VII. Vegetation development in and around the Gietsenveentje since the Preboreal

VII.1 Regional vegetation development

When all data presented in the preceding chapters are combined, a general description can be made of the vegetation development in and around the Gietsenveentje since the Preboreal. This section discusses the development of the regional vegetation; in VII.2, the development of the local vegetation will be treated.

The regional vegetation development in the neighbourhood of the Gietsenveentje will be described on the basis of the pollen zones distinguished in VI.3 (table 7). These pollen zones are connected with the Blytt/Sernander periods (see I.4.1). When the dates of the zones are in *italics*, they are estimated by comparison with other studies (see appendix II; LANTING & VAN DER PLICHT 1995/1996; 1997/1998; 1999/2000) or by extrapolation; when the dates are in regular type, they are ^{14}C dates from this study (see VI.4). This description of the regional vegetation development can be compared with the general description of the vegetation development of the Drenthe Plateau in III.6.2.

Emphasis is put on the vegetation development during the Neolithic Occupation Period. Following Spek (1993), maps are presented showing the vegetation around the Gietsenveentje in the Atlantic and in the three phases of the Neolithic Occupation Period (figs. 67-70). The potential natural vegetation is reconstructed on the basis of the soil map (fig. 20; see III.3.3). On each map, the archaeological finds of the contemporary cultures are indicated (see fig. 24). The Gietsenveentje pollen diagrams reveal the changes in the vegetation caused by the people of these cultures. The maps are intended to offer a global idea of the scale of human interference in the Neolithic Occupation Period.

Zone 1 - *Betula* zone, 9800-8700 cal BC: Preboreal

The oldest sediments in the Gietsenveentje date from the Preboreal. In this period, open *Betula* forests, in which *Pinus* also played an important role, dominated the landscape. These forests predominantly occurred in damp places (BOTTEMA 1988), like the valleys of the Hunze and the Scheebroekerloop, and near circular depressions with water, like the Gietsenveentje. *Corylus* and *Ulmus*, two taxa which immigrated into the Netherlands during the Preboreal, were already present in the vicinity of the Gietsenveentje. In the relatively rich undergrowth of these forests, Gramineae and Cyperaceae species dominated, while *Artemisia* species also occurred frequently.

Zone 2 - *Pinus-Betula* zone, 8700-6950 cal BC: Boreal

Because of more favourable climatic conditions, in the Boreal, trees spread also to the drier parts (BOTTEMA 1988), like the coversand areas southwest of the Gietsenveentje (see fig. 19). *Pinus* became dominant in the still rather open forests. The open spots were for a large part colonized by *Corylus*, which partly replaced *Betula*. *Betula* was pushed back to the moist, peaty soils. *Quercus* now first appeared in the neighbourhood of the Gietsenveentje. Compared to the Preboreal, the share of herbs in the vegetation became smaller. In moist places, like those near depressions, Cyperaceae and to a lesser extent Gramineae species dominated.

Zone 3a - *Corylus-Ulmus* zone, 6950-5850 cal BC: Atlantic I

Because of optimal climatic conditions, stable climax forests were formed. In this period, *Alnus*, *Fraxinus* and *Tilia* occurred for the first time in the neighbourhood of the Gietsenveentje.

Different soil types would carry different types of forest (see III.3.3). In fig. 67, the potential natural vegetation of the Gietsenveentje area is shown for the Atlantic (zone 3a/3b). Findspots of Mesolithic artefacts are indicated. It can be seen that most Mesolithic sites are located near open water, either circular depressions or brooks.

In the pollen diagrams, *Alnus*, *Corylus* and *Quercus* are the dominant AP types in this period. *Alnus* most probably occurred (together with *Betula*) in carr forests in the direct neighbourhood of the Gietsenveentje. On the till plateau, which forms the highest part of the Hondsrug ridge near the Gietsenveentje, fairly dense forests rich in species occurred, possibly forest types related to the present oak-hornbeam forest (*Stellario-Carpinetum*, but without *Carpinus*) and the oak-

beech forest (*Fago-Quercetum*, but without *Fagus*) (STORTELDER et al. 1999). In these forests, *Quercus*, *Ulmus*, *Tilia* and *Fraxinus* were the most common trees, but *Corylus* and *Pinus* also occurred quite frequently. The coversand areas, which are located to the west and the southwest of the Gietsenveentje, carried more open forests, less rich in species, possibly forest types related to the present birch-common oak forest (*Betulo-Quercetum roboris*). In these forests, *Quercus* and *Betula* were the most common trees (STORTELDER et al. 1999).

In the Atlantic forests, only a very scanty undergrowth was present, including Gramineae species. In all pollen diagrams, spores of *Pteridium aquilinum* reach relatively high values in this zone. *Pteridium aquilinum* especially grows in the undergrowth and in light spots in forests of the *Betulo-Quercetum roboris* and the *Fago-Quercetum* (WEEDA et al. 1985). According to Iversen (1949), *Pteridium* maxima are indicative of burning. Evidence for the presence of fires in this zone is also given by high peaks of charcoal particles in several pollen diagrams. Presumably, natural fires are the cause of these peaks; however, the possibility cannot be excluded that Mesolithic people burnt vegetation in the neighbourhood of the pingo scar in order to create open spaces.

Zone 3b - *Alnus-Ulmus-Fraxinus* zone, 5850-4050 cal BC: Atlantic II

The pollen picture of this zone very much resembles that of zone 3a. The share of *Pinus* and *Betula* in the forests slowly fell, while the share of *Quercus* and *Ulmus* increased. At the end of this zone, a few grains of *Fagus* are found in several diagrams. Possibly, *Fagus* was already present somewhere in the neighbourhood; because of the relatively poor distribution of *Fagus* pollen grains - they are only seldom found in surface samples -, the possibility of long-distance transport of *Fagus* pollen seems small (oral comm. A.J. Kalis).

Zone 4a - *Quercus-Fraxinus* zone, 4050-1770 cal BC: Subboreal I

The Subboreal is the first period in which human influence on the landscape becomes visible in the pollen picture. There is also a possibility that a world-wide climatic change, which occurred around 3800 cal BC, caused changes in the pollen assemblage (see II.4). However, the changes observed in the pollen diagrams are only small. It seems as if the influence of the first farmers as well as the influence of a climatic change on the vegetati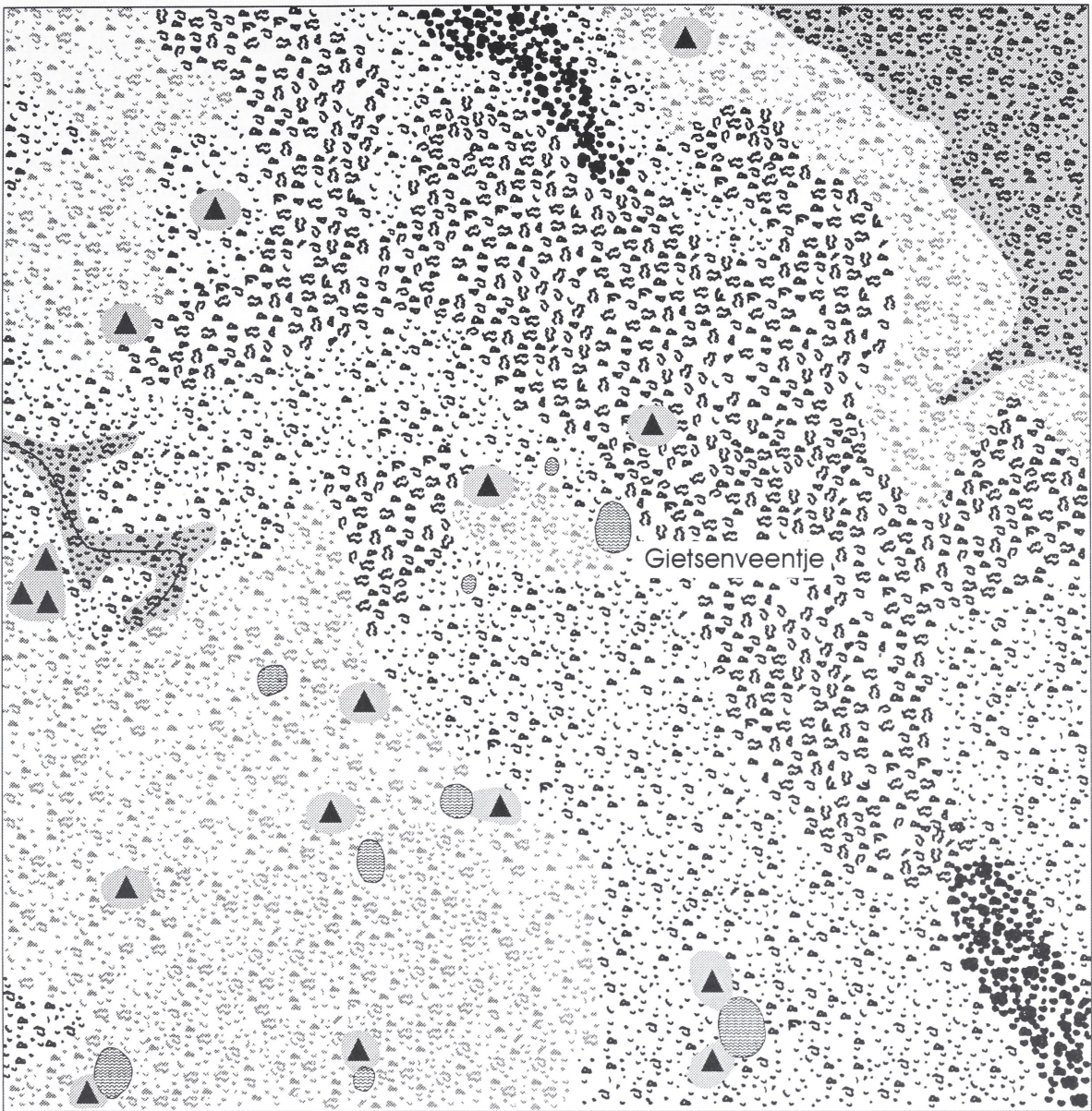on was limited: the major part of the forests remained unaltered. *Quercus* and *Alnus* are the dominant AP types in this zone. *Quercus* occurred in the forests on the till plateau as well as the coversand areas; *Tilia* and *Fraxinus*, which grew in the forests on the till plateau, reach relatively high values, while *Ulmus*, which occurred in the same type of forest, slowly decreases. *Alnus* grew in carr forests at the edge of the Gietsenveentje. A strong decrease of *Betula* pollen demonstrates that *Betula* lost ground in these carr forests. *Fagus* pollen is frequently present in this zone, indicating that this tree became more important in the forests on the till plateau. Furthermore, the first pollen grains of *Carpinus* are found in this zone. These possibly indicate the immigration of this tree into Drenthe, but they may also originate from long-distance transport.

