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THE DEVELOPMENT OF THE LANDSCAPE OF THE NATURE RESERVE DE HAMERT AND ITS ENVIRONS IN THE NORTHERN PART OF THE PROVINCE OF LIMBURG, THE NETHERLANDS[1]

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ABSTRACT

Teunissen, D. 1983 The development of the landscape of the nature reserve De Hamert and its environs in the nothern part of the province of Limburg, The Netherlands. In: J.H.J. Terwindt & H. Van Steijn (eds): Developments in physical geography – a tribute to J.I.S. Zonneveld –Geol. Mijnbouw 62: 569-576.

As appears from geomorphological and palynological data, the Heerenven lake in the nature reserve De Hamert forms a remnant of a branch of the river Meuse, dating from the Weischselian Glacial Period. In the early Holocene this river branch was almost completely covered by eolian sands; only the Heerenven remained free of an eolian cover. In the area between the Heerenven and the present valley of the river Meuse there is a clay layer with peaty intercalations between the eolian cover and the underlying terrace sediments; the peat/clay layer could palynologically be dated in the Weichselian Late-Glacial. The combined data permit the conclusion that the terrace west of the Heerenven-Meuse belongs to the Weichsel-glacial Lower Terrace. The terrace at the east side of the Heerenven is older and can be correlated with the 'Krefelder Mittelterrasse', the sediments of which were formed during the height of the Saalian glaciation.

INTRODUCTION

In the basin of the Lower Rhine ('Cologne Bight'), north of the line Maastricht-Bonn, the Rhine and Meuse formed an extensive terrace landscape since the end of the Tertiary Period as a result of alternating phases of erosion and sedimentation. The main terrace steps that can be distinguished are: 'Ältere Hauptterrasse' (Older Main Terrace), 'Jüngere Hauptterrasse' (Younger Main Terrace), 'Obere Mittelterrasse' (Higher Middle Terrace), 'Untere Mittelterrasse' (Lower Middle Terrace), 'Krefelder Mittelterrasse' (Lowest or Krefeld Middle Terrace) and 'Niederterrasse' (Lower Terrace); cf. QUITZOW (1956), QUITZOW ET AL. (1962).

In the Dutch-German borderland east of the Meuse section between the North Limburg villages of Arcen and Bergen, several relief elements (among which some flat-topped, isolated hills) form part of this landscape. The classification of these elements under the above-mentioned units led to divergent interpretations (WUNSTORF & FLIEGEL, 1910; BREDDIN, 1938; STEEGER, 1952; QUITZOW, 1955; 1959, BRAUN, 1955; QUITZOW & ZONNEVELD, 1956; ZONNEVELD, 1956b; 1977; BRAUN & QUITZOW, 1961; PAAS & TEUNISSEN VAN MANEN, 1975; STIBOKA, 1975; and others).

ZONNEVELD (1956b), on the basis of a heavy-mineral study, correlated the terrace remnants of Straelen, Lingsfort, Walbeck, Twisteden and Wemb (Fig. 1) with the terrace region to the southeast, where unanimity concerning the age of the terraces is much greater. He concluded that the terrace remnants of Straelen, Walbeck and Wemb belong to the Younger Main Terrace, which can be correlated with the Sterksel Formation (Menapian-early Cromerian). The terraces of Lingsfort and Twisteden, according to ZONNEVELD, belong to the Higher Middle Terrace, which can be correlated with the Urk Formation (middle Cromerian–Holsteinian). Apart from the 'Mittlere Mittelterrasse' (not morphologically present in these regions), the Rhine terraces, which are younger than the Higher Middle Terrace, all have about the same heavy-mineral composition and cannot be distinguished on these grounds.

