a bract. By most sedges, this bract is tightly connected with the fruit. Only a few sedges, including the bottle sedge, have an inflated bract, which highly improves its floating capacity. The huge number of seeds may, therefore, either originate from a local population or from more remote populations. With their floating and creeping stems, both cowbane and marsh cinquefoil are capable of covering the water surface over considerable distances. A continuous, floating vegetation is develo-

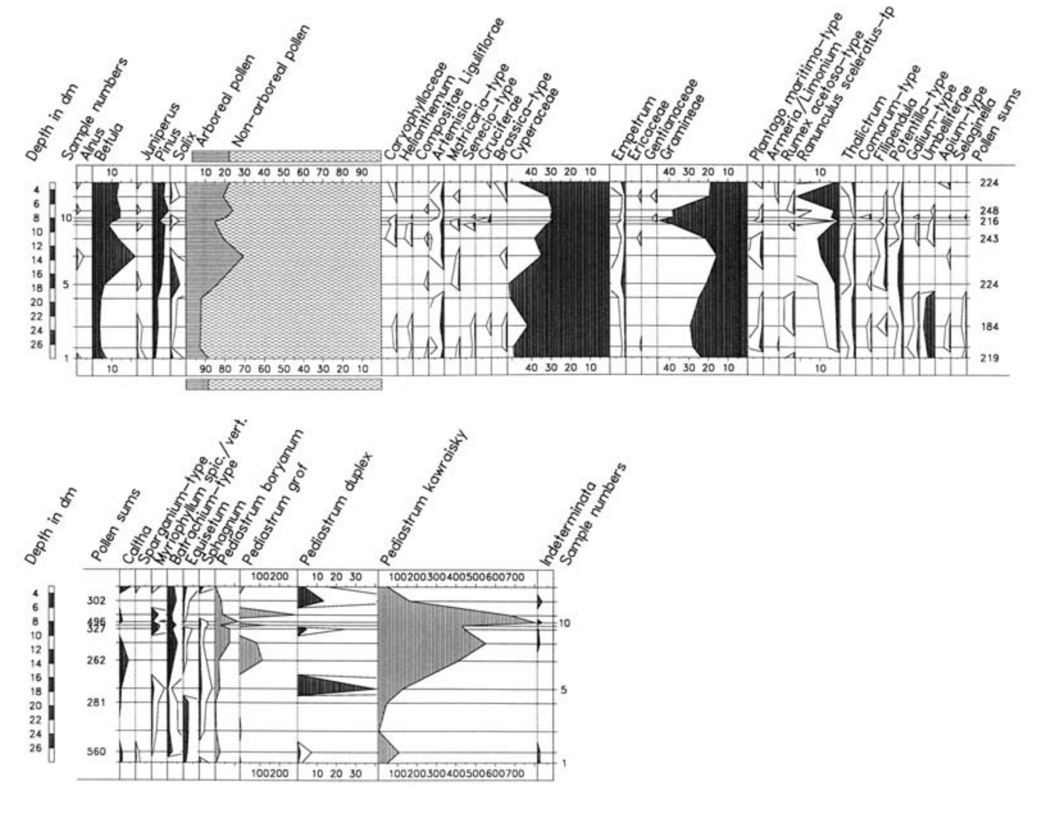

Figure 2 Orvelte pollen diagram; anal. by E. Mook-Kamps.

ped in this way, in which cowbane may initiate the formation of trembling bogs. Other riparian plants that are represented in the Orvelte record, although by lower numbers, are bur-reed (*Sparganium*), common cotton-grass (*Eriophorum angustifolium* HONCK.) and marsh-marigold (*Caltha palustris* L.).

On a higher level around the lake a marshland was present which included plants such as marsh yellow-cress (*Rorippa palustris* (L.) Besser), common valerian (*Valeriana officinalis* L.), marsh lousewort (*Pedicularis palustris* L.), lesser spearwort (*Ranunculus flammula* L.) and marsh willowherb (*Epilobium palustre* L.). Judging by the coarse sediment, this vegetation was probably only temporarily dominated by marsh fleawort [*Senecio congestus* (R.BR.) DC.] as it took advantage of the destruction of the established vegetation.