The influence of the first farmers on the vegetation is predominantly reflected in the Non-Arboreal Pollen: Gramineae, Cyperaceae, *Calluna* and *Rumex acetosa* increase, while *Plantago lanceolata* and Cerealia-type appear. As mentioned before, in Drenthe the Atlantic-Subboreal transition coincides with the beginning of the Neolithic Occupation Period (NOP). Pollen zone 4a coincides with the complete NOP. The NOP is subdivided into three phases:

Phase NOP-1: 4050-3450 cal BC, Swifterbant Culture (Middle and Late Phase)

In this phase, *Ulmus* very slowly decreases. However, the other components of the forests on the till plateau, *Quercus*, *Tilia* and *Fraxinus*, do not decrease; *Tilia* and *Quercus* even reach maximum values in this phase. Because the *Ulmus* decline is so slow, it is unlikely to have been caused by a pathogenic attack (see II.3). Just as Kalis & Meurers-Balke (1998) assumed for the western Baltic area, an anthropo-zoogenic cause seems more plausible. Large leaf-eating mammals prefer the nutritious leaves of *Ulmus*, *Fraxinus* and *Tilia*; most probably, the branches of these trees were cut and fed to the cattle. Apparently, *Ulmus* is the only tree which suffers from this treatment, because the pioneer tree *Fraxinus* takes advantage of the opening up of the forest (KALIS & MEURERS-BALKE 1998) and *Tilia* regenerates much faster than *Ulmus*, flowering again just four years after the cutting of the branches (VAN ZEIST 1959; see II.2.3).

Apart from *Ulmus*, the only other tree which decreases considerably in this phase is *Betula*. This decrease is a real decrease, because it is also visible in the influx diagrams (see VI.5). It is assumed that *Betula* grew close to the edge of the

Zone 3a / 3b   Mesolithic

Stream valley vegetation	Open vegetation around habitations
Forest vegetation of heavy till plateau	Circular depression with water
Forest vegetation of till plateau	Findspot of Mesolithic artefacts
Forest vegetation of moist till plateau	
Forest vegetation of coversand landscape	
Forest vegetation of moist coversand landscape	

Fig. 67. Reconstruction of the landscape in the surroundings of the Gietsenveentje in pollen zones 3a/3b (Atlantic). This map and the following three maps represent the same area as fig. 15. The potential natural vegetation of the area is constructed on the basis of the soil map of fig. 20 (SPEK 1993; see III.3.3). The findspots of Mesolithic artefacts are indicated.

Gietsenveentje in carr forest, because also large numbers of seeds and wood of this tree have been found inside the Gietsenveentje. For this reason, *Betula* has been excluded from the pollen sum. However, a considerable decrease of *Betula* at the beginning of the NOP is also found in other pollen diagrams from pingo scars in Drenthe (for example Hijkermeer and Eexterveld, see II.2.2), indicating that this may be a regional phenomenon which deserves further explanation. First it has to be remarked that the *Betula* decrease is not accompanied by an increase of another tree pollen type, not in the influx diagrams either; the values of all other trees (except *Ulmus*) remain constant. However, the value of the NAP increases, also in the influx diagrams. From this, it may be concluded that *Betula* stands were replaced by open spaces which were colonized by various kinds of herbs. *Alnus* carr forest (*Alnetea glutinosae*) nowadays grows in marshy habitats, for example at the edges of fens and raised bogs, where the vegetation has contact with mineral-rich surface or groundwater; *Betula* carr forest (*Vaccinio-Betuletea pubescentis*) nowadays grows in peaty habitats where the vegetation has no contact with surface water or groundwater (STORTELDER et al. 1999). Changes in the water balance may cause a renewed contact with surface water or groundwater. When mineral-rich water reaches carr forest in this way, eutrophication will occur and *Alnus* will become more important in these forests, eventually allowing the development of *Alnus* carr forest. In the Atlantic, carr forests with *Alnus* as well as *Betula* seem to have occurred at the edge of the Gietsenveentje. There must have been contact with surface water and groundwater in that period. At the beginning of the NOP, *Betula* slowly decreases. As we saw above (see III.4.2), forest clearances on a till plateau can lead to a considerable rise of the water table. Possibly, mineral-rich water could thus have reached the carr forests, which benefited *Alnus* at the expense of *Betula*. The source of this mineral-rich water was possibly the dung of livestock that was kept by the first farmers. This dung may have been used to manure the arable fields. A small increase in the phosphorus content of the sediment in this phase also points to the inwashing of mineral-rich water into the Gietsenveentje. Because the increase is only very small, the source of this mineral-rich water seems to be located beyond the immediate vicinity of the Gietsenveentje (see VI.7.3).

On the other hand, an influx peak in all pollen types, AP as well as NAP, around 3700 cal BC seems to point to the inwashing of soil and pollen, possibly caused by small-scale forest clearance (see VI.5.3). Because generally the effects of inwashing of soil and pollen are noticeable only locally, this clearance must have taken place in the neighbourhood of the Gietsenveentje.

Of the NAP types, the culture-indicator types in particular can provide useful evidence about the influence of the first farmers on the vegetation. At the beginning of the NOP, Gramineae, Cyperaceae and *Rumex acetosa* show a slight increase, while *Plantago lanceolata* first appears. These taxa point to the presence of moist grass-rich vegetation with a moderate to high nutrient availability (BEHRE 1981; see fig. 2). Pollen of Cerealia-type (*Hordeum* group as well as *Triticum* sp.) appears and occurs in low values, pointing to the presence of arable fields. A small increase of *Calluna* and maximum values of *Genista*-type and *Jasione montana* are indicative of dry grass-rich vegetation with a low nutrient availability (BEHRE 1981; RUNHAAR et al. 1987).

The NAP types point to the presence of arable fields and various types of grass-rich vegetation that were most probably maintained by livestock. However, the extent of this arable and grass-rich vegetation must have been very small, because almost no decrease of AP can be seen in this phase.

According to very accurate ^{14}C dates (see VI.4), the pollen picture probably reflects the agricultural activities of people belonging to the Middle and Late Phase of the Swifterbant Culture. The presence of Swifterbant people on the Drenthe Plateau is also demonstrated by more and more archaeological finds (see fig. 23).

Fig. 68 shows the landscape in the neighbourhood of the Gietsenveentje as it might have been in phase NOP-1. The larger part of the Atlantic forest was undisturbed. Only a few small-scale clearances in the forests on the till plateau and on the poorer, sandy soils revealed the presence of Swifterbant people. Up till now, the only archaeological find contemporary with the Swifterbant Culture near the Gietsenveentje is a Rössen-type adze, found "on the heath near Eext" (see fig. 24, no. 1). However, this find dates from the period of the Rössen Culture (4700-4300 cal BC), which is a few hundred years before the beginning of NOP-1. Habitations of Swifterbant people have so far not been found on the Drenthe Plateau.

Zone 4a   Swifterbant   NOP - 1

Stream valley vegetation

Forest vegetation of heavy till plateau

Forest vegetation of till plateau

Forest vegetation of moist till plateau

Forest vegetation of coversand landscape

Forest vegetation of moist coversand landscape

Open vegetation around habitations

Circular depression with water

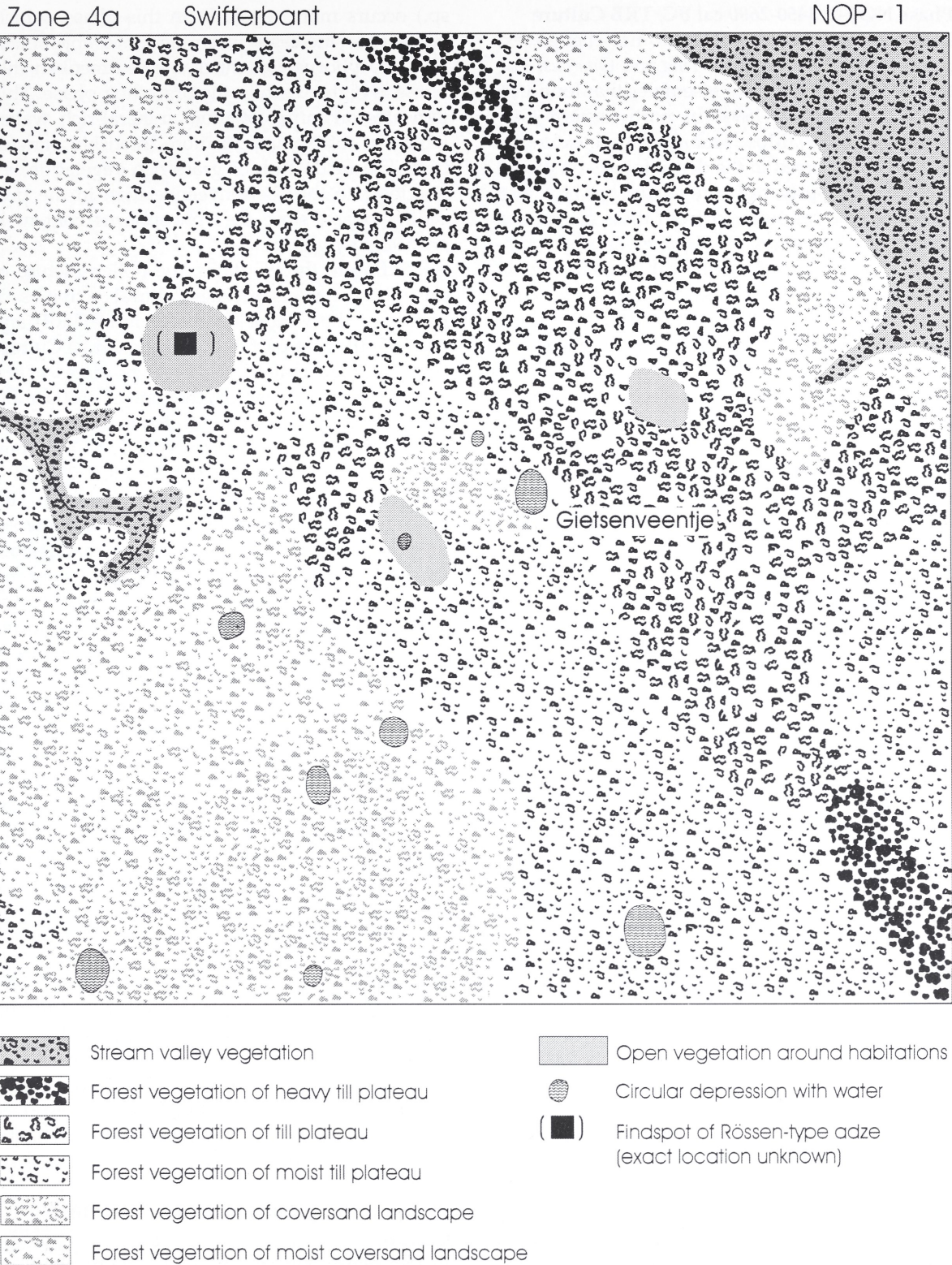Findspot of Rössen-type adze (exact location unknown)

Fig. 68. Reconstruction of the landscape in the surroundings of the Gietsenveentje in phase NOP-1, which is a part of pollen zone 4a (Subboreal I). Phase NOP-1 is connected with the Swifterbant Culture. The only findspot (approximate) of a possible Swifterbant artefact is indicated.