In the area of Arcen, Lingsfort, Well and Wemb (Fig. 1) the post-Holsteinian terraces are partly of Rhine-, partly of Meuse origin. ZONNEVELD (1956b) is of the opinion that the

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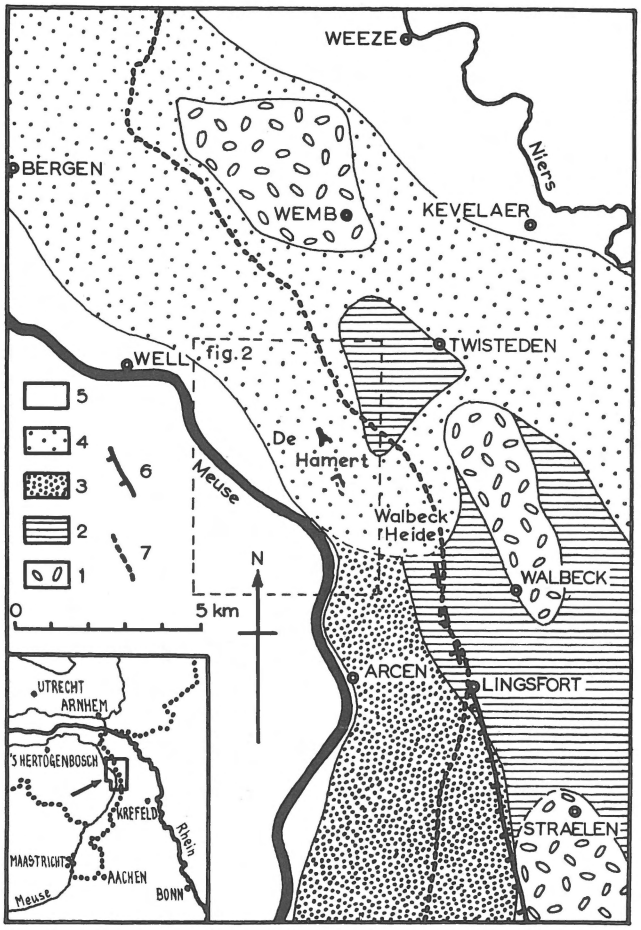


Fig. 1
The terrace landscape between Straelen and Weeze, according to Zonneveld 1956b. 1. Younger Main Terrace (Sterksel Formation); 2. Higher Middle Terrace (Urk Formation); 3. Lower Middle Terrace (Veghel-B Formation); 4. Lowest or Krefeld Middle Terrace (Well Sands); 5. Lower Terrace (Kreftenheye Formation) and younger landforms and formations; 6. Boundary Fault; 7. State boundary. Eolian sands not indicated.

low lying terrace between the Meuse and the terrace remnants of Staelen and Lingsfort belongs to the Lower Middle Terrace of the Meuse (Veghel-B Formation, Saalian Early-Glacial Period; cf. VAN DEN TOORN, 1976). In the area east of the Meuse and west of the terrace remnants of Twisteden and Wemb, ZONNEVELD found Rhine sands near Bergen, near Well and on the Walbeck Heide (Walbeck Heath); he named them Well Sands. On the grounds of their Rhine-origin, their altitude and their geographical situation, ZONNEVELD (1956a; b; 1958) concluded that it is highly probable that these sands belong to the Krefeld Middle Terrace. He placed the Well Sands in the period in which the expanding Saalian inland ice forced the Rhine to divert its course in westerly directions; the depression between the terraces of Walbeck and Twisteden would have acted as the southernmost escape route of the Rhine waters at that time.

In one of the figures of his paper ZONNEVELD (1956b) gave evidence of his opinion that the Well Sands form the subsoil of the whole area between the terrace remnant of Twisteden and the recent Meuse valley, the greater part of which area is occupied by the nature reserve De Hamert (Fig. 1). New palynological, geological and geomorphological data, however, lead to the conclusion that a considerable part of the subsoil of the reserve belongs to the Lower Terrace (Kreftenheye Formation).

GEOLOGY AND GEOMORPHOLOGY OF DE HAMERT

The terrace landscape

In the Hamert area three lakes respectively lake complexes are present: the Westmeerven, the Heerenven and the Pikmeeuwenwater (Fig. 2). As each of these lakes has its own typical geological position, we will, in discussing the geological structure of the area, frequently refer to them.