Marsh fleawort is a species from an early successional stage and grows on wet soils with a high concentration of ammonium-nitrogen and an organic surface. Today, the most extensive populations of marsh fleawort are found in the Netherlands, thanks to the large embankment projects that have been carried out during the last decades of the 20th century and which provided this plant species with huge areas of suitable habitats. Open parts in the vegetation along the water, which might have been created by drinking animals, will have been occupied by plant species with a more prostrate growth-form and that are partly also adapted to a high light intensity. Such species are: toad rush (*Juncus bufonius* L.), golden dock (*Rumex maritimus* L.), silverweed (*Potentilla anserina* L.), blinks (*Montia fontana* L.) and water-starwort (Callitriche).

The last two species can also grow into the water.

Like most of the vascular plants that have been found, also the majority of the mosses are adapted to moist or wet conditions. For mosses, this is less surprising as their reproduction heavily relies on the presence of water. These subfossil mosses are indicative of both open water, in particular *Calliergon giganteum* (SCHIMP.) KINDB., and soils with a low to moderate nutrient availability and eventually seepage, such as *Scorpidium revolvens* (SWARTZ) RUB., *Philonotis fontana* (HEDW.) Brid and *Bryum pseudotriquetrum* (HEDW) GAERTN. Leaves of peat moss (*Sphagnum*) are easily dispersed and are found in most waterlogged samples. Therefore, the single leaf in the Orvelte sample will certainly not have originated from plants that were locally present, in which case more substantial parts of this moss would have been found.

On the more elevated parts of the brook valley and on the plateau proper, a vegetation was present that was adapted to more dry conditions. In comparison with pollen diagrams from other periods, the proportion of tree pollen is low. This is especially true for the lower part of the pollen diagram, which is closely linked, with the burial of the mammal bones. Here, arboreal percentages fluctuate between 8-10% and increase up to 18% in spectrum 2 (= 180 cm). The dominating tree species are pine (*Pinus*) and birch (*Betula*). Willow (*Salix*), juniper (*Juniperus*) and alder (*Alnus*) have only low values and are sporadically present in the diagram. Pollen of pine is easily dispersed over large distances because of the presence of two large wings. Therefore, it is difficult to decide whether this small number of pollen originated from a small local population or had been transported from larger populations at a more distant part. The treeless character of the plateau is further confirmed by the identification of the dwarf birch (*B. nana*) on the basis of seeds and female cone-scales. This tree, with procumbent to ascending stems, has a maximum height of 1 m. Willow and alder will have grown in the brook valley. The scarcity of trees seems to be a common phenomenon in Weichselian vegetation types. A satisfactory explanation for the near absence of trees for this period, which lasted for more than 40,000 years, is still not available. For example, the presence of organic deposits, the presence of organisms that indicate mild winter temperatures and the absence of permafrost are all indicative of conditions that are basically favourable for tree growth. Kolstrup (1990) suggests that a combination of unstable conditions might have prevented the establishment of trees. Great changes in temperature and moisture regimes would have resulted in rapid changes of the vegetation, which in turn resulted in erosion and deposition. This hampered the development of a topsoil which is necessary for the establishments of trees. According to Marchand (1987), it is not the dry winter winds that result in desiccation of plants that are exposed above the snowpack, but bright sunshine and calm conditions. Although the humid shell of air from around the leaf is removed, thereby increasing the rate of transpiration, it also cools the leaf. The latter effect results in maintaining the temperature equilibrium between the leaf and the surrounding air and, consequently, transpiration decreases. On the other hand, exposure to high winds that transport ice particles may result in mechanical injury of the trees. Damage of fresh tissue will accelerate water loss as wound-healing processes are delayed during winter.

