EEN-SCHIPSLOOT – THE GEOLOGICAL-PALYNOLOGICAL INVESTIGATION OF A TJONGER SITE

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CONTENTS

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1. INTRODUCTION

In 1969-1971 P. Houtsma and J. Schilstra carried out the excavation of a site of the Tjonger tradition along a ditch known as the Schipsloot near Een, *gemeente* of Norg (province of Drenthe), fig. 1. The report on this excavation is published in this volume, see Houtsma, Roodenberg and Schilstra. The geology of this region has been studied in detail and two organic deposits have been analyzed palynologically, by the second and first author respectively. The aim of these investigations was to gain a better insight into the genesis of this region and into the geological and vegetational development at the time when the settlement was occupied, and also to provide an explanation for a number of curious basin-shaped structures and to obtain a more accurate dating for some of these phenomena. The interpretation of the data presented in this publication has been arrived at in close collaboration with the two excavators, in particular with P. Houtsma.

The drawings were made by W.J. Dijkema (B.A.I.) and M.A. Smakman (R.G.D.). The photos, except for those provided by the authors, were made by B. Klijnstra (R.G.D.). Mrs. G. Entjes-Nieborg (B.A.I.) typed the manuscript and Mrs. S.M. van Gelder-Ottway translated the article into English. We wish to express our thanks to all those concerned for their cooperation.

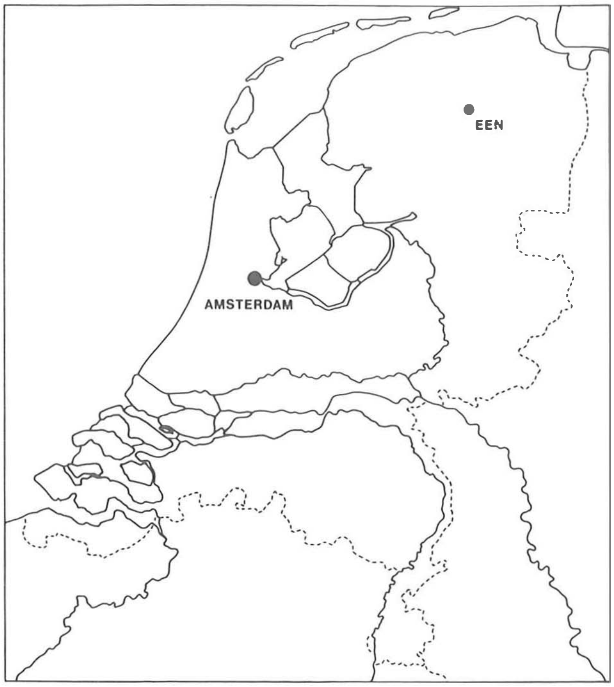

Fig. 1. Location of the Een excavation.

2. THE GEOLOGICAL SITUATION

The Tjonger site that concerns us here is situated near the watershed between the valley system of the Tjonger, that flows towards the south-west, and that of the Peizerdiep, that drains the area towards the north.

The primary watershed of these two valley systems became considerably narrower and lower-lying at the time when these valley systems originated. In the Pleniglacial period, when the sea-level was low in the last ice-age, the Tjonger valley increased in extent from the south-west as far as here as a result of headward erosion. From the north the valley system of the Peizerdiep also became more deeply extended back this far as a result of erosion, such that the two valley systems became interconnected and separated merely by a low, narrow watershed.

After this erosion phase, still during the Pleniglacial, both valley systems became filled up with stream sediments, i.e. moderately fine sands with layers of loam and gyttja, and some fine gravel. These sediments fill up the valley systems almost completely, so that on the geological map (fig. 2) it appears as though there is one single valley system; see also the stratigraphical table (below).

In the final phase of the last ice-age, the Late Glacial, the climate was cold but dry. Wind action had a severe effect on the landscape, that was sparsely vegetated at that time, and the sand on the surface was blown about by the wind. On the boulder-clay, on the pre-

Stratigraphic table for Een-Schipsloot.

		10,200	
	Late Dryas stadial		Younger Cover sand II
		11,000	
	Allerød interstadial		Layer of Usselo peat
Late Glacial (Late Weichselian)		11,800	
	Early Dryas stadial		Younger Cover sand I
		12,000	
	Bølling interstadial		
		13,000	
Pleniglacial (Middle Weichselian)			stream sediments
		yrs B.P.	

glacial sands and also to some extent in the stream valleys a layer of cover sand was deposited. The oldest cover sands here belong to the Younger Cover sand I and form a cover sand ridge in the watershed region (fig. 2). During the Allerød interstadial when the climate was less cold, a soil developed on top of the Younger Cover sand I, that undergoes a transition into a peat-gyttja layer (valley fill) in the low-lying part of the valley system (fig. 2).

The Allerød level has been definitely dated by means of the pollen-analytical investigation (see below) and the Tjonger tradition that has been investigated by Houtsma, Roodenberg and Schilstra.

The somewhat undulating Allerød horizon is an approximate reflection of the morphology of the former cover sand landscape. It is clear that the cover sand ridge in the Younger Cover sand I formed the watershed in Allerød time and that this cover sand ridge, situated high and dry, was an ideal passage for the reindeer-hunters. After the Allerød interstadial there followed the Late Dryas stadial, during which period the Younger Cover sand II was deposited. This cover sand lies like a blanket over the Younger Cover sand I and accentuates the cover sand ridge already present and the watershed in this locality (fig. 2).

The Schipsloot was dug in historical times. This ditch served to facilitate drainage from the peat region in the upper reaches of the Tjonger, the Eenderveen, into the valley system of the Peizerdiep. As a result of the digging of this ditch the existing watershed was shifted to the beginning of the Schipsloot; about four kilometres south-west of the natural watershed.