Phase NOP-2: 3450-*2600* cal BC, TRB Culture

In this phase, the AP values do not change, except for small decreases of *Tilia* and *Quercus*. The decline of these two taxa resembles that found by Behre and Kučan (1994) in northwestern Germany (see II.2.6). Most probably, more extensive clearances occurred in the dense forests on the till plateau. Obviously, not only *Ulmus*, but now also *Tilia* and *Quercus* suffered from these clearances. However, the values of *Fraxinus*, another component of the forests on the till plateau, remain constant. Possibly, the branches of *Ulmus*, *Tilia* and *Fraxinus* were still fed to the livestock; owing to more intensive branch-cutting than in the preceding phase, *Tilia* too could not properly regenerate. The more open forests were to the advantage of *Fraxinus*, a tree which prefers light forests (WEEDA et al. 1988). Pollen of *Fagus* occurs more regularly in this phase, but still only sporadically, and therefore it seems unlikely that this tree was replacing *Tilia*. This conclusion was also reached by Van Zeist (1959, 177).

Of the NAP types, Gramineae, Cyperaceae, *Calluna*, *Pteridium*, *Plantago lanceolata*, *Rumex acetosa* and Cerealia-type (*Hordeum* group as well as *Triticum* sp.) reach relatively high values. Also a small increase in the number of charcoal particles is observed. Maxima of charcoal particles and *Pteridium* spores might point to burning (IVERSEN 1949). However, the values of *Pteridium* in this phase reach only 3-4%. Only very small-scale burning could have taken place. Burning would also benefit *Quercus*, because this tree has a thicker bark than most other trees (WEEDA et al. 1985). However, the low values of *Betula* in this phase argue against the use of burning: Iversen (1941) states that the pioneer tree *Betula* is one of the first trees to regenerate after fire in the ashy soil. The increase of Gramineae, Cyperaceae, *Rumex acetosa* and *Plantago lanceolata* points to larger areas of grass-rich vegetation with a moderate to high availability of nutrients. In the pollen diagrams of Gieten I, V-A and V-D, *Rumex acetosa/acetosella* reaches values of more than 1% in this phase; not all pollen grains of *Rumex acetosa/acetosella* were attributable to either *Rumex acetosa* or *Rumex acetosella*, but those which could be identified nearly all belonged to *Rumex acetosa*. According to a study of modern vegetation types with *Rumex* (see V.4), this indicates that considerable amounts of *Rumex* plants must have grown not far from the southern edge of the pingo scar (see fig. 71).

Cerealia-type (*Hordeum* group as well as *Triticum* sp.) occurs more regularly in this phase, which points to an increased importance of arable fields. The phosphorus content of the sediment in this phase is higher than in the preceding phase. This indicates an influx of more mineral-rich water, which in turn points to more intensive agriculture. The fields and/or grass-rich vegetation lay no closer to the Gietsenveentje than in the preceding phase, since the phosphorus content is only slightly higher.

According to the ^{14}C dates, the pollen picture of this phase reflects the agricultural activities of people of the Funnel Beaker Culture (TRB) and possibly the first part of the Single Grave Culture (EGK). Unfortunately, there are no dates of the NOP-2/NOP-3 transition; the date of 2600 cal BC is an extrapolated value, and therefore far less reliable than the date of the NOP-1/NOP-2 transition. It seems probable that the NOP-2/NOP-3 transition coincides with the transition from TRB to EGK, but as long as there are no accurate ^{14}C dates, no definitive statement can be made about this. Still it seems safe to conclude that the largest part of phase NOP-2 has to be ascribed to the TRB Culture. The presence of TRB people in the neighbourhood of the Gietsenveentje is documented by many archaeological finds (see fig. 24). In fig. 69, the landscape around the Gietsenveentje is shown as it might have been in phase NOP-2. All TRB "settlement sites" (findspots of flint and pottery) and megalithic tombs (*hunebedden*) are shown. The megalithic tombs and also most "settlements" are located on the western edge of the till plateau (western part of the map area), near the valley of the Scheebroekerloop. To create the necessary open spaces, TRB people predominantly cleared forest vegetation on the till plateau, of a type related to the present-day oak-beech forest (*Fago-Quercetum*). A few "settlements" are located on the highest part of the till plateau (eastern and northern part of the map area). Here, it was mostly forest on heavy till, of a type related to the present-day oak-hornbeam forest (*Stellario-Carpinetum*), that was cleared (see III.3.3). However, the major part of the Atlantic forest remained undisturbed.

Phase NOP-3: *2600*-1770 cal BC, EGK/BB Culture

In this phase, the percentage diagrams show no changes in the AP values except for a small increase of *Corylus*, while the total NAP value decreases slightly. In the influx diagrams, however, the influx of all AP types declines (see fig. 64b),

Stream valley vegetation

Forest vegetation of heavy till plateau

Forest vegetation of till plateau

Forest vegetation of moist till plateau

Forest vegetation of coversand landscape

Forest vegetation of moist coversand landscape

Open vegetation around habitations

Circular depression with water

TRB settlement
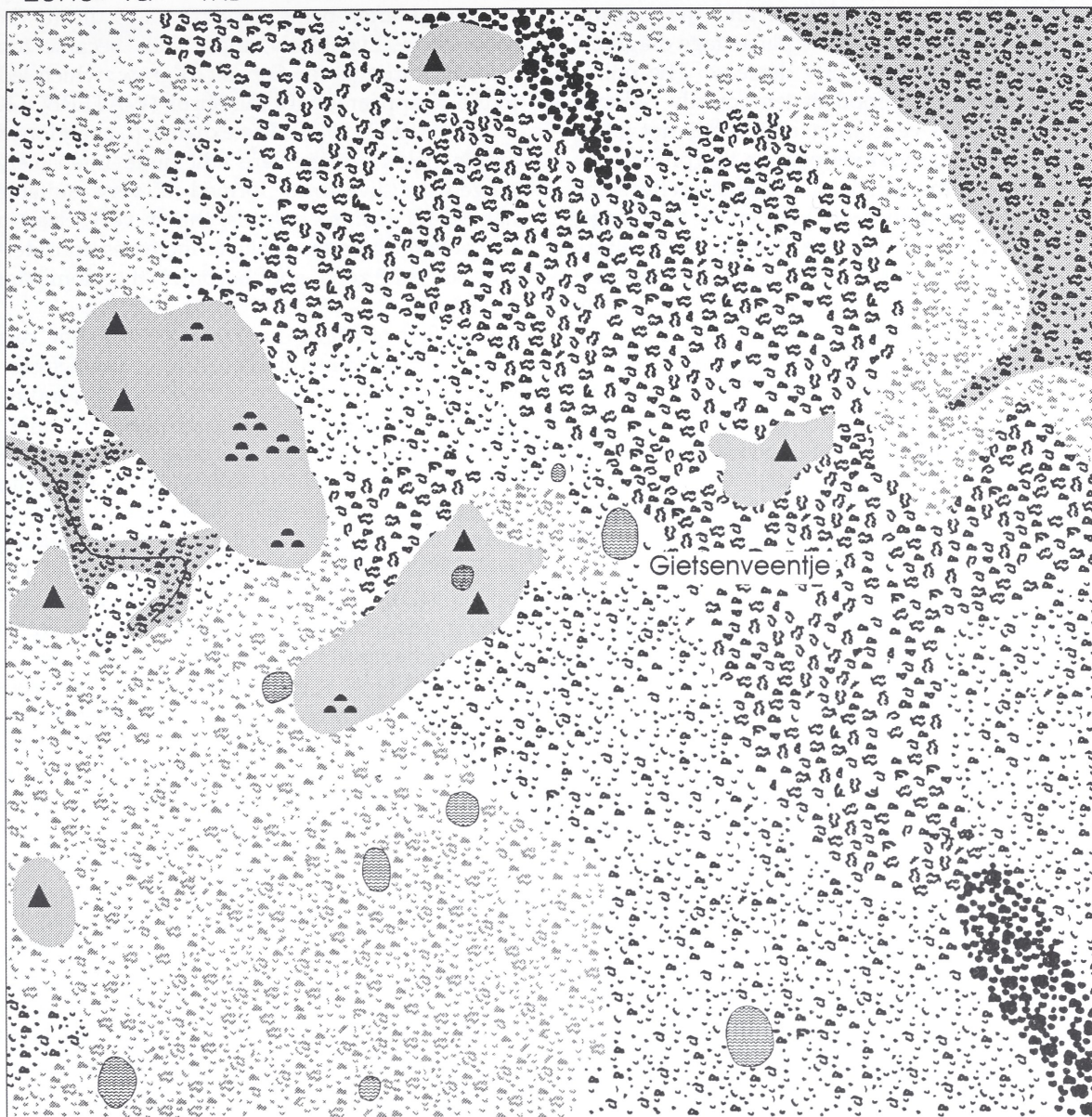
Megalithic tomb *(hunebed)*

Fig. 69. Reconstruction of the landscape in the surroundings of the Gietsenveentje in phase NOP-2, which is a part of pollen zone 4a (Subboreal I). Phase NOP-2 is connected with the Funnel Beaker Culture (TRB). The locations of megalithic tombs *(hunebedden)* and possible settlements are indicated.

while that of the total NAP remains constant. The values of Gramineae, *Calluna* and the culture-indicator pollen types in the percentage diagrams remain constant or slightly decrease. The pollen picture reflects a period of temporarily reduced pressure on the vegetation: apparently not much new forest clearance took place in this phase.

According to the ^{14}C dates, this phase reflects the agricultural activities of people of the Single Grave Culture (EGK), the Bell Beaker Culture (BB) and possibly the first part of the Bronze Age. There are only a few dates of the NOP-3/zone 4b boundary; for this reason, the date of 1760 cal BC is less accurate than the dates of the beginning of NOP-1 and the NOP-1/NOP-2 boundary. The NOP-3/zone 4b boundary probably coincides with the BB/Bronze Age boundary; however, in this case too more ^{14}C dates are needed to provide clarity. It is clear that the major part of phase NOP-3 is attributable to the EGK and BB Cultures.

In fig. 70, the landscape in the vicinity of the Gietsenveentje is shown as it might have been in phase NOP-3. Also the archaeological finds from this period are shown: one EGK/BB "settlement" and a number of burial mounds. Compared to the TRB period, the density of habitation seems to be less. The burial mounds are situated on the western edge of the till plateau, very close to the megalithic tombs. Possibly, part of the land which for several centuries had been cultivated by TRB people, was by now exhausted, resulting in the first, small, grass-rich heathfields. The presence of EGK people on the very edge of the Gietsenveentje is documented by the find of a horn sheath in the pingo scar itself; according to Prummel & Van der Sanden (1995), this horn sheath was thrown into the water for ritual purposes.

Zone 4b - *Alnus-Corylus*-Ericaceae zone, 1770-1100 cal BC: Subboreal II

A strong decrease of *Quercus*, *Fraxinus* and *Tilia* at the beginning of this zone shows that the forests on the till plateau were cleared on a much larger scale than in the preceding period. Most probably, also parts of the forest in the coversand areas were now cleared. In these forests, *Quercus* also played an important role (see III.3.3). *Corylus* reaches its highest values in this zone: because of the rapidly increasing number of open spaces, *Corylus* could easily expand. However, at the end of this zone, the values of *Corylus* fall considerably. This possibly marks the beginning of the widespread degradation of soils. The already

poor soils in the coversand areas were rapidly exhausted after being used for agriculture for some time. Eventually, these soils became too poor in nutrients for *Corylus* to grow, which led to the disappearance of this shrub (WATERBOLK 1954; IVERSEN 1973). The exhausted, abandoned arable fields which were still quite intensively grazed by livestock, formed a very suitable habitat for *Calluna vulgaris*; this is very clear in the pollen diagrams: *Calluna* increases considerably in this zone and becomes the dominant NAP type.