The subsoil of the nature reserve De Hamert is formed by rather coarse, gravelly fluviatile sands, their top having an

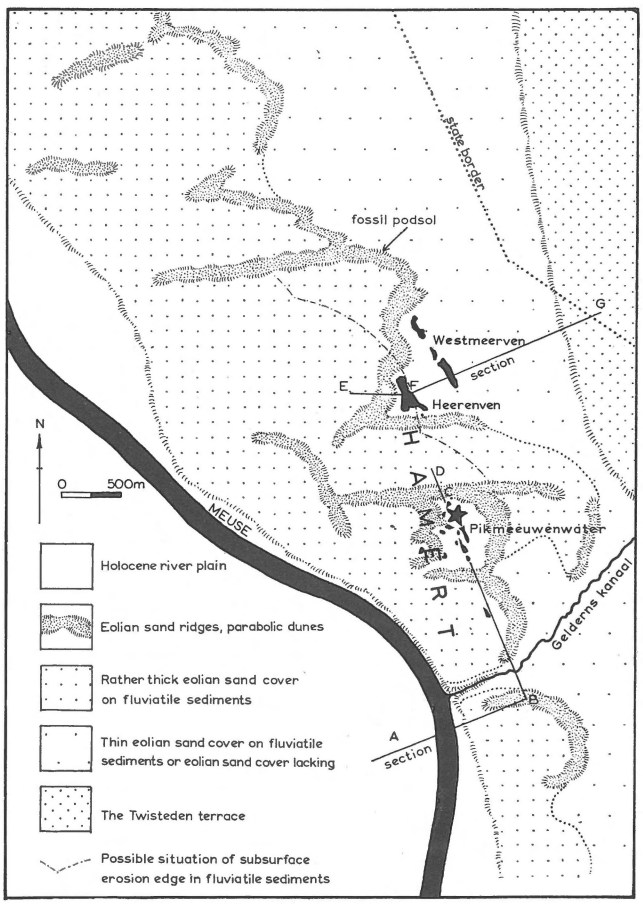


Fig. 2
The distribution of the eolian sediments in the area between the river Meuse and the Twisteden Terrace in the environs of the nature reserve De Hamert.

altitude of circa 17,5 m + NAP in the Pikmeeuwenwater area and of nearly 18,5 m + NAP in the surroundings of the Westmeerven (NAP = circa mean sea level). The Heerenven is situated in the transition zone of these two areas. West of the Heerenven and in the environments of the Pikmeeuwenwater a circa 30 cm thick clay and peat layer lies on top of the fluviatile sands. This layer is absent in the area east of the Heerenven. Thus, the Heerenven divides two distinct sedimentation areas, that is to say two different terraces, of which the western one is the younger. As in these regions the older terraces have a steeper gradient than the younger, the intersection of both terraces can be expected not far to the north.

The top of the younger Hamert terrace (the clay/peat layer included) has an altitude of circa 17,8 m + NAP. On the basis of 15 observation points between Echt (south of Roermond) and Vierlingsbeek (half-way Venlo and Nijmegen) PONS (1954) constructed a grade-line of the Lower Terrace of the Meuse. Relying on this line, the surface of the Lower Terrace in the vicinity of De Hamert can be expected at a level of about 18 m + NAP. The data of the 'pre-Bølling Lower Terrace' of the Meuse, as constructed by VAN DEN BROEK & MAARLEVELD (1963) lead to the same conclusion. So it is highly probable that the younger of the two Hamert terraces belongs to the (Weichselian) Lower Terrace of the Meuse.

In that case, the older Hamert terrace must have been formed before Weichselian times. As this terrace is younger than the terrace of Twisteden (the formation of which was ended in the Holsteinian) it can be placed in the Saalian Glacial Period or shortly before or after that time. The older Hamert terrace may than be correlated with the Lower Middle Terrace of the Meuse (early Saalian) or with the Krefeld Middle Terrace of the Rhine (Well Sands, Saalian Pleni-Glacial).