3. PALYNOLOGICAL INVESTIGATION OF THE VALLEY FILL

In the low-lying part of the Allerød level the organic valley fill was sampled. The spot where sampling was done, to the west of the site, is indicated in fig. 2 by 1. At this spot the valley fill consists of a complex of thin layers of sandy peat, alternating with thin layers of sand, see fig. 3, that gives an overall picture of the fill. The section that was analyzed comes from the part on the left, near the arrow, where the deposit is richest in organic material. In fig. 4 a detail of the sandy peat layer is shown, just to the right of the

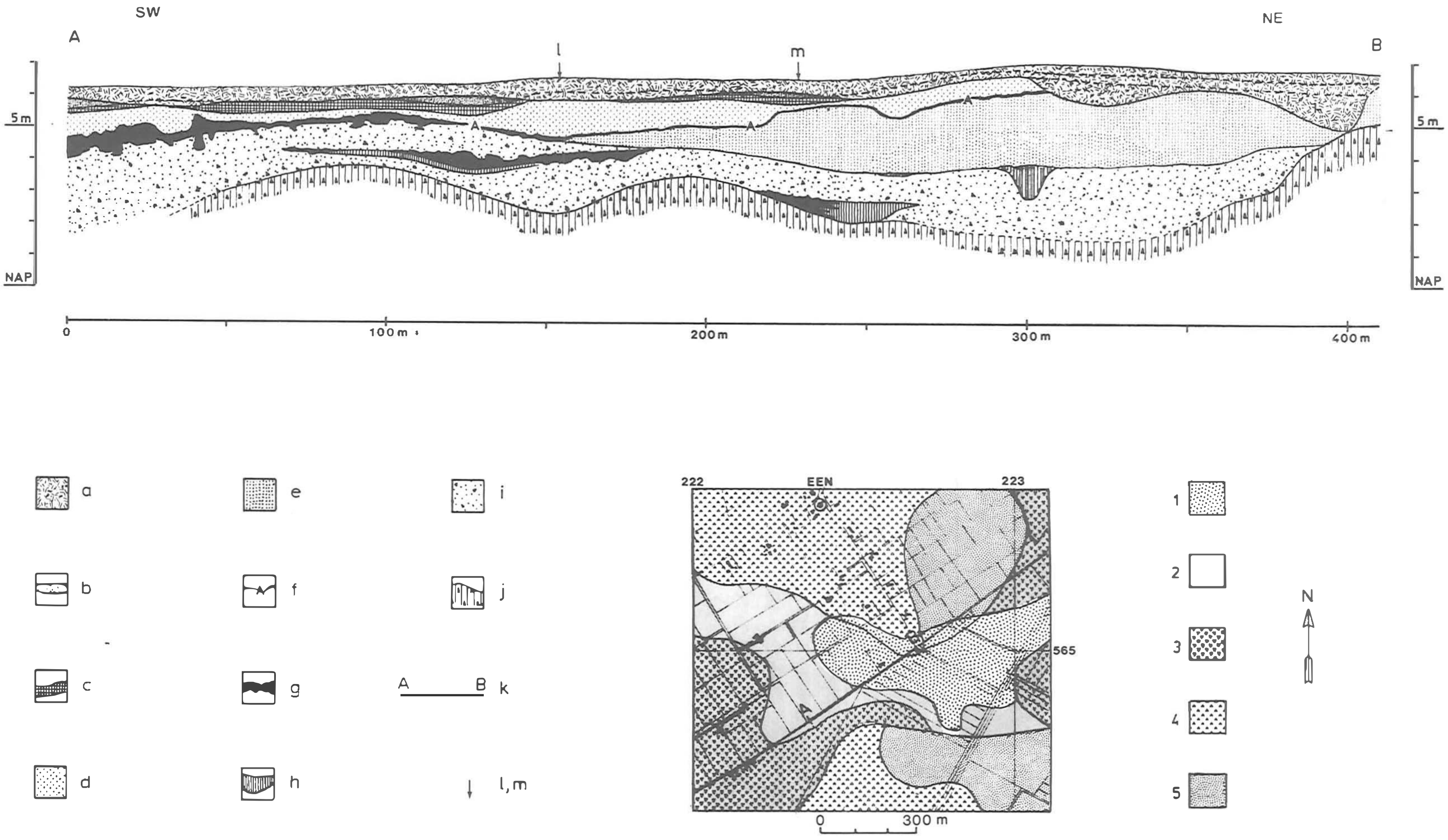

Fig. 2, below: ***The area investigated.*** Legend: 1. cover sand thicker than 2 m. – 2. stream deposits covered by cover sand thinner than 2 m. – 3. stream deposits covered by Holocene peat. – 4. boulder-clay (basal till) covered by cover sand thinner than 2 m. – 5. Preglacial sands covered by cover sand thinner than 2 m.

Fig. 2, above: ***The geological section.*** Legend: a. disturbed and/or transported soil. – b. A-horizon. – c. B-horizon. – d. Younger Cover sand II. – e. Younger Cover sand I. – f. Allerød horizon. – g. gyttja. – h. fluvial loam. – i. fluvial sands. – j. boulder-clay (basal till). – k. situation of the cross-section (in the lower figure). – l. site of the analyzed peat section in the valley. – m. site of basin I.

spot where sampling was done. The (Late Dryas) frost crack, that originates from the top of the Tjonger culture layer, and the cryoturbate layering indicate a Pleniglacial or Late Glacial age of this deposit, that is c. 50 cm thick and that contains organic material particularly in its lower half. The pollen diagram, fig. 5, relates to this part.

Concerning the preparation of this pollen diagram, as well as of the pollen diagram shown in fig. 12 of the organic filling of one of the basins to be discussed in this article, the following can be said.

From both profiles samples, c. 1 cm thick, of peat or peaty material were prepared in the usual way and analyzed with the aid of a microscope. The results are set out in 'Iversen pollen diagrams'. As a basis for calculation purposes was taken the sum of pollen from trees, shrubs, wind-pollinated herbs, and also of *Empetrum* and the Ericaceae.

The wall from which the profiles were taken is the slope of the Schipsloot, that has an inclination of c. 45°. The scale-bars shown together with the pollen diagrams relate to this ditch slope; therefore they do not give the real thickness of the peat layers.