The pollen of *Alnus* dominates the AP: the carr forests in the immediate vicinity of the Gietsenveentje consisted largely of this tree. Expanding agriculture caused an influx of more and more nutrient-rich water into the pingo scar. A nutrient-rich environment is very suitable for *Alnus* (RUNHAAR et al. 1987). Pollen of *Carpinus* is found more frequently than in the preceding zone, although its values are still very low. The pollen values of *Fagus* are the same as in the preceding zone, which indicates that the share of *Fagus* in the forest vegetation did not increase.

The values of most culture-indicator pollen types rise. In the diagrams of Gieten I and Gieten V-A, *Rumex acetosa/acetosella* reaches values of more than 1%, which means that considerable numbers of *Rumex* plants must have grown in the direct neighbourhood of the pingo scar.

Zone 4c - Ericaceae-*Alnus* zone, 1100-800 cal BC: Subboreal III

In this zone, *Quercus* and *Corylus* decrease, while *Fagus* reaches relatively high values. Most probably, *Fagus* had established itself in the remaining forests on the till plateau, having partly replaced *Quercus*. In this period the oak-beech forest (*Fago-Quercetum*; VAN DER WERF 1991; STORTEL-DER et al. 1999) on the Drenthe Plateau may for the first time have occurred in its present-day form, that is with a dominant role of *Fagus*. Given the high values of *Alnus*, the direct surroundings of the Gietsenveentje were still dominated by *Alnus* carr forest.

As for the NAP types, a considerable increase of *Calluna* is noted. Because of the ongoing exhaustion of soils and grazing pressure of livestock, heathfields could progressively expand. However, the culture-indicator pollen types do not increase in this zone. This seems to indicate that, compared to the preceding zones, there was no increase in the total area of cultivated fields and pastures. This implies that the human population did not grow in this period. Because of the

Gietsenveentje

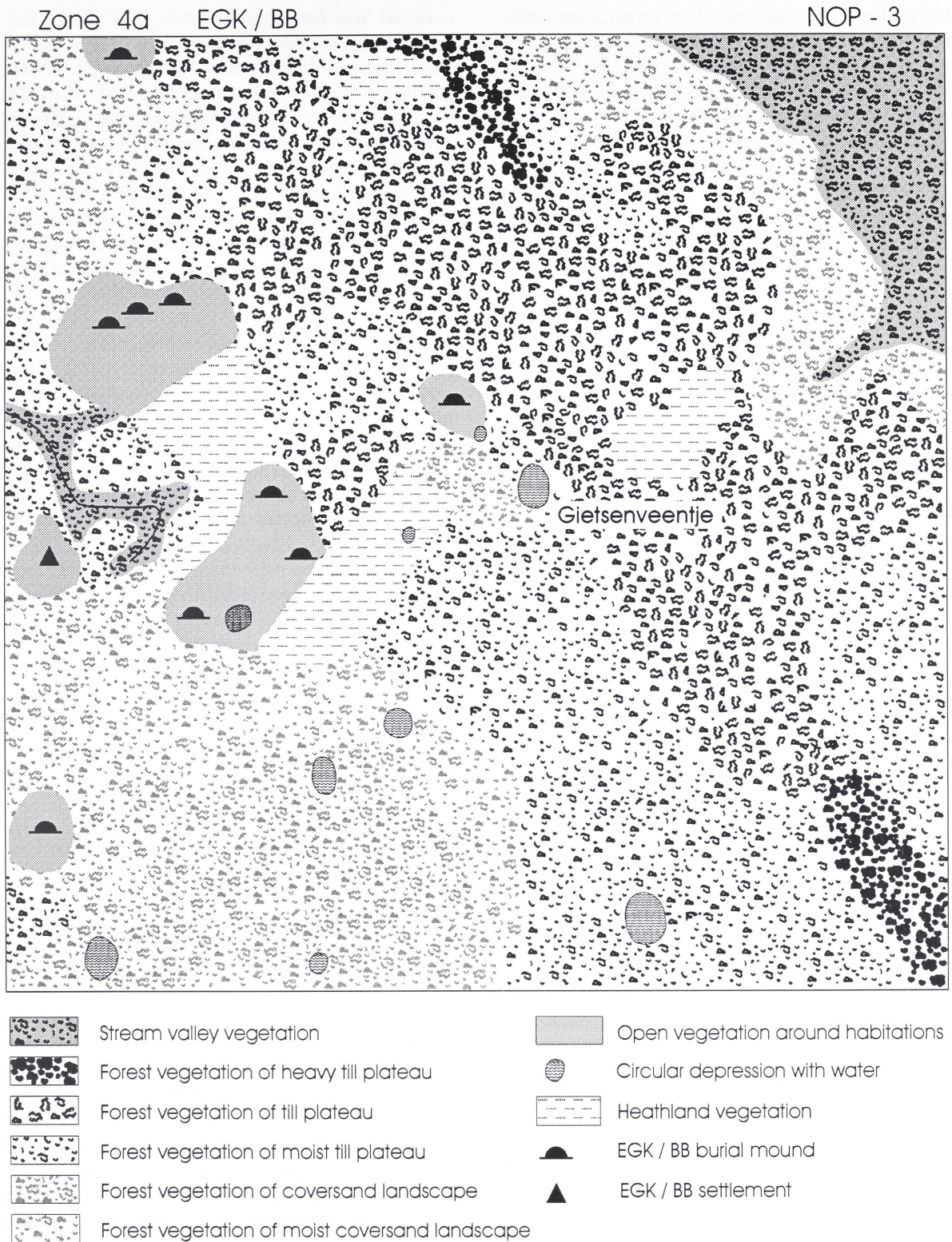|			
Stream valley vegetation		Open vegetation around habitations	
Forest vegetation of heavy till plateau		Circular depression with water	
Forest vegetation of till plateau		Heathland vegetation	
Forest vegetation of moist till plateau		EGK / BB burial mound	
Forest vegetation of coversand landscape		EGK / BB settlement	
Forest vegetation of moist coversand landscape			

Fig. 70. Reconstruction of the landscape in the surroundings of the Gietsenveentje in phase NOP-3, which is a part of pollen zone 4a (Subboreal I). Phase NOP-3 is connected with the Single Grave Culture (EGK) and the Bell Beaker Culture (BB). The locations of burial mounds and a possible settlement are indicated.

exhaustion of soils used for agriculture, continually new areas had to be reclaimed. As a result, the total area of exhausted and useless fields steadily increased. The coversand soils were exhausted particularly rapidly (*veld* and *haar* podzols, see fig. 21).

Zones 4b and 4c together represent the larger part of the Bronze Age.

Zone 5a - Ericaceae-*Fagus* zone, *800 cal BC-1500* cal AD: Subatlantic I

The Subboreal-Subatlantic transition is marked by a large increase of *Calluna* and by the beginning of a period with constantly high values of *Fagus*. In this period, most remaining forests on the Drenthe Plateau were cleared. Even the *Alnus* carr forests near the Gietsenveentje largely disappeared. Gramineae, *Plantago lanceolata* and *Rumex acetosa/acetosella* increase, but Cerealia-type occurs only very sporadically. This indicates an increase of grass-rich vegetation but no increase of arable fields. Most of the former forest, however, was replaced by extensive heathfields. The *Rumex acetosa/acetosella* pollen values exceed 1% in this zone. Relatively high values of *Rumex acetosa/acetosella* (here most probably originating from *Rumex acetosella*) together with high values of *Calluna* may well point to abandoned arable fields (see V.4) which have become so poor in nutrients that they form a suitable habitat for *Calluna vulgaris* and *Rumex acetosella*.

Although there are no ^{14}C dates of this zone from the Gietsenveentje, it most probably covers the Iron Age, the Roman Period and the Middle Ages. From the Gietsenveentje pollen diagrams, no radical changes in agricultural methods can be traced in this period.

Zone 5b - Gramineae-Cerealia-Ericaceae zone, *1500-1900* cal AD: Subatlantic II

In this zone, the AP pollen values have decreased to an absolute minimum: 10-15%. *Fraxinus*, *Ulmus* and *Tilia* have practically disappeared. It seems as if all forest up to the very edge of the Gietsenveentje was cleared. In part of this zone, pollen of *Betula* occurs massively. This most probably points to *Betula* trees growing within the pingo scar itself, which may indicate a lowering of the water table.

Pollen of *Fagopyrum* occurs for the first time in this zone. This crop was introduced in western Europe in the late Middle Ages (LANG 1994, 246). Furthermore, pollen of *Secale* and *Centaurea cyanus* makes its first appearance. The winter cereal *Secale* was introduced in central Europe as

early as the Iron Age (LANG 1994, 240). The earliest finds of cultivated *Secale* in Drenthe date from the Roman Period (VAN ZEIST 1976). Apparently, this crop was not cultivated in the neighbourhood of the Gietsenveentje until the Middle Ages. *Centaurea cyanus* preferably grows as an arable weed in *Secale* fields (WEEDA et al. 1991), which explains the similarity of the pollen curves of these two taxa. According to Behre (1981), *Rumex acetosella* also grows as a weed in *Secale* fields. Indeed, pollen of *Rumex acetosella* occurs frequently in this zone. However, other biotopes of this species include areas where dry deciduous and pine forests have been cut and former arable land (WEEDA et al. 1985). These man-made biotopes gained in importance in this zone. It is difficult to establish from which of these three biotopes the pollen of *Rumex acetosella* in this zone originates. Very high values of Gramineae and Cerealia-type (*Hordeum* group and *Triticum* sp.) attract attention. In this period, arable fields must have been located directly on the edge of the pingo scar. Topographical maps of the 19th century (figs. 25-27) indeed show a complex of arable fields called "Grietsche Akkers" immediately west and south of the Gietsenveentje. The poor soils of the coversand landscape were covered with extensive heathfields (see fig. 27). Relatively high values of Compositae Liguliflorae and *Matricaria*-type point to increased areas of fallow land, ruderal communities and/or wet meadows (BEHRE 1981).

Zone 5c - *Quercus*-Gramineae zone, *1900* cal AD-present: Subatlantic III

This zone is represented by only one sample from sequence Gieten V-A, which was cored in the centre of the Gietsenveentje (core location 59). The pollen picture of this sample very much resembles that of a surface sample from the same location (see VI.2.3). In the 20th century, the pingo scar was drained for the cutting of peat. The Gietsenveentje is now for the larger part overgrown with woodland. In an undisturbed part in the centre, where also the core location of Gieten V-A is situated, *Betula* nowadays is the dominant tree (see fig. 48). According to the large numbers of *Betula* pollen in this zone in diagram Gieten V-A, *Betula* must have been the dominant tree since the drainage of the pingo scar.