ZONNEVELD (1956b) found the Well Sands in some localities south and north of De Hamert (Walbeck Heide, Well, Bergen); according to him the Rhine waters that deposited these sands laterally eroded the Veghel-B Formation near Walbeck Heide, so that the Well Sands must have been formed after early Saalian times, that is to say during the height of the Saalian Glaciation. If the Lower Middle Terrace of the Meuse north of Walbeck Heide has disappeared by erosion (remnants of it are supposed to be present in the deeper subsoil; cf. VAN DEN TOORN, 1976) the older Hamert terrace must be correlated with the Well Sands and be placed in Saalian pleni-glacial times. In all probability it can, then, be considered as a part of the Krefeld Middle Terrace.

Eolian morphology

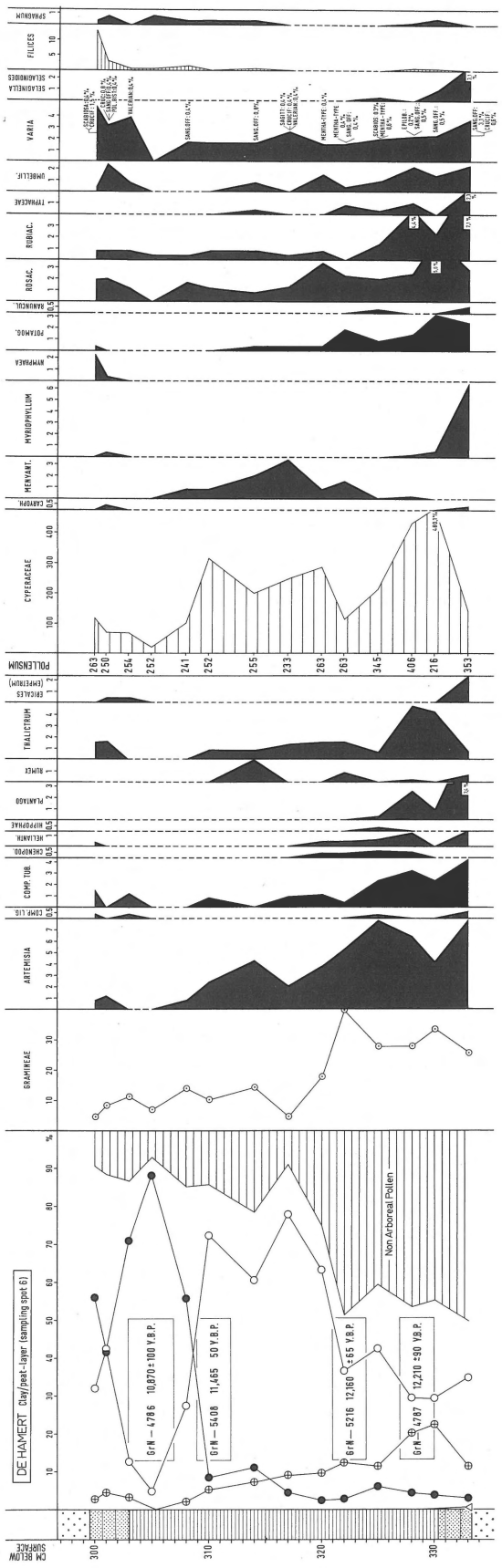
In the area of De Hamert, but also south and north of it, the terrace strip between the river Meuse and the terrace remnants of Lingsfort, Twisteden and Wemb is to a large extent covered by eolian drift-sands. On many places these sands have been blown into well-developed parabolic dunes which migrated in easterly directions but are now fixed by vegetation (Fig. 2). With the exception of the nearest surroundings of the Heerenven, the dunes cover the low erosion scarp between the two Hamert terraces. In the hinterland of the parabolic dunes, between the recent Meuse valley and the dune front, the drift-sand cover is several metres thick; here we find the Pikmeeuwenwater lake complex. Between the dune front and the terrace remnant of Twisteden the fluviatile sediments bear only a thin eolian cover or none at all; here the Westmeerven is situated.