In the pollen diagram Een Schipsloot-A for the valley fill, fig. 5, the values for *Pinus* (c. 10%) and the fairly high *Betula* values (c. 50%) indicate a Late Glacial age, with *Pinus* being present already in this region. *Juniperus* occurs only sparingly, *Empetrum* is hardly present and also *Calluna* and *Erica* have only small percentages. This places the deposit in the *Betula* phase of the Allerød, before the beginning of the sharp increase in *Pinus*. The somewhat high herb percentages (c. 30-50%) for this period can be ascribed to local sedge vegetations. There is a relatively great abundance of herbs, but the heliophytes show no conspicuous maxima; thus *Artemisia* values are remarkably low. Of the herb types some occur on damp to very damp soils: *Filipendula, Sparganium, Menyanthes, Equisetum*. Several types are indicative of open water: *Batrachium, Myriophyllum, Pediastrum*. The last-mentioned shows no great maxima however. The indicator species of extremely wet conditions are marked in the pollen diagram by means of an asterisk.

We are concerned here with a *Betula* forest, dating from the first half of the Allerød, in a fairly wet location, undoubtedly adjacent to or in the stream valley in question, of which the geological profile fig. 2 shows a cross-section. Between the stream and the forest there was a transitional peaty zone, probably of considerable extent, with sedges and *Sphagnum* present. The absence of extremely high maxima of *Pediastrum* suggests that there was relatively little open water.

The thin layers of sand that are present between the thin layers of peat are undoubtedly deposits of fluviatile origin, in view of the occurrence of secondary pollen such as *Quercus, Picea, Tilia, Acer* and *Taxus*. The spectra 1-5 show a considerable degree of mutual correspondence as against spectra 6-8, that show some degree of mutual correspondence, albeit to a lesser extent. This could indicate that peat formation and the sedimentation of sand took place at a considerably slower rate from spectrum 5 onwards, and that hiatuses are present in the upper part of the profile.

In the diagram a distinct *Pinus* phase with a conspicuous maximum is lacking. Nevertheless it is probable that spectra 6-8 in particular can be placed precisely at the beginning of such a phase; as a result of the conspicuously high (for the Allerød) Cyperaceae values in this section of the pollen diagram the onset of the *Pinus* expansion is, as it were, veiled.

The end of the formation of peat indicates that conditions in the valley system became drier, possibly as a result of the climate becoming drier. This situation favoured the expansion of *Pinus* and at the same time led to wind erosion taking place, for example as occurred in Southeast Drenthe during the *Pinus* phase of the Allerød (Casparie, 1972). In this valley system in any case wind erosion had a predominating effect; the level of the frost crack, that can be dated in a fairly early stage of the Younger Dryas (see fig. 3), is indica-

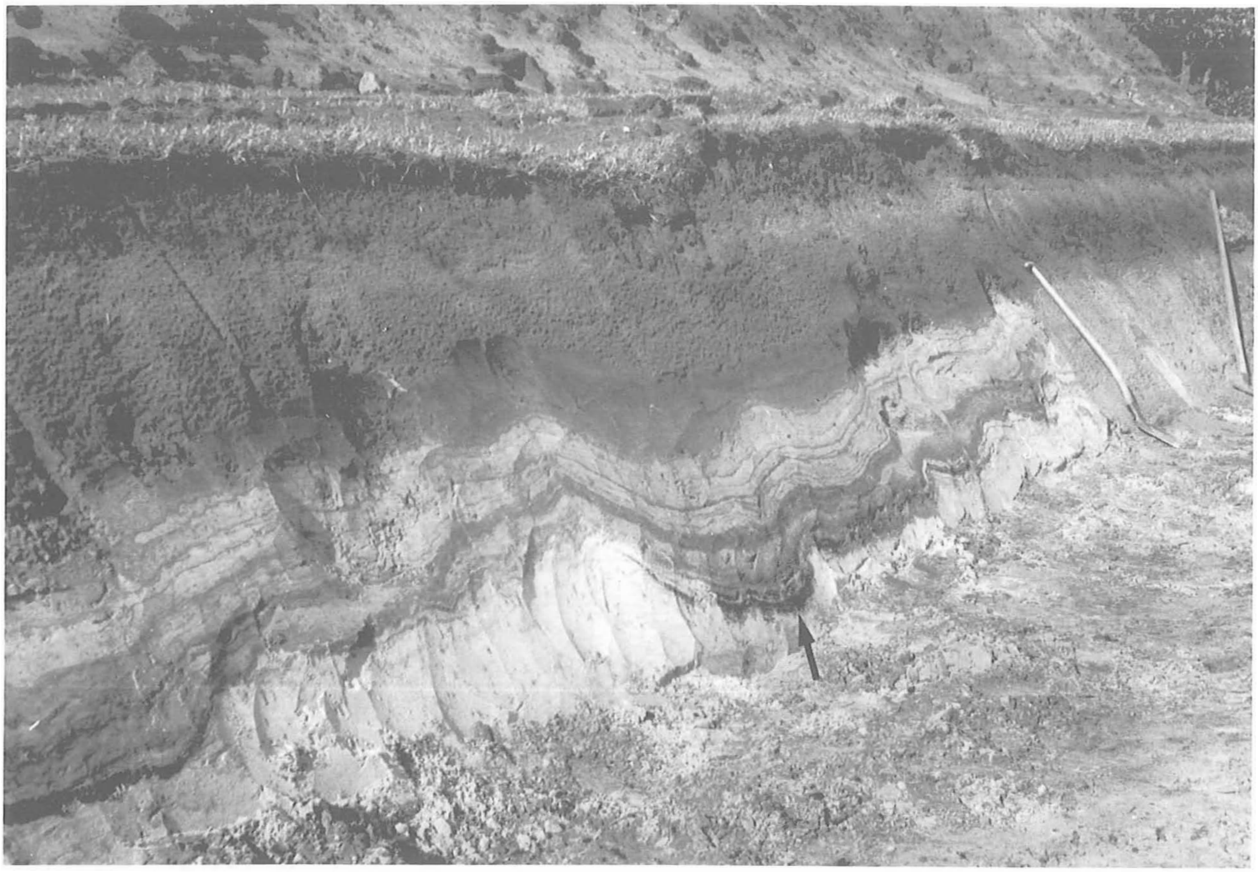

Fig. 3. The valley fill. The arrow indicates the spot where sampling was done.

tive of a sand deposit of c. 0.5 m after the *Betula* phase of the Allerød.