Many AP types increase markedly, especially *Quercus*, *Corylus* and *Pinus*. This pollen may originate from trees which in the course of the 20th century were planted in the neighbourhood of the Gietsenveentje.

222

Because of the introduction of artificial fertilizer at the beginning of the 20th century, the vast heathfields could be transformed into farmland. This is reflected in the pollen picture by a strong decrease of *Calluna*.

NAP types which increase in this zone are Gramineae, *Ranunculus acris* group, Compositae Liguliflorae, *Senecio*-type, *Matricaria*-type, Caryophyllaceae and Umbelliferae. Most probably, the pollen of these taxa originates from wet meadows which nowadays border the Gietsenveentje on its northern and eastern sides.

A comparison between pollen diagrams of various locations within the Gietsenveentje

In the Gietsenveentje, a number of sequences were cored on a north-south transect through the centre of the pingo scar (see VI.1). Four of these sequences were used for pollen analysis, resulting in four pollen diagrams: Gieten V-A to V-D. By comparing the pollen record of the four locations, it may become more clear which pollen came from local sources and which from regional sources. Local (non-aquatic) pollen is expected to display higher values in diagrams near the edge of the pingo scar. Regional pollen will show either similar values in all diagrams or higher percentages in diagrams in the centre of the pingo scar, where the influence of local pollen is less.

Fig. 71 shows histograms of the average values of twelve pollen types in the four pollen diagrams on the transect in three global periods: the last part of the Atlantic (ca. 5500-4050 cal BC), which can be connected with the Mesolithic, NOP-1 (4050-3450 cal BC), which corresponds with the Swifterbant Culture, and NOP-2 (3450-ca. 2600 cal BC), which can be linked with the TRB Culture (and possibly the beginning of the EGK Culture). The characteristics of the pollen histograms in fig. 71 will now be discussed in greater detail.

Quercus. The pollen values are generally quite similar, which points to a regional origin of the pollen. In the Atlantic and NOP-1, slightly higher pollen values are found at the southern edge. Generally, the values of *Quercus* do not decrease in NOP-1 and NOP-2.

Tilia. In the Atlantic, the highest values are found near the southern edge; in NOP-1 and NOP-2, the highest values are found more towards the centre. The values of *Tilia* more or less follow the pattern of *Quercus*. It is remarkable, that especially at the locations in the centre, the highest *Tilia* values are found in NOP-1. Apparently, the

changes in the vegetation caused by Swifterbant people were to the advantage of *Tilia*.

Ulmus. The pollen values are generally quite similar, which points to a regional origin of the pollen. The *Ulmus* values at all locations slightly decrease in NOP-1 and again in NOP-2. This decrease is ascribed to the "classic" *Ulmus* decline (see II.3).

Corylus avellana. The values of *Corylus* are quite constant, both in the three periods and at the four locations. This points to a regional origin of the pollen. Even during TRB times and later, when larger areas of forest were cleared, the values of *Corylus* do not increase.

Calluna vulgaris. In NOP-1, the first increase in the pollen of *Calluna* is observed, especially in Gieten V-B. In NOP-2, the values increase further. In all three periods, the highest values of *Calluna* are found in Gieten V-B. It cannot be excluded that this has something to do with the local situation: Gieten V-B is the only sequence in which the NOP occurs in *Sphagnum* peat (see fig. 45), which indicates the presence of raised-bog vegetation at this spot in the Gietsenveentje. It is possible that *Calluna vulgaris* grew locally in small numbers on hummocks in this narrow raised-bog zone within the Gietsenveentje (WEEDA et al. 1988). However, because the highest values of *Calluna* are found in the centre, it is supposed that the majority of the pollen has a regional origin.

Cerealia-type. Pollen of Cerealia-type is found only very sporadically in all periods and at all locations. The highest values (only 0.1%!) are observed during the TRB period and later. It is difficult to determine the origin of the Cerealia-type pollen on the basis of a few grains. Yet it might be concluded that the Cerealia-type pollen has a regional origin, because most grains are found in the centre.

Alnus glutinosa. The values of *Alnus* are generally quite constant, only its values in Gieten V-C and V-D (northern and southern edge, respectively) are slightly higher. It is expected that *Alnus* grew mainly at or near the edges of the pingo scar, which means that it is a local tree, but in the pollen diagrams *Alnus* behaves very "regionally": at various locations and in various periods, its values are almost constant.

Gramineae indiff. The values of the Gramineae only slightly rise in NOP-1; a considerable increase at all locations is observed in NOP-2. In all periods, the highest values of Gramineae are found in Gieten V-A and V-D, which indicates that the source of most Gramineae pollen must

Pollen type	Period, core location and pollen percentage			Probable origin of the majority of the pollen
	Atlantic ca.5500 - 4050 cal BC	NOP - 1 4050 - 3450 cal BC	NOP - 2 3450 - ca.2600 cal BC	
Quercus				regional
Tilia				regional
Ulmus				regional
Corylus avellana				regional
Calluna vulgaris				regional
Cerealia - type				regional
Alnus glutinosa				local ?

Fig. 71. Average pollen values of a selection of twelve pollen types in four pollen diagrams in three periods. The pollen diagrams originate from four core locations on a transect through the Gietsenveentje. This transect with the core locations is shown at the bottom.

Pollen type	Period, core location and pollen percentage			Probable origin of the majority of the pollen
	Atlantic ca.5500 - 4050 cal BC	NOP - 1 4050 - 3450 cal BC	NOP - 2 3450 - ca.2600 cal BC	
Gramineae indiff.				local (S)
Rumex acetosa				local (S)
Plantago lanceolata				local (S) ?
Betula (excluded from ΣP)				local (N)
Cyperaceae indiff. (excluded from ΣP)				local

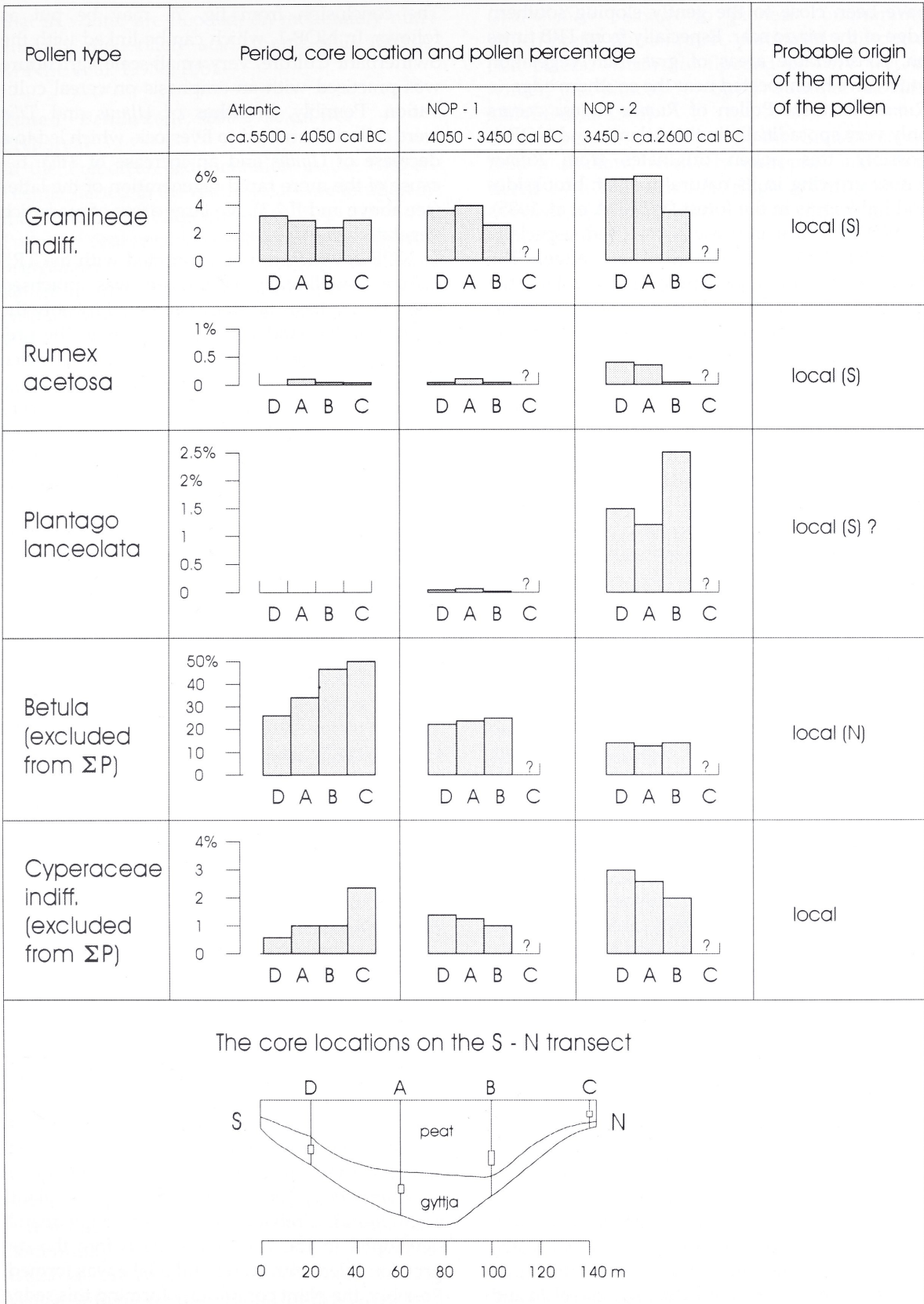The core locations on the S - N transect

Fig. 71 (continued).

have been close to the gently sloping southern edge of the pingo scar. Especially from TRB times on, considerable areas of grass-rich vegetation must have been located near the southern edge.

Rumex acetosa. Pollen of *Rumex acetosa* occurs only very sporadically in the Atlantic and NOP-1. Possibly, this pollen originates from *Rumex acetosa* growing in its natural habitat: brooksides and light spots in the forest (WEEDA et al. 1985). In NOP-2, a clear increase is observed, especially in Gieten V-A and V-D (southern edge). The values of *Rumex acetosa* more or less follow the pattern of the Gramineae. This suggests that *Rumex acetosa* grew in the grass-rich vegetation which occurred not far south of the Gietsenveentje especially from TRB times on.

Plantago lanceolata. Pollen of *Plantago lanceolata* appears for the first time in NOP-1 in very low values at all locations. In NOP-2, the values increase explosively: they are 11 to 44 times as high as in NOP-1! The values of *Plantago lanceolata* follow a pattern which more closely resembles that of the Gramineae than that of Cerealia-type. This may mean that *Plantago lanceolata* occurred in the grass-rich vegetation types where the livestock grazed, and was not an arable weed (BEHRE 1981; GROENMAN-VAN WAATERINGE 1986).

Betula (excluded from ΣP). The highest values of *Betula* are found in Gieten V-B and V-C, near the northern edge. At the location of Gieten V-C, also many macroscopic remains of *Betula* were found (see VI.6.2). For this reason, *Betula* was excluded from the pollen sum. At all locations, *Betula* decreases in NOP-1 and decreases further in NOP-2. *Betula* must have grown mainly on or near the steep northern slope of the pingo scar. It probably disappeared because mineral-rich water, originating from settlements and agricultural areas of the first farmers, reached the pingo scar.