Comparision

A comparison of the Orvelte pollen diagram with other Dutch diagrams from the Moershoofd Interstadial Complex (Van der Hammen 1951; Zagwijn 1961, 1974; Teunissen & Teunissen-van Oorschot 1974; Kolstrup & Wijmstra 1977; Van der Meer *et al.* 1984; Brinkkemper *et al.* 1987; Van der Hammen 1989; Ran 1990), reveals that some plant species are well represented by pollen, but are absent in the records of the botanical

Figure 3 *Rhytidium rugosum* growing together with mouse-ear-hawkweed (*Hieracium pilosella* L.) in the coastal dunes of the Netherlands. [photo: R.T.J. Cappers]

macroremains. It may be assumed that such plant taxa (viz. *Artemisia*, *Selaginella*, *Helianthemum*, Plantaginaceae, Chenopodiaceae, Rubiaceae, *Filipendula*, *Equisetum* and Gentianaceae) represent primarily the regional vegetation. The discrepancy between the high pollen values of grasses and the few seeds that have been found, may also indicate that grasses were abundant in the regional vegetation. The high pollen values of the sedge family (Cyperaceae), on the other hand, could be largely attributed to the local growing species that have been attested by macroremains. The absence of seeds of members of the goosefoot family (Chenopodiaceae) is striking as these seeds mostly dominate waterlogged sediments from the Holocene. In addition to the above mentioned taxa that seems to represent the regional vegetation on a large scale, the following taxa from Orvelte could also be attributed to this vegetation: spring sedge (*Carex caryophyllea* LATOURR.), crowberry (*Empetrum nigrum*), yellow-rattle (*Rhinanthus*), thrift (*Armeria maritima*), wood-rush (*Luzula*), knawel (*Scleranthus*), small scabious (*Scabiosa columbaria* L.), sheep's sorrel (*Rumex acetosella* L.) and pink (*Dianthus*). Mosses that were present in these vegetations, are: *Homalothecium* cf. *lutescens* (HEDW.) Robins., *Rhytidium rugosum* (HEDW.) KINDB., *Hylocomium splendens* (HEDW.) SCHIMP., *Hypnum cupressiforme* HEDW. and *Thuidium delicatulum* (HEDW.) MITT./PHILIBERTII LIMPR. These taxa not only represent a possible local element of the Orvelte flora in comparison with other parts of the Netherlands, they also indicate a patchy environment around the site proper as can be deduced from their ecology. For example, species such as spring sedge, small scabious and the moss *Homalothecium lutescens* are indicative of calcareous soils, whereas sheep's sorrel is strongly calcifuge.

Some plants, such as knotgrass (*Polygonum aviculare* L.) and knawel (*Scleranthus*), are today indicators of anthropogenic influence. Assuming that even during this time span the ecological range did not change, it is imaginable that suitable habitats were created under influence of trampling and by the accumulation of dung.

Low temperatures are not only illustrated by the low percentage of tree pollen, but also by the presence of glacial species. In addition to the dwarf birch (*Betula nana*), the following arctic-alpine species have been recorded: *Ranunculus hyperboreus* ROTTB., string sedge (*Carex chordorrhiza* L.F.), *Potamogeton vaginatus* TURCZ. and slender-leaved pondweed (*P. filiformis* PERS.). Nevertheless, it is striking that most plant species that once witnessed the mammoths and woolly rhinos in the Netherlands, are still part of the present vegetation. Some of these species are, however, rare such as the moss *Rhytidium rugosum* (Fig. 3). Both the present distribution and the distribution of the few records that are dated back to the mid-19th century, are confined to a relatively small area in the Dutch dunes. The find of this moss in Orvelte is not only the first Pleistocene record, but also the first find outside its known distribution area in the Netherlands. Weeda (1996) draws a parallel between the present vegetation of the coastal dunes, the geological formation of which took place during the Holocene, and the treeless vegetation on unpodzoled soil of the Pleistocene. *R. rugosum* can be considered as a relict species of this former treeless vegetation, just as other species of which the present distribution is almost or completely confined to the coastal dunes: sea-buckthorn (*Hippophae rhamnoides* L.), teesdale violet (*Viola rupestris* F.W. SCHMIDT) and the moss *Tortella flavovirens* (BRUCH) BROTH. (Weeda 1996). A similar disjunct distribution is known from another relict species, the dwarf birch. Today, this species is still known from some isolated localities in Middle Europe, where it is a bad competitor and therefore heavily endangered (Dierssen 1977). Another example is possibly pink (*Dianthus*). Two seeds resemble *D. superbus*, a species with pink flowers that are almost 5 cm across. This species has only been recorded from one hour-square near Meppel, some 40 km southwest of Orvelte. Due to culture-technical levelling, it disappeared in the beginning of this century (Mennema *et al.* 1980).

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