The fact that conditions became drier in the valley system could also be attributed to the disappearance of the permafrost during the warm Allerød phase, which resulted in a considerable lowering of the ground-water level and the pronounced compaction of the complex of sand and peat layers, as shown in fig. 3. The very shallow character of this valley system, i.e. in comparison to its width, does not exclude the possibility of peat formation on a frozen subsoil.

During the Late Dryas the deposits were affected by cryoturbation.

4. DESCRIPTION OF THE (COVER SAND) BASINS

In that part where the Schipsloot cuts through the cover sand ridge discussed above, in the course of the excavation of this Tjonger site nine round basins were found in the Younger Cover sand I, that were filled with Younger Cover sand II (Houtsma, Roodenberg & Schilstra, this volume). In addition an oval basin was found, that is included here in the category of the round type.

The level at which these basins begin is as a general rule, the uppermost part of the remnant of the culture layer containing the Tjon-

Fig. 4. Detail of the valley fill with the (Late Dryas) frost crack.

ger tools (fig. 6). The basins were already visible in part slightly above the culture level. The basins vary in depth from 0.15-1.00 m, while the diameter varies between 0.50 and 3.00 m. The largest, most spectacular basin, basin I, has the most complete and varied filling (figs. 6,7).

The wall of this basin against the Younger Cover sand I is very sharply defined and is partly accentuated by a thin secondary iron oxide band. At the base of the basin filling a coarse sandy layer is present, like a thick crust, and this continues also against the wall practically as far as the periphery of the basin. This sand is coarsest at the bottom, where the stones, artefacts and wood also occur, and becomes increasingly finer higher up the slope. This crust-like sand-layer is finely layered, and its layering is more or less parallel to the boundary of the basin (fig. 7). There follows a light brown, fine-grained Hypnaceae-peat lens and from this there is a lateral transition into grey, very fine, possibly somewhat loamy sand with some rust coloration.

The rest of the filling of this basin consists of cover sand containing in the basal part one or possibly two thin irregular lenses with grey, very fine, loamy sand, partly accentuated by bands of rust. The cover sands in the basin correspond to the Younger Cover sand II out-

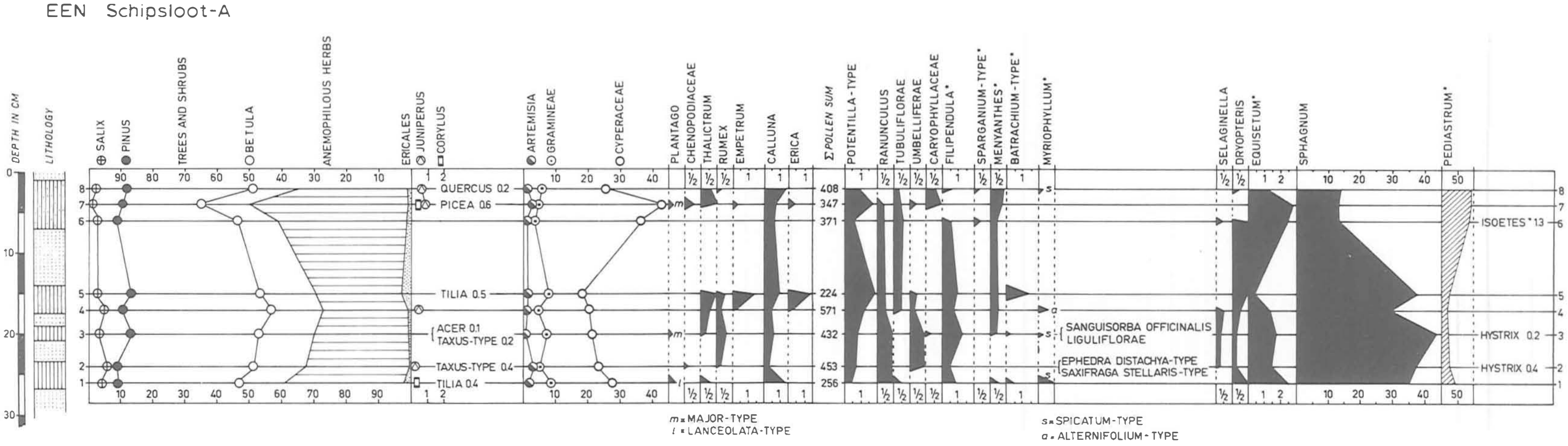

Fig. 5. Pollen diagram for Een Schipsloot-A (valley deposit). For legend relating to lithology: see fig. 12.