Cyperaceae indiff. (excluded from ΣP). In NOP-1 and NOP-2, Cyperaceae values follow the same pattern as those of the Gramineae: the highest Cyperaceae values are found in NOP-2, especially towards the southern edge (Gieten V-D). The low and stable values of Cyperaceae indicate that probably no Cyperaceae grew inside the pingo scar in these three periods. Since in other periods far higher values of Cyperaceae (up to 25%) are found, pointing to Cyperaceae growing inside the pingo scar, it was decided to remove the Cyperaceae from ΣP. But in NOP-2 especially, during TRB times, most Cyperaceae appear to have grown together with *Plantago lanceolata* and *Rumex acetosa* in the grass-rich vegetation not far south of the Gietsenveentje.

The conclusion from fig. 71 may be put as follows. In NOP-1, which can be linked with the Swifterbant Culture, very small-scale agriculture was practised with an emphasis on cereal cultivation. Possibly, branches of *Ulmus* and *Tilia* were collected and fed to livestock, which led to a decrease of *Ulmus* and an increase of *Tilia*, because of the more rapid regeneration of the latter (see above and II.2.3). No large areas of grass-rich vegetation were present.

In NOP-2, which can be connected with the TRB culture, small-scale agriculture was practised with an emphasis on stock keeping. Probably the area of arable land was the same as in the preceding period, while the area of moist grass-rich vegetation with Gramineae, Cyperaceae, *Plantago lanceolata* and *Rumex acetosa* increased considerably. This grass-rich vegetation was located somewhere south of the Gietsenveentje, possibly close to its southern edge. A small increase of *Calluna* shows that the area of dry grass-rich vegetation also increased in this period. However, this vegetation with *Calluna* was situated further away than the moist grass-rich vegetation to the south.

VII.2 Local vegetation development

The development of the vegetation within the Gietsenveentje and the vegetation growing directly on its edges is described on the basis of the curves of local pollen types and macroscopic remains. The definitions of regional and local pollen types are given in IV.5. The local vegetation development of the Gietsenveentje will be described in units parallel to the regional pollen zones proposed in VI.3, and also used in VII.1. By comparing trends in the local vegetation with the regional pollen zones, it may be easier to trace any (direct or indirect) human influence on the local vegetation.

In the Gietsenveentje, sedimentation started in the Preboreal. Of the sequence Gieten IV-HL, which is located near the centre of the pingo scar (core location 49A, see fig. 38), a macroscopic sample from the base of the sequence was analyzed. Most macroscopic remains belonged to *Carex rostrata/vesicaria*; no remains of aquatic plants were found. Probably a kind of sedge marsh developed in the Gietsenveentje before the depression filled with water and a lake was formed. Possibly, the plant community forming this sedge marsh was related to the present-day *Caricetum vesicariae* association, which occurs in depressions

that in winter are flooded, on moderately nutrient-rich, moderately acid, humic soils (SCHAMINÉE et al. 1995b, 208).

Zone 1 - *Betula* zone, 9800-8700 cal BC: Preboreal

In the Preboreal, sedimentation in the Gietsenveentje started in the centre, near core location 59, the site of pollen diagram Gieten V-A.

Pollen of *Sparganium*, probably originating from *Sparganium angustifolium*, reaches maximum values in this zone. Nowadays, *Sparganium angustifolium* occurs in heath pools with a varying water table, especially in western Drenthe. It occurs in moderately nutrient-rich water up to 1 metre deep and grows optimally at a summer water depth of ca. 0.5 m (WEEDA et al. 1994). Unidentified microfossils of Type 128 (VAN GEEL et al. 1989), which may be algal spores, are found regularly in this zone. These occur in eutrophic to mesotrophic open water. Zygo- or aplanospores of Type 314 (*Zygnema* type) reach maximum values in this zone. The occurrence of this type indicates shallow, mesotrophic to eutrophic open water (VAN GEEL et al. 1981).

This period saw a small, shallow, mesotrophic to eutrophic lake in the centre of the Gietsenveentje.

Zone 2 - *Pinus-Betula* zone, 8700-6950 cal BC: Boreal

In the Boreal, sedimentation in the Gietsenveentje extended to core location 49A (pollen diagrams Gieten IV-P and IV-HR: figs. 54-55; macroscopic-remains table Gieten IV-HL: table 14), which is located near the centre of the pingo scar.

The finds of pollen as well as considerable amounts of seeds of *Sparganium* sp. and *Potamogeton* sp. at core locations 49A and 59 document the presence of open water in this period. The finds of spores of Types 128 and 314 (VAN GEEL et al. 1981; 1989) also indicate mesotrophic to eutrophic open water. The presence of zygospores of Type 315 (*Spirogyra* sp.) is another indication for open, relatively eutrophic water in this zone (VAN GEEL et al. 1981). At core location 49A, many seeds were found of *Carex nigra*-type (most probably originating from the species *C. acuta* and *C. elata*) and of *Carex rostrata/vesicaria*. Around the small lake in the centre of the Gietsenveentje a sedge marsh developed, with a plant community related to the present-day *Caricetum vesicariae*. At core location 49A, seeds of *Polygonum lapathifolium* are found in this zone. Core location 63 (Gieten V-C) produced seeds of this species at the beginning of zone 3a. *Polygonum*

lapathifolium belongs to pioneer communities which prefer nutrient-rich, particularly nitrogen-rich places, which are flooded or very wet in winter, and almost dry out in summer (SCHAMINÉE et al. 1998).

In this period, the centre of the Gietsenveentje held a shallow, relatively eutrophic lake, bordered by a sedge marsh fringe, which possibly flooded in winter and almost dried out in summer (fig. 72a).

Zone 3a - *Corylus-Ulmus* zone, 6950-5850 cal BC: Atlantic I

In the first part of the Atlantic, sedimentation in the Gietsenveentje extended to the very edges. In this period, gyttja was deposited at all core locations. The lake in the Gietsenveentje reached its maximum size. Finds of seeds of *Sparganium* sp. and *Potamogeton* sp. and eggs of the water flea *Daphnia* at core locations 49A and 63 demonstrate the presence of open water.

In this period, still many seeds are found of *Carex nigra*-type (most probably originating from *C. acuta* and *C. elata*) and *Carex rostrata/vesicaria*. Compared to the preceding zone, the share of *Carex nigra*-type has increased considerably. Macroscopic-remains and/or pollen values of the following taxa show maxima in this zone: macroscopic remains of *Cladium mariscus, Lycopus europaeus, Mentha aquatica, Glyceria fluitans* and *Juncus effusus*; macroscopic remains and pollen of *Lythrum salicaria* and *Potentilla palustris* (the pollen of *Potentilla*-type most probably originates from this species); pollen of *Galium*-type (most probably originating from *Galium palustre*), Ranunculaceae (from *Ranunculus lingua, R. flammula*), *Lysimachia vulgaris*-type (from *L. thyrsiflora, L. nummularia, L. vulgaris*) and *Dryopteris*-type (from *Thelypteris palustris*).

According to Runhaar et al. (1987) the species listed above are part of a semi-aquatic helophytic vegetation with a moderate nutrient availability. In VI.6 these species were called "shore weeds". Most probably, they were part of plant communities related to the present-day *Cladietum marisci* and *Caricetum elatae* associations (SCHAMINÉE et al. 1995b). These communities, which are poor in species, occur in mesotrophic to eutrophic heath pools where the water depth is less than 0.8 m. In this zone the "shore weed" communities, which formed a belt around the open water in the Gietsenveentje, may partly have replaced the sedge marshes of the preceding zone. Given the macroscopic-remains and pollen finds of *Betula* and *Alnus*, a belt of carr forest with
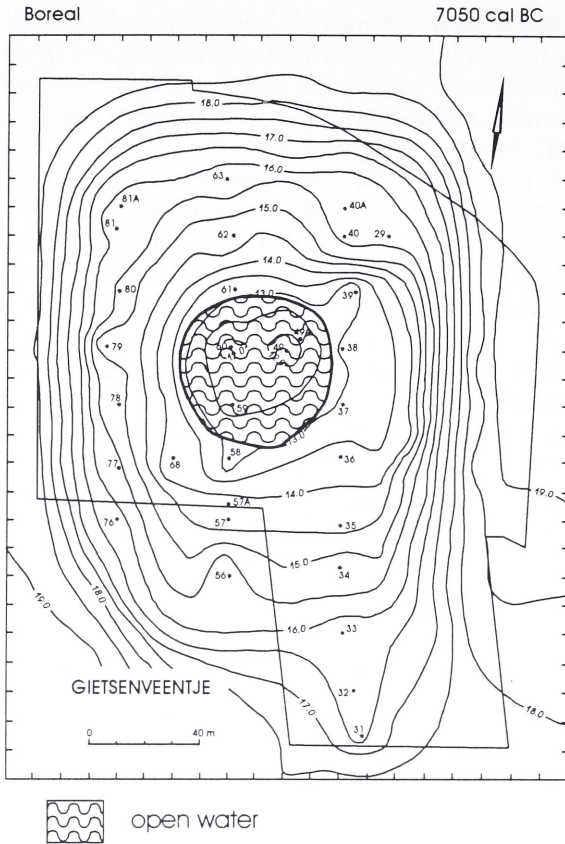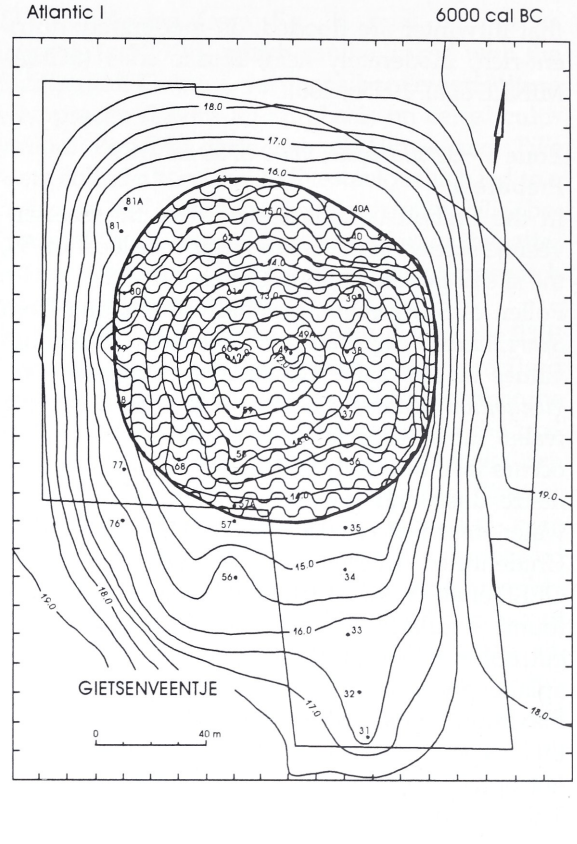
Fig. 72a.

Fig. 72b.