In 1957 PONS published a study on the geology and the soil formation in the area west of Nijmegen (the Country of Meuse and Waal and a part of the Nijmegen Realm). The area is situated 40 km downstream of De Hamert, east of the river Meuse. Here too, extensive eolian drift-sand complexes occur. PONS proved that these eolian sands were blown from the Meuse valley in the Late Dryas time. Late in this period and in the early Holocene the drift-sands must have developed a dune relief. The eolian sands are situated on the fluviatile sediments of the Lower Terrace (Kreftenheye Formation), which is here of a mixed Rhine-Meuse origin. In the Nijmegen area a clay layer occurs between the blown-sands and the fluviatile sediment. Palynological investigations proved that the clay layer was formed in a period ranging over the Bølling till late in the Allerød Interstadial; in that time the rivers, as a result of incision elsewhere, were retreating from the Lower Terrace (TEUNISSEN & DE MAN, 1981). It is highly probable that the clay/peat layer in the western part of De Hamert is as old as the clay layer at the base of the eolian complex in the Nijmegen area, and that the history of the blown-sands in both areas is analogous. As we will see, palynological investigations confirm these presumptions.

The lakes

The clay/peat layer in the western Hamert area is strongly compressed by the weight of the overlying wind-blown sands and forms an impermeable layer at the base of the eolian complex. In consequence, the eolian sediments here contain a local body of ground water. When this body expanded, several blown-out depressions in the eolian complex were inundated. The Pikmeeuwenwater lakes were formed in this way; they are exclusively fed by rain water. In the area of the Pikmeeuwenwater the regional ground water level stands far beneath the clay/peat layer, in the fluvial sands (Fig. 5).

The Heerenven, on the contrary, reaches deeply into the fluviatile sediments; the lake sediments not taken into account, the lake bottom finds itself at 14 m + NAP. This lake basin cannot be the result of wind erosion, but it must have been formed by running water. We think that the Heerenven, situated in the transition zone between the two Hamert terraces, is a remnant of a Weichselian Meuse branch that belonged to the younger Hamert terrace. After its degeneration the old river bed was covered by dunes south and north of the present lake (Fig. 2).



The Westmeerven is situated in a rahter shallow depression in the fluviatile sediments of the older Hamert terrace. Probably it is a remnent of a former drainage channel. Dune sands did not play a role in the origin of the lake. Heerenven as well as Westmeerven are in more or less open connenction with the regional ground water level (TEUNISSEN, 1976; cf. Fig. 5).

THE PALYNOLOGICAL AND RADIOCARBON DATA

In order to check our suppositions concerning the age of the younger Hamert terrace and the Heerenven-Meuse, we sampled both the clay/peat layer in the Pikmeeuwenwater area and the lake sediments of the Heerenven for palynological investigation.

The clay/peat layer was sampled at the north side of the largest lake of the Pikmeeuwenwater complex (asterix in Fig. 2). The layer was found 300 – 333 cm below surface (surface altitude 20,8 m + NAP). On this spot the layer is mainly composed of strongly compressed peat, with thin humic clay layers at the base and at the top. The palynological and ^{14}C-data of the layer indicate an age ranging from the Bølling Interstadial till late in the Allerød Period (the uppermost ^{14}C-sample was somewhat contaminated with younger material; Fig. 3). Indeed, the situation is analogous to that in the wind-blown sand area near Nijmegen, studied by PONS (1957). This confirms the presence of the Lower Terrace (Kreftenheye Formation) in the subsoil of the western part of De Hamert.