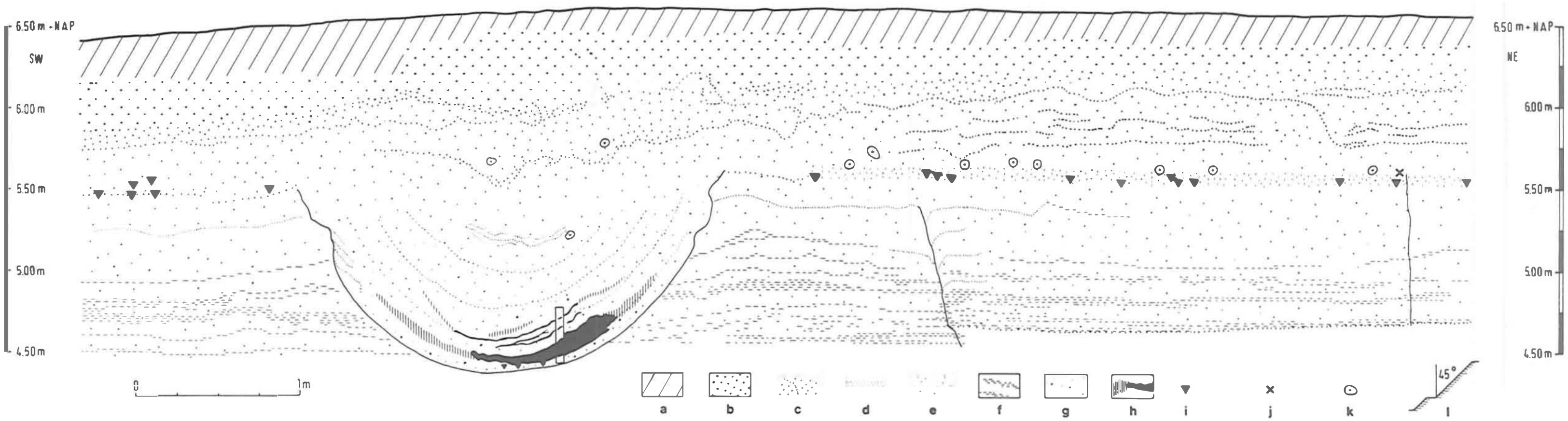

Fig. 6. *Cross-section through basin I.* Legend: a. disturbed and/or transported soil. – b. Younger Cover sand II, humous part of the podsol (A-horizon). – c. Younger Cover sand II, B-horizon with fibres. – d. Younger Cover sand I, slightly bleached layer (± level of the Tjonger tradition). – e. Younger Cover sand I. – f. loam and very loamy sand. – g. coarse sand, occasionally with fine gravel. – h. gyttja (left) and peat. – i. artefacts. – j. bone fragment. – k. fine gravel. – l. indication of the angle of inclination of this section. – Continuous lines: 1. frost cracks. – 2. contour of basin I.

side the basin, with which they form a whole. The layering in the basin is very much disturbed, however, and in some places the layering is more or less vertical. This basin I is the largest that has been found in the course of this excavation. The other basins show a similar structure; they are however much smaller and do not contain a Hypnaceae-peat layer, although in several basins there is a loam layer (see Houtsma, Roodenberg & Schilstra, this volume), that is possibly in the same position as the Hypnaceae-peat layer in basin I. Also the structure in the cover sand can vary; thus the filling of basin II (fig. 10) shows a pattern of layering of the cover sand that is parallel to the contour of the basin (figs. 8,9).

5. PALYNOLOGICAL INVESTIGATION OF THE PEAT FILL OF BASIN I

The location of this basin is indicated by m in fig. 2. The remarkable position of the peat layer is clearly visible in fig. 6. The exact spot where sampling was carried out is indicated here by means of a rectangle. As mentioned previously, under the peat layer a number of stones, several artefacts and a piece of wood were found. This wood, *Pinus*, came from a thick tree, in view of the pattern of annual rings. A C14-dating has been established for the peat: GrN-6341, 10,495±60 B.P. (Lanting & Mook, 1977). The precise thickness and the level of the dated sample are given in the pollen diagram, fig. 12. The diagram was prepared in the same way as that for the valley fill, see section 3 and fig. 5. Here too the indicator species of extremely wet conditions are marked by means of an asterisk.

Concerning the pollen diagram Een Schipsloot-B for the basin filling, fig. 12, the following can be said. The values for *Pinus* (almost 15%) and *Betula* (± 60%) and the herb pollen are indicative of a Late Glacial age for this peat layer. The occurrence of *Empetrum* shows that we are concerned here with the Late Dryas period. The C14-dating points to the same.

Pediastrum has high values; Gramineae and Cyperaceae on the other hand are relatively low. There is a not inconsiderable hydrophyte vegetation. In the pollen diagram there are nine indicator species of damp to very wet conditions. The peat most probably originated as floating bog vegetation in a depression with open water where there was no shade. In this vegetation Hypnaceae (not further identified) played an important role.

Also present are rather many types that are associated with dry soils, such as *Juniperus, Hippophaë, Urtica* (?), *Epilobium, Helianthemum* and *Sedum.* This shows that this basin was a very localized aquatic biotope in an otherwise relatively dry environment.

The regularity of the tree pollen curves and the low values for Gramineae and Cyperaceae make it probable that peat formation was able to continue for a relatively brief part of the Late Dryas. Here we are thinking in terms of decades rather than of centuries. In view of the C14-dating (10,495± 60 B.P.) this would have been approximately in the middle of this period. The occurrence of the piece of *Pinus* wood, that probably came from the Allerød forest, indicates rather developments at the beginning of the Late Dryas, since a piece of wood lying on the surface does not remain preserved for a length of time of the order of centuries.

In view of the layered structure of the cover sand and this peat layer in the basin, we can assume that peat formation came to an end as a result of the basin drying up, so that the peat layer ended up at the bottom. The thin layers, indicated as peat, in the rest of the cover sand filling of the basin, see fig. 6, could point to brief wet periods during the time when the basin was becoming filled up. The analysis of these layers showed that these are thick illuvial iron-oxide horizons, not containing any pollen or other organic remains. Wet phases during the period of filling up with cover sand cannot be demonstrated in this way.

Fig. 7. Basin I, overall view. The puddle at the front of the basin indicates the deepest point. Here a lot of flint material was found.

6. GENESIS OF THE (COVER SAND) BASINS

The climatic conditions under which these basins originated and the time when this occurred have become clearly evident from the pollen-analytical investigation, the C14-dating of the Hypnaceae-peat, the geological phenomena and the archaeological study by Houtsma, Roodenberg and Schilstra, and others. The time at which these basins originated coincides, as one would expect, with a period in which the permafrost started to develop once again.

On the basis of the evidence provided below the time of origin of the permafrost, that resulted from a considerable decrease in temperature, can be dated more accurately. Many Late Glacial pollen diagrams show precisely at the transition from Allerød to Late Dryas a sharp decline of *Pinus*. From the pollen diagram for Waskemeer (Casparie & Van Zeist, 1960) it can be deduced that the decrease in pollen production of *Pinus* from 47% to 6% took place within 100 years and possibly even within 60-80 years. This is supported by various other pollen diagrams. The rapid rate of this decline indicated that not only did the rejuvenation of forest fail to take place, but that the flourishing of many pines came to an abrupt end, possibly with trees dying off altogether. We can therefore assume that the permafrost, in which the above-mentioned basins originated, started to form immediately at the beginning of the Late Dryas. As for the length of time that was necessary for a thickness of 1 m to be attained (that was required for the formation of basin I – see below), no direct information is available.

We assume that the origin of these basins must be regarded in association with the (developing) permafrost, although, we are not able to point out precisely how the two phenomena are related. Nevertheless we will mention a few possibilities here in further detail.