Fig. 72 (pp. 228-230). Vegetation development inside the Gietsenveentje between 7050 and 1500 cal BC. The vegetation development is projected onto a present-day contour map of the Pleistocene subsoil with all core locations. The estimated areas of open water as well as *Sphagnum* peat bog are indicated at five points in time: a. 7050 cal BC (Boreal); b. 6000 cal BC (Atlantic I); c. 5000 cal BC (Atlantic II); d. 2500 cal BC (Subboreal I); e. 1500 cal BC (Subboreal II).

Betula and *Alnus* occurred outside the belt of "shore weed" communities.

In several diagrams, maxima of (asco?)spores of Type 16A are observed in this zone. According to Van Geel et al. (1981), the fungus producing these spores prefers mesotrophic conditions in *Sphagnum* peat, which coincide with relatively dry phases. Possibly, the fungus develops on Graminaceous host plants (VAN GEEL 1978). In the Gietsenveentje diagrams, Type 16A only occurs in gyttja sediment, far below the earliest *Sphagnum* peat. It cannot be correlated with Gramineae maxima.

In the Atlantic I, the largest part of the Gietsenveentje was covered by a shallow, relatively eutrophic lake, bordered by a zone of "shore weed" communities. Outside this margin, carr forests with *Alnus* and *Betula* flourished (fig. 72b).

Zone 3b - *Alnus-Ulmus-Fraxinus* zone, 5850-4050 cal BC: Atlantic II

In the beginning of the second part of the Atlantic, gyttja was still being deposited at all core locations, which points to the presence of open water. In the course of this period, the gyttja sediment gradually turned into *Sphagnum* peat sediment at core locations 49A, 61 and 63, which are situated in the northern part of the Gietsenveentje. Around this transition, *Scheuchzeria* peat, *Carex* peat, and *Sphagnum* peat with *Eriophorum* were deposited at separate locations in the Gietsenveentje (see figs. 44-47).

Seeds and pollen of *Potamogeton* sp. and pollen of *Sparganium* sp. in the gyttja sediment confirm the presence of open water. For the first time pollen and macroscopic remains of *Nuphar lutea* are encountered. Not only pollen and seeds are found,
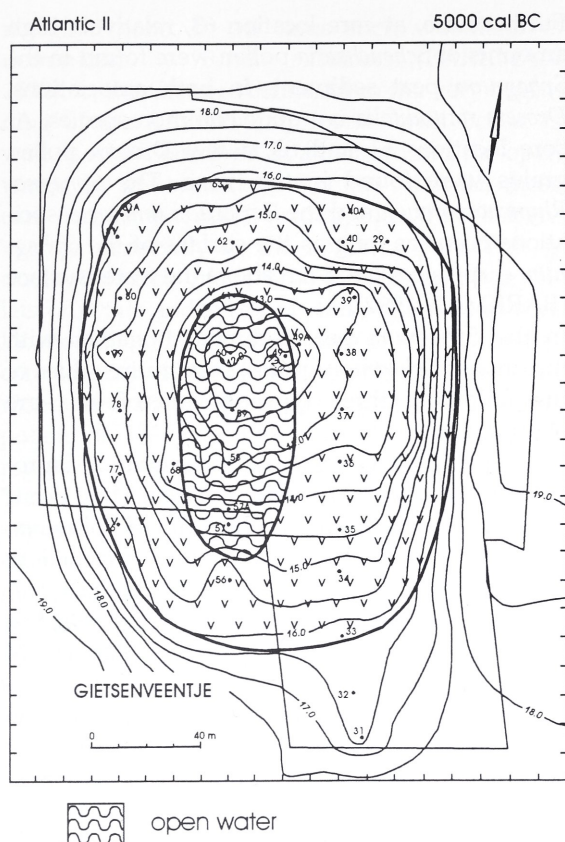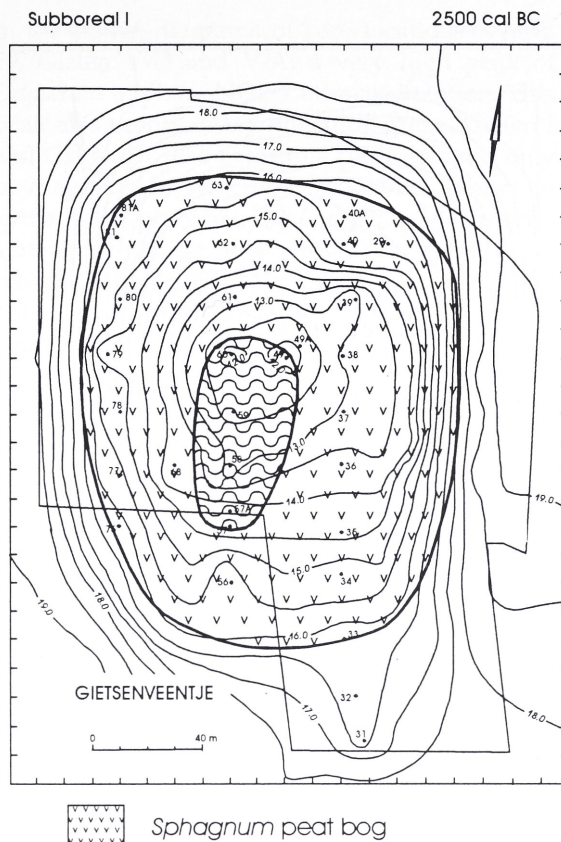
open water

Fig. 72c.

Sphagnum peat bog

Fig. 72d.

but also asterosclereids (star-shaped hairs) and parts of the epidermis with stomata. *Nuphar lutea* grows in deep to fairly shallow, nutrient-rich water (WEEDA et al. 1985). In the gyttja sediment of core location 63, many coenobia of the green alga genus *Pediastrum* are found. Two taxa could be identified: *Pediastrum duplex* var. *asperum* and *Pediastrum boryanum* var. *brevicorne* f. *brevicorne* (see PARRA BARRIENTOS 1979). According to Nielsen & Sørensen (1992), these two taxa especially occur in slightly eutrophic to eutrophic waters. Apparently, the availability of nutrients in the Gietsenveentje had increased since the Preboreal.

The transition from gyttja to *Sphagnum* peat, which occurs at all locations in the Gietsenveentje, is explained as follows. Until the second part of the Atlantic, the Gietsenveentje was a mesotrophic to eutrophic pool. Via groundwater and surface water, it was in contact with the rich subsoil. This contact caused a relatively high availability of nutrients in the pingo scar. However, it gradually became filled with an impermeable layer of gyttja, which more and more

insulated the surface water from the mineral bottom. This caused a considerable decrease in the availability of nutrients in the pool. In turn, this enabled the growth of *Sphagnum* carpets. The gyttja-*Sphagnum* peat transition occurred earlier in the northern than in the southern part of the Gietsenveentje, possibly because the northern edge is much steeper than the southern slope (see figs. 44-47).

The vegetation succession in heath pools in Drenthe, many of which are pingo scars, is described by Barkman (1992). An attempt was made to match the data from the Gietsenveentje with Barkman's description. The succession starts with the *Sphagnetum cuspidato-obesi* association (SCHAMINÉE et al. 1995b, table 10.2): a floating or barely submerged mat of *Sphagnum cuspidatum* is colonized by various species, viz. *Carex rostrata* and *Eriophorum angustifolium*. In richer pools, also *Sparganium angustifolium* and *Menyanthes trifoliata* occur in this stage. At core location 63, many seeds of *Carex rostrata/vesicaria* are found at the transition from gyttja to peat (fig. 65: 95-90 cm). At core location 49A (pollen diagrams Gieten

Subboreal II   1500 cal BC

GIETSENVEENTJE

0   40 m

[v v v v v]
[v v v v v]   *Sphagnum* peat bog
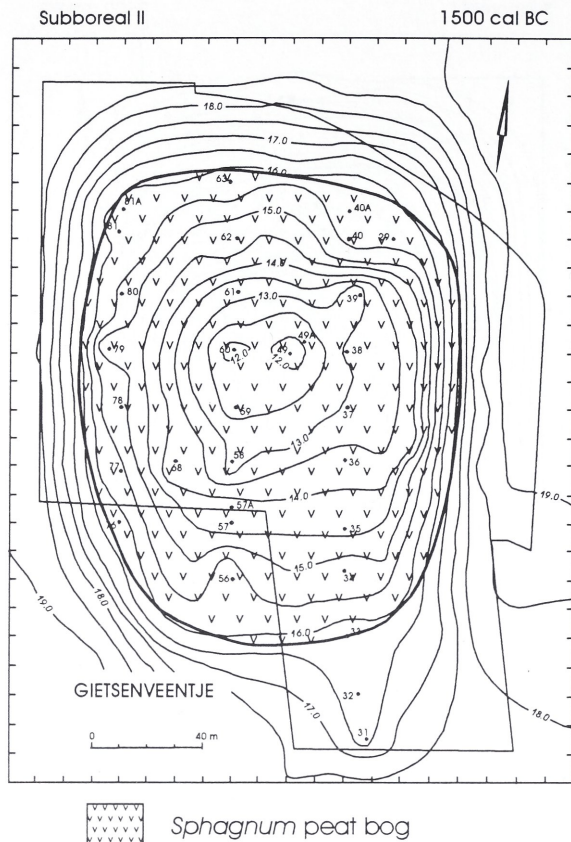[v v v v v]

Fig. 72e.

IV-P and IV-HR: figs. 54-55), peaks are observed in the Cyperaceae pollen values at the same transition. The *Sphagnetum cuspidato-obesi* association occurs as long as the surface of the *Sphagnum* carpet lies between 16 cm below the water surface to 2 cm above it (BARKMAN 1992).

The next stage in the terrestrialization process is formed by the *Sphagno-Rhynchosporetum* and the *Caricetum limosae* associations (SCHAMINÉE et al. 1995b, table 10.2). The former occurs in more nutrient- and ion-poor biotopes than the second. The most characteristic species of these associations are *Rhynchospora alba* and *Eriophorum angustifolium*. The *Caricetum limosae* is characterized by the presence of *Scheuchzeria palustris*. At core location 63, *Sphagnum* peat sediment (fig. 65: 85-70 cm) contained macroscopic remains of the following taxa which could have been part of these two associations: *Rhynchospora alba*, *Oxycoccus palustris*, *Potentilla palustris*, *Menyanthes trifoliata*, *Carex rostrata/vesicaria*, *Scheuchzeria palustris* and also many *Sphagnum* leaflets, stem and root remains, capsules and opercula.

Furthermore, at core location 63, relatively high amounts of *Scheuchzeria* pollen were found in the *Sphagnum* peat sediment. In both associations, *Drosera rotundifolia* is a quite common species. At core locations 61 and 63, a few *Drosera* pollen grains were found in this zone. The *Sphagno-Rhynchosporetum* and the *Caricetum limosae* associations occur as long as the surface of the *Sphagnum* carpets lies 6 to 8 cm above the water surface (BARKMAN 1992).

In the *Sphagnum* peat sediment, together with maxima of *Sphagnum* spores, maximum values of the following three types of microfossils are observed:

❑ Type 13: sporangia of the aquatic, saprophytic fungus *Entophlyctis lobata*. They occur mainly in the oligotrophic part of *Sphagnum* peat. Generally they are found attached to leaves of *Scheuchzeria palustris*, *Calluna vulgaris*, *Andromeda polifolia*, *Oxycoccus palustris*, *Sphagnum imbricatum* and *Erica tetralix* (VAN GEEL 1978).