While the palynological data of the Pikmeeuwenwater lake complex indicate that the terrain depressions in question were inundated only since late Holocene times, the data of the Heerenven prove that sedimentation here started already in the Late Dryas time, possibly even somewhat earlier (Fig. 4). The development of the bottom sediments of the Heerenven

Fig. 3 ←
Pollen-diagram of the clay/peat layer in De Hamert. Lithography: 0-329,5 cm eolian drift-sands; 329,5-303 cm humic clay; 303-330,5 cm strongly compressed peat; 330.5-333.5 cm humic clay; 333.5-350 cm fluviatile sands. From an earlier sample of the clay/peat layer taken at a site near the palynological sampling location, the age of the transition zone between the peat and the underlying thin clay layer was established at 12,760 ± 150 ^{14}C-BP (GrN-4478).

Key for the pollen-diagrams: Figs 3 and 4)
- □ Alnus
- ■ Quercetum mixtum (Quercus, Ulmus, Fraxinus, Tilia)
- ◆ Corylus
- ● Pinus
- ○ Betula
- ⊕ Salix
- △ Picea

did not stop earlier than in the Atlantic Period; younger sediments are absent, but in all probability they accumulated until sub-recent times and have been removed during the last centuries by the local rural population, to obtain fuel (till in the 19th century extensive peat bogs were present in the area between the dune front and the terrace remnants of Twisteden and Wemb).

The sediments on the bottom of the Heerenven consist maily of soft clays, gyttjas and peat. The deeper layers of these sediments contain a fine-sandy admixture, proving drift-sand movements in the environs of the early Heerenven. The palynological data indicate that the wind-blown sands continued to be mobile till in the *Corylus*-phase of the Boreal Period. Then the increasing thickness of the vegetation cover must have led to the fixation of the drift-sands. These data confirm the findings of PONS (1957) in the Nijmegen area.

On the eastern slope of a parabolic dune in De Hamert (Fig. 2) we found a fossil podsol, covered by a thick layer of younger wind-blown sands. These younger sands, meanwhile, also heavily podsolized, probably came to rest here in late Holocene times, when renewed moving of eolian material was made possible by extensive clearing of the forests by man (Bronze and/or Iron Age). A ^{14}C-analysis of the A1-horizon of the podsol pointed to an age of 5,350 ± 40 ^{14}C-BP (GrN-7053). The possibility of contamination taken into account, the conclusion must be that the fossil podsol has an Atlantic or older age; the palynomorphs in the horizon (showing a rather high *Alnus* representation besides high values for *Calluna*) exclude, however, an age older than an Atlantic one. Thus, the front of the parabolic dunes was immobile since late Boreal to Atlantic times.

The Westmeerven can be left out of consideration in this study. The lake is substantially shallower than the Heerenven, and the oldest sediments it contains can be dated palynologically in the early Holocene.