As a result of the downward extension of the permafrost, at the beginning of the Late Dryas, and possibly also on account of the inflow of water from higher areas, the ground-water in the aquiferous sand-layer above the hardly permeable boulder-clay (fig. 2) came to be under increasingly greater pressure. It is possible that the ground-water that was under pressure was able to find a way out via weak spots, such as cracks and fractures, and that an ice lens was able to develop next to the base of the permafrost or inside it, whereby a small pingo originated.

That the origin of such basins could be the result of human activities is an idea that has been suggested by Mr. Rinke Nolles of the Rijks Geologische Dienst (Geological Survey of the Netherlands). He has drawn our attention to the fact that these basins are only found in an archaeological context, notably in several sites of the Tjonger tradition (including Siegerswoude). It is quite remarkable, moreover, that in the course of this excavation no hearths were found. Now Mr. Nolles proposes that the Tjonger tradition people weakened the permafrost locally with their fires in such a way that the ground-water that was under pressure was able to escape. The actual hearth material (charcoal) could have become pulverized. During the excavation small fragments of charcoal were indeed found here and there.

Fig. 8. Basin II, overall view. The cover sand layering here follows the curvature of the basin. At the bottom of the basin several artefacts are present. The dark-coloured layer near the top is the B-horizon of the podsol profile; the darker layers towards the bottom are iron-oxide illuvial horizons.

From the photos and the lacquer peels it can clearly be seen that the boundary of the basins is very sharply defined and that the adjacent finely layered cover sand is in no way disturbed. This leads to the conclusion that this contact surface originated as a result of water erosion, while the adjacent layered cover sand was in a frozen state (fig. 13). This view is supported by a local undermining of part of the wall of the basin (fig. 14).

Whether the upward escaping water, in the event of the situation suggested above, crys-

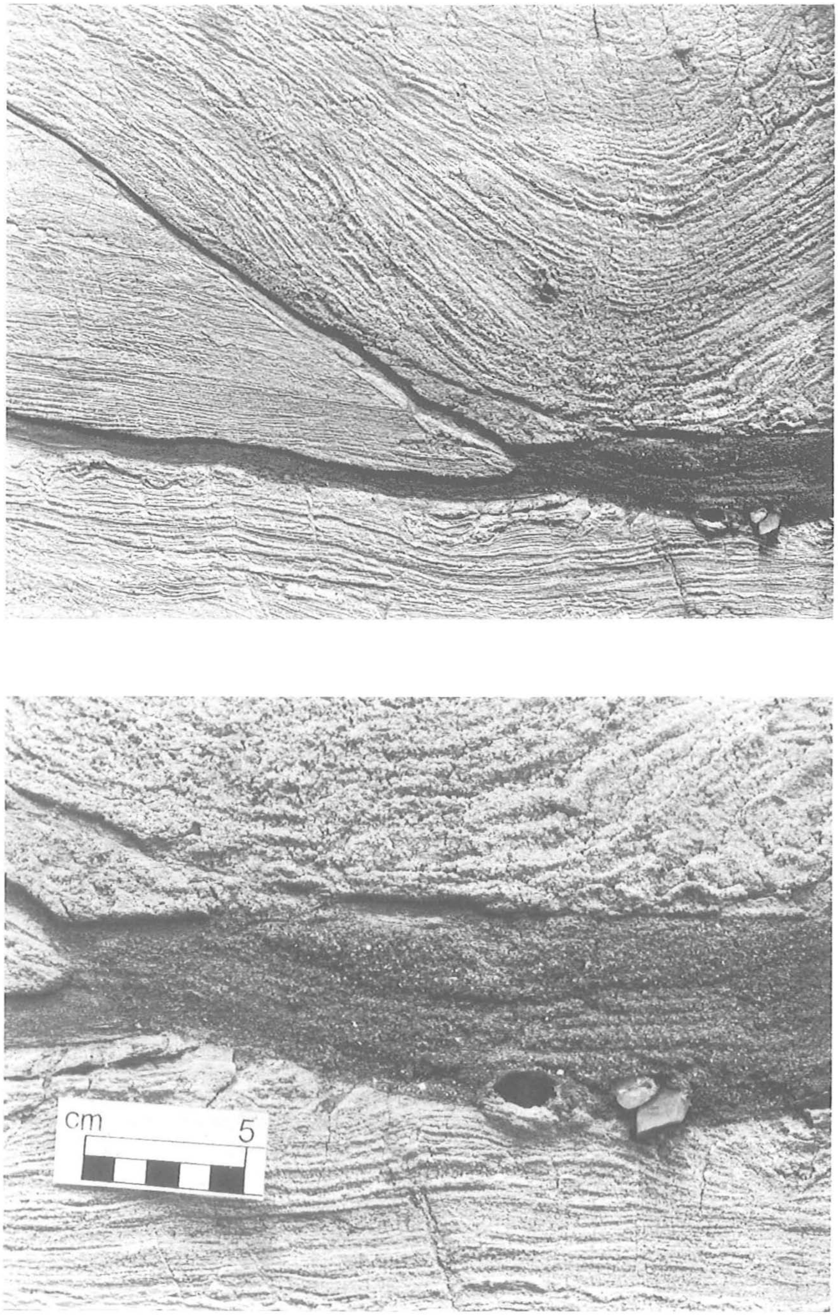

Fig. 9 a-b. Basin II, detail. The coarser sand with artefacts at the bottom.

tallized into an ice-lens and thus resulted in the formation of a pingo, a hillock with an ice-core, or whether the escaping groundwater washed out a basin it is impossible to say.