❑ Type 27: spores of "*Tilletia sphagni*". The matrix of this fungus is formed by *Sphagnum* capsules, especially by capsules of *Sphagnum cuspidatum* (VAN GEEL 1978).

❑ Type 31(A): the rhizopod *Amphitrema flavum* (Thecamoebae). The increase of this type indicates increasing humidity. Generally, it points to more oligotrophic and wet phases. There is a negative correlation between this type and Type 16A (VAN GEEL 1978; VAN GEEL et al. 1981).

The occurrence of these three types of microfossils in the *Sphagnum* peat fits in with the presence of species of the *Sphagno-Rhynchosporetum* and *Caricetum limosae* associations in this phase.

The next stage in the succession is formed by the *Erico-Sphagnetum magellanici* association, which is an oligotrophic raised-bog community forming comparatively dry hummocks in terrestrializing pools (SCHAMINÉE et al. 1995b). This association is dominated by various Ericaceae species (*Erica tetralix*, *Oxycoccus palustris*, *Andromeda polifolia*, *Calluna vulgaris*) and *Eriophorum angustifolium*. At core location 63, this association can be tentatively recognized in the upper part of the macroscopic-remains sequence (fig. 65: 70-65 cm), where leaflets of *Oxycoccus palustris* and seeds of *Eriophorum* sp. were found. In the *Erico-Sphagnetum magellanici*, the water table occurs ca. 22 cm below the surface (BARKMAN 1992).

In meso-oligotrophic heath pools in Drenthe, woodland is nowadays the natural climax in the

marginal zone. In all cases such woodland is dominated by *Betula pubescens* (BARKMAN 1992). In the Gietsenveentje, from the very beginning of the Atlantic, carr forests with *Betula* as well as *Alnus* occurred in a belt around the open water. In the second half of the Atlantic, these carr forests extended further into the Gietsenveentje, especially in the northern part. This is documented by many seeds, scales and branchlets of *Betula* and seeds of *Alnus glutinosa* at core location 63 and by a large piece of *Alnus* wood at core location 49A. At core location 61, pieces of wood of *Frangula alnus* are found in this zone; pollen of *Frangula alnus* and *Sorbus aucuparia* regularly appears, especially at core location 63. These finds point to the presence of *Frangula alnus* and *Sorbus aucuparia*, species which are common in carr forests (STORTELDER et al. 1999).

In this zone, the phosphorus content (P content) of the sediment in the centre and northern part of the Gietsenveentje (core locations 59, 61 and 63) is low; it is comparable to the P content of recent oligotrophic lakes and raised bogs (table 19).

At the beginning of the Atlantic II, a shallow, relatively eutrophic lake remained in the largest part of the Gietsenveentje. In the course of time, the ongoing process of terrestrialization caused a development from open water to marsh in the northern part. Because at a certain moment groundwater and surface water could no longer reach the marsh, it developed into a raised bog. In this part of the pingo scar, the availability of nutrients decreased considerably. Most probably, this raised-bog vegetation flourished in a belt around the open water in the centre (fig. 72c). In turn, the belt of raised-bog vegetation was bordered by a belt of carr forest with *Betula* and *Alnus*. In the course of this period, the raised-bog vegetation belt extended towards the centre of the pingo scar at the expense of the open water.

Zone 4a - *Quercus-Fraxinus* zone, 4050-1770 cal BC: Subboreal I

At the beginning of the Subboreal, the human influence on the vegetation is for the first time observed very clearly in the pollen diagrams. In discussing the local vegetation development of this zone, we have to bear in mind that human influence may also have caused changes in the vegetation within and at the edges of the Gietsenveentje. In the early Subboreal, gyttja was deposited only in the centre and the southern part of the Gietsenveentje (core locations 57 and 59). Compared to the preceding period, the area of open water had become considerably smaller.

In the pollen diagrams of core locations 57 and 59, Gieten V-D and V-A, a very high peak of *Equisetum* in phase NOP-1 attracts attention. This peak also occurs in the pollen diagrams Gieten I and Gieten III. The *Equisetum* peak is found only in diagrams in which phase NOP-1 occurs in gyttja. Most probably, the *Equisetum* spores originate from *Equisetum fluviatile*. This species is a pioneer of terrestrialization in shallow, stagnant, phosphorus-poor water (WEEDA et al. 1985). It often points to seepage areas. However, as was stated already in VI.4.3, the Gietsenveentje is not a seepage area, because it is located on top of the Hondsrug. *Equisetum fluviatile* is not a characteristic species of one or a few plant communities; it is common in many plant communities of the class *Phragmitetea* (SCHAMINÉE et al. 1995b). It can form dominance communities, which are poor in species. Such communities dominated by *E. fluviatile* seem to have occurred on or near the edge of the open water of the Gietsenveentje. The presence of *E. fluviatile* points to mesotrophic conditions in this part of the pingo scar. At core location 61, wood of *Frangula alnus* is found in phase NOP-1. This species probably grew in the carr forest which occurred around the edge of the Gietsenveentje.

In the pollen diagrams from core locations 57 and 59, Gieten V-D and V-A, *Nuphar lutea* reaches maximum values in the gyttja sediment of phase NOP-2. Apart from pollen, also asterosclereids and epidermis parts with stomata of this species are found. The occurrence of *Nuphar lutea* in the central and southern parts of the Gietsenveentje points to fairly eutrophic conditions in the remaining open water.

At core location 57, which is in the southern part of the Gietsenveentje, the boundary between phases NOP-2 and NOP-3 also marks the transition from gyttja sediment to *Sphagnum* peat sediment. During phase NOP-3, open water was only present in the deepest part of the pingo scar, around core location 59.

As a result of the continuing terrestrialization of the Gietsenveentje, only a small area of open water in the centre remained by the end of the Subboreal I, bordered by a broadening belt of raised-bog vegetation. Outside this belt, there was carr forest with predominantly *Alnus* and to a lesser extent *Betula* (fig. 72d).

Zone 4b - *Alnus-Corylus*-Ericaceae zone, 1770-1100 cal BC: Subboreal II

At core location 59 the transition from gyttja to *Sphagnum* peat sediment occurs at the interface of

zones 4a and 4b. Around this transition, small peaks of *Scheuchzeria* and *Menyanthes* pollen occur in the Gieten V-A diagram from core location 59, which demonstrate the presence of the *Sphagno-Rhynchosporetum* and *Caricetum limosae* associations in this period.

At the beginning of the Subboreal II, the open water had completely disappeared; the entire Gietsenveentje was covered by raised-bog vegetation, bordered by a belt of carr forest dominated by *Alnus* (fig. 72e).

Zone 4c - Ericaceae-*Alnus* zone, 1100-800 cal BC: Subboreal III

At core location 59, pollen of *Equisetum* reaches a second maximum, which is, however, not as high as the maximum in phase NOP-1. Pollen grains of *Rhynchospora*-type and *Drosera* are found, which demonstrate the presence of the *Sphagno-Rhynchosporetum* association at core location 59 in this period.

Zone 5 - *800* cal BC-present: Subatlantic

From 800 cal BC onwards, the human influence on the landscape in the surroundings of the Gietsenveentje strongly increased. At the end of zone 5a, minimum values of all tree pollen types show that nearly all trees in the neighbourhood of the Gietsenveentje had disappeared, including the *Alnus* carr forest. Apparently, arable fields and pastures were laid out right up to the edge of the pingo scar. A maximum of charcoal particles points to the use of fire by man. It is improbable that fire was used to clear the carr forest, because it is very difficult to set such a humid forest on fire. It is more likely that the carr forest was felled and that the waste wood was burned in the vicinity of the pingo scar.

In zones 5b and 5c, suddenly very high values of *Betula* pollen are found at core location 59. This points to the presence of *Betula* inside the Gietsenveentje. As a result of the ongoing terrestrialization and of drainage for the cutting of peat, the Gietsenveentje dried out more and more. As a result, *Betula* could invade the pingo scar. A *Betula* carr forest (belonging to one or more communities of the *Vaccinio-Betuletea pubescentis* class, see STORTELDER et al. 1999) established itself in the centre of the Gietsenveentje. Because no peat digging was practised in the central part of the pingo scar, this *Betula* carr forest still survives there (fig. 48). In a surface sample of core location 59, *Betula* reaches values of more than 50% (fig. 49). Nowadays, owing to an extreme lowering of the water table for agri-

Core location	Sequence	Beginning of sedimentation	Gyttja-peat transition
57	Gieten V-D	6000 cal BC	2600 cal BC
59	Gieten V-A	9800 cal BC	1770 cal BC
49A	Gieten IV-P	8700 cal BC	5850 cal BC
61	Gieten V-B	?	5000 cal BC
63	Gieten V-C	6000 cal BC	5350 cal BC

Table 20. [14]C dates of the beginning of sedimentation and of the gyttja-peat transition at various locations in the Gietsenveentje. A map with all the core locations is shown in fig. 38.

cultural reasons in a large area around the Gietsenveentje, some parts of the pingo scar have dried out to such an extent, that even *Quercus robur* has been able to establish itself.

Table 20 summarizes ^{14}C dates indicating the beginning of sedimentation and the gyttja-peat transition at various locations in the Gietsenveentje. It was presumed that the earliest sedimentation occurred in the centre of the pingo scar. Indeed, at core location 59, sedimentation started around 9800 cal BC, in the Preboreal. At core locations 57 and 63, which are near the edges, sedimentation started only around 6000 cal BC, in the last part of the Atlantic. The gyttja-peat transition was assumed to have occurred earliest near the edges of the pingo scar, because in the shallowest parts of the pingo scar the growing gyttja layer filled the open water most rapidly, marking the beginning of *Sphagnum* peat growth. However, this expectation proves not to be entirely right in the Gietsenveentje; the earliest gyttja-peat transition occurs at core location 49A, which is near the centre of the pingo scar. The explanation of this early transition is that a certain layer of gyttja sediment was deposited twice at this location (see VI.3.2). The extra thick layer of gyttja sediment caused a more rapid filling up of the open water, resulting in an early transition to *Sphagnum* peat, even earlier than at the edges. The final gyttja-peat transition occurs at core location 59, roughly the deepest point of the pingo scar. It is remarkable that at the northern edge (core locations 61 and 63), the gyttja-peat transition occurs far earlier than at the southern edge (core location 57). One explanation for this difference is the asymmetric

shape of the pingo scar: to the north it has a steep edge, to the south the slope is more gentle (see figs. 44-47). Near the steep edge, the gyttja layer may have filled up the open water at an earlier stage. Another explanation is that the prevailing wind came from a southerly direction. This caused all floating peat carpets to end up at the northern edge of the lake, filling up the open water more rapidly there than at the southern edge.

It was hoped to detect, in one way or another, direct or indirect human influence on the local vegetation in the Neolithic Occupation Period. In fact, human influence on the local vegetation of the Gietsenveentje can be demonstrated only in zone 5, which covers the period from the Iron Age up to the present day. In the Neolithic Occupation Period (zone 4a), human presence in the area is only detectable in changes in the values of regional pollen types.