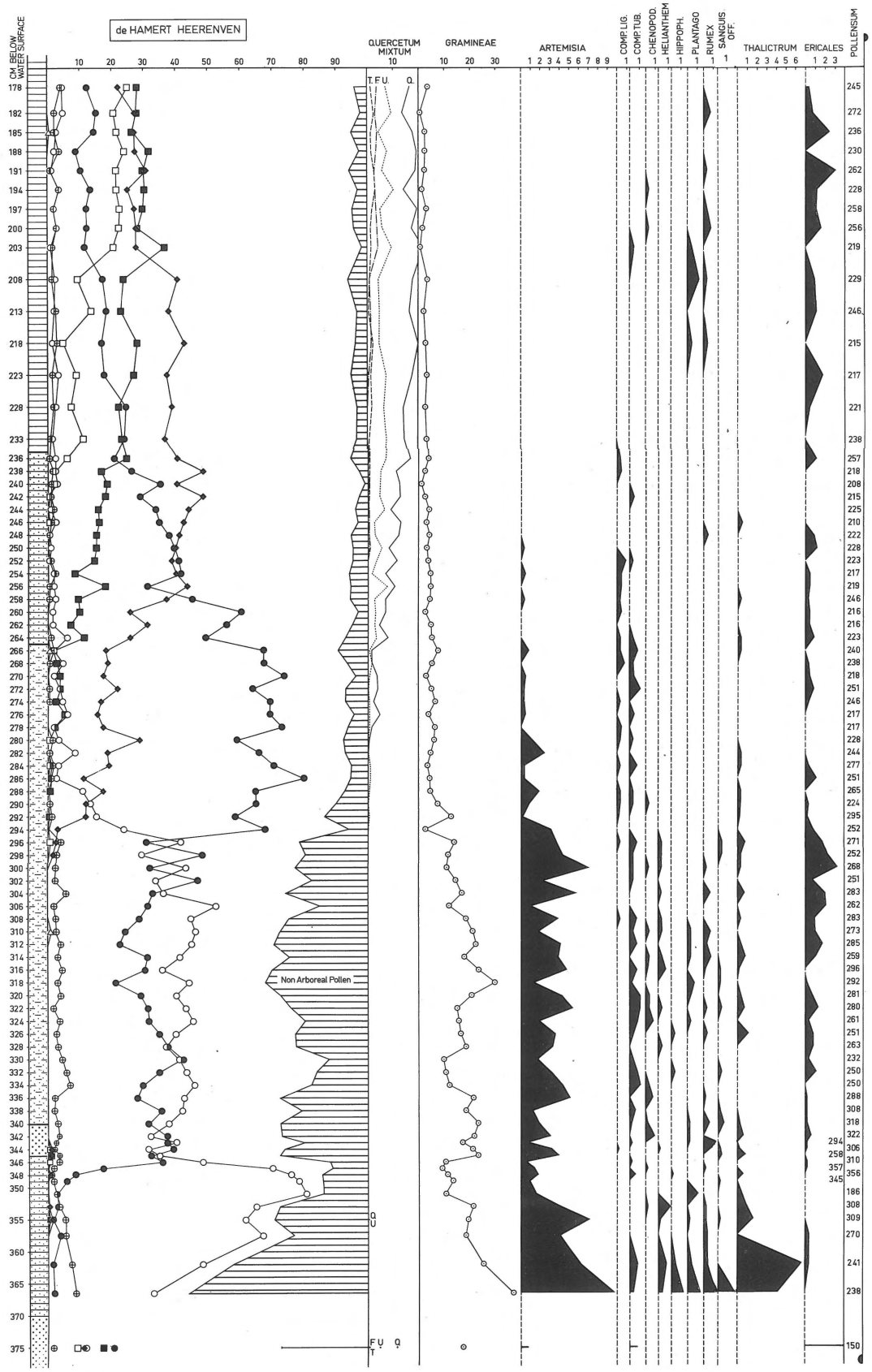
CONCLUSIONS

Our investigations have proven that each of the lakes respectively lake complexes in the nature reserve De Hamert has its own history, and that the differences in their mode of origin can be connected with differences in the subsoil geology. The Pikmeeuwenwater lakes were formed when, rather late in Holocene times, eolian depressions in the wind-blown sand area were inundated by an expanding local ground water body, borne by a Weichselian late glacial clay/peat layer at the base of the eolian sands. The subsoil of this lake complex belongs to the Lower Terrace of the Meuse. The Heerenven lake is a remnant of a Weichselian Meuse branch, situated at the foot of a low erosion scarp which separates the Lower Terrace of the Meuse from a terrace that in all probability belongs to the Krefeld Middle Terrace, which is of Rhine origin. This river bed was abandoned by the Meuse in late Allerød or early Late Dryas times; in the early Holocene it was transformed into a lake by parabolic dunes which, while migrating eastward, covered the old river bed at both the south and the north side of the Heerenven. The Westmeerven is possibly an old drainage channel of the Krefeld Middle Terrace.

The genesis of the landscape of De Hamert and its surroundings can be summarized as follows (cf. Fig. 5):

1. In early Saalian times the Meuse formed here the sediments of the Lower Middle Terrace (Veghel-B Formation).
2. From Walbeck