That water played a role at the time when these basins originated is also evident from the crust-like sand layer against the boundary of the basin (fig. 15). This residue layer, that shows fine parallel layering, consists of the

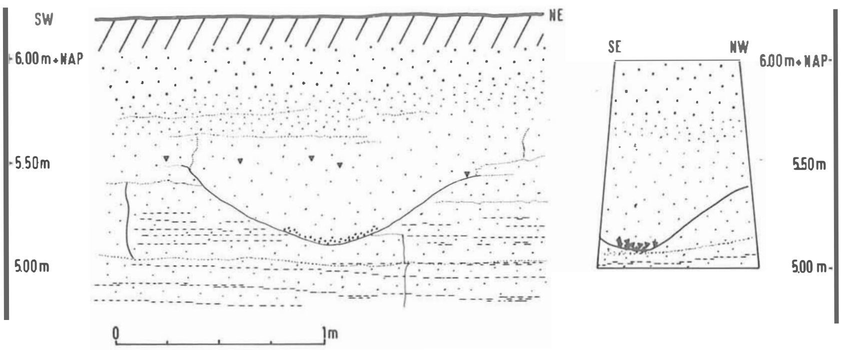

Fig. 10. Sections through basin II, left: parallel to the Schipsloot; right: at right angle to the Schipsloot. Legend: see fig. 6.

coarser sand grains of the cover sand complex, several glacial stones, artefacts and (in the case of basin I) wood. In fact this material represents the coarsest fraction of the cover sand plus culture layer at the spot where each basin occurs. Perhaps this situation could have arisen when at each spot a hearth melted the permafrost, the ground-water gushed out under pressure and washed out a small pond, in which this material became sedimented. How this material became washed out we do not know.

As stated previously, the peat originated as floating bog, undoubtedly in open water. In view of the bowl-like shape of the basin the soil must still have been frozen. The peat layer is situated remarkably deep in the (dried up) basin, namely immediately above the crust-like sand layer. During the process of peat formation there was therefore no sedimentation of mineral material of any significance. The almost sand-free character of the peat indicates that during the process of peat formation there was little or no transport of wind-

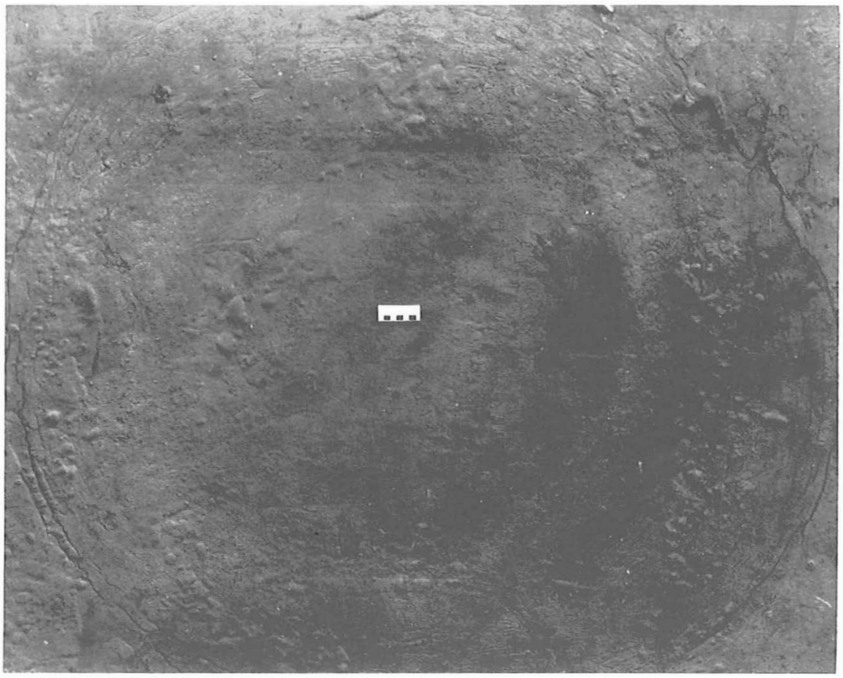

Fig. 11. Basin IV, horizontal cross-section. Above right two finds next to the periphery of the depression. Measuring staff: 5 cm.

blown sand taking place. It can be excluded that the peat-forming vegetation hindered sedimentation in the basin.

While peat formation was taking place the basin may still have been filled to a considerable extent with ice, so that there may have been open water of very limited depth in which peat formation occurred. The (virtual) absence of slumping phenomena along the wall of basin I is indicative of the permanent presence of ice in the basin.

The occurrence of the conspicuous crust-like sand layer, that consists partly of coarse sand, is not conclusively explained in this way. This applies particularly to the layering, that continues practically as far as the periphery of the basin, as already mentioned in section 4.

The ice lens finally melted completely, and the water sank away downwards fairly rapidly, so that the peat layer ended up on top of the coarser layered sand of the crust-like layer. With regard to the dating of this development the following can be said. The smoothness of the curves of many pollen types, see fig. 12, such as *Salix, Pinus, Betula, Juniperus* and *Artemisia*, suggests that we are not concerned here with a process of peat formation lasting several centuries, as already stated in section 5. The emptying of the basin can therefore probably be dated only somewhat later than the age obtained for the peat layer, 10.495 ±60 B.P. It must be remembered that this C14-dating does not indicate the time of emptying, and that we cannot say how long a period of time elapsed after this dating before the basin became dry.

The fact that the water in the basin sank away fairly rapidly is attributable in our opinion to the disappearance of the permafrost, as the result of a climatic improvement. For the rest the basin subsequently became filled up with cover sand. Towards the bottom of the cover sand filling there are one or more thin loamy sand-lenses present, that could indicate repetition of the process, possibly as a result of very slight improvements in climate. But subsequently the basin became filled up

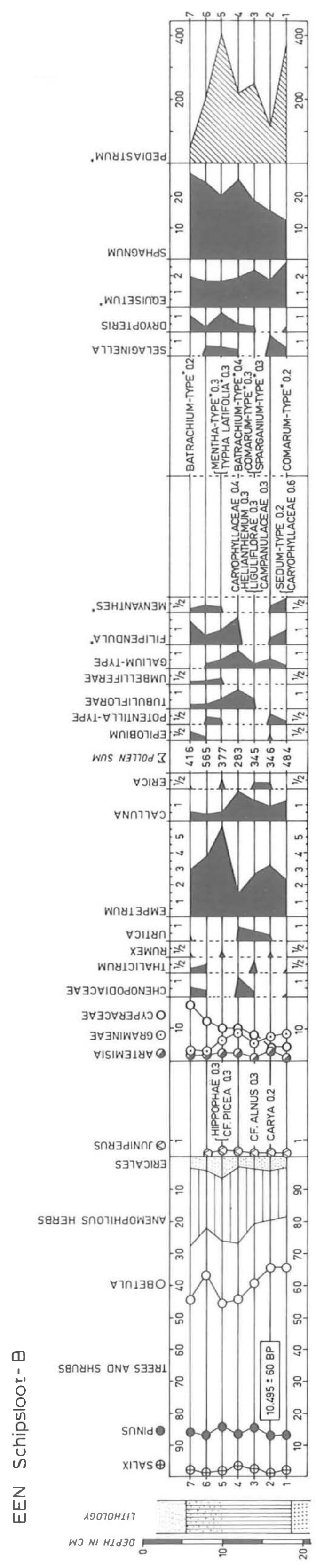

Fig. 12. Pollen diagram for Een Schipsloot-B (filling of basin I).

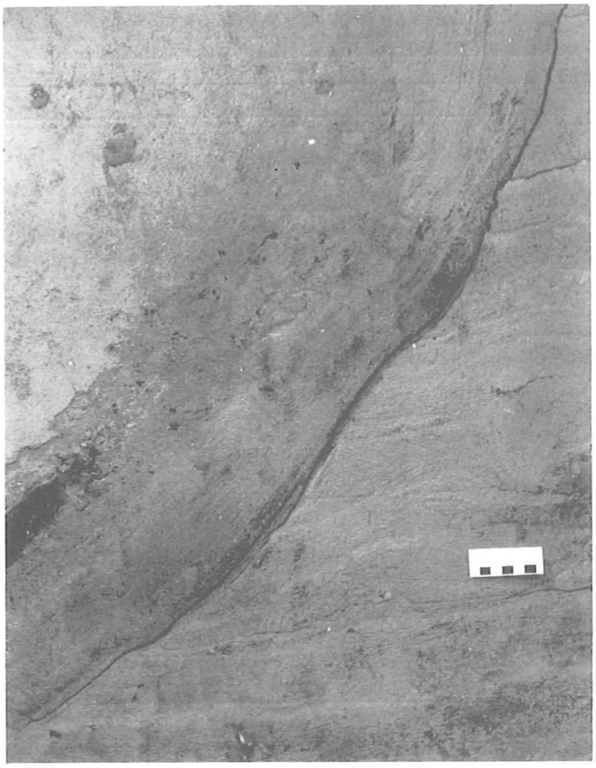

Fig. 13. Basin I, detail, showing the sharply defined base of the basin filling. This base is accentuated here by an iron-oxide horizon.

Fig. 14. Basin I, detail of the upper part of the wall, where locally undercutting had taken place (photo 1/3 of actual size).

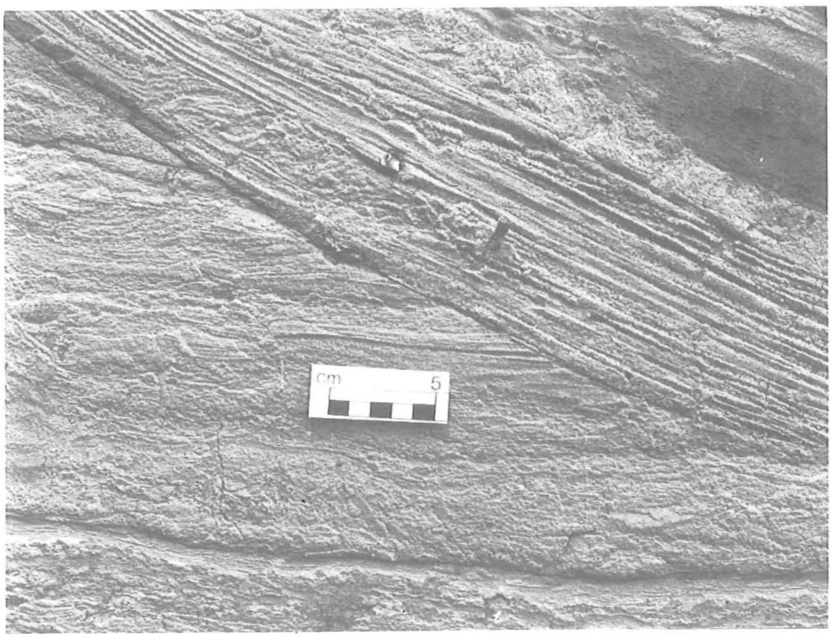

Fig. 15. Basin I, detail, showing at upper right the edge of the peat lens and underneath it the finely-layered, crust-like layer of coarse sand. The base of the basin filling is very sharply defined against the horizontally layered cover-sand.

with cover sand, Younger Cover sand II; outside the basins too this cover sand was deposited in a series of layers.

In the small basins the layering of this cover sand follows the curvature of the wall (figs. 8,9), while in the large and fairly deep basin I (fig. 7) these finely layered sands are disturbed in the central part of the basin.

The depth of the basins varies from 0.15-1.00 m. Assuming that the depth of the basin indicates approximately the thickness of the permafrost at the time when the basin originated, the question arises whether we are concerned here with considerable differences in thickness in a developing permafrost, or with differences in time. In the latter case a relative chronology could be established on the basis of depth.

7. SUMMARY

In the very narrow watershed region of the valley systems of the Tjonger and Peizerdiep, that originated during the Pleniglacial, remains have been found of the Tjonger tradition. The site lies at a relatively high point of the somewhat undulating Allerød horizon, developed as a soil over the Younger Cover sand I. At the lower spots of this horizon a thin, sandy peat layer formed in the *Betula* phase of the Allerød.

At the beginning of the Late Dryas a permafrost was formed here; possibly in connection with this, round basins originated in the frozen soil, with a diameter of 1-3 m and a depth of 0.15-1.00 m. The upward movement of ground-water under pressure probably played a role in this. In the basins open water was present; in the largest basin (basin I) peat formation took place. This is dated to 10,495 ± 60 B.P. (GrN-6341).

Precisely how the basins originated cannot be satisfactorily explained; it is possible that hearths of the Tjonger people weakened the permafrost to such an extent that the process of upward movement of ground-water was set in motion as a result. At the bottom of the basin filling a coarse sandy layer is present, like a crust, that continues against the wall of the basin practically as far as its periphery. The boundary between the wall of the basin and the crust-like sand layer is very sharply defined. Ultimately the basins dried up, after which they became filled up with Younger Cover sand II. This occurred still during the Late Dryas, possibly in connection with the disappearance of the permafrost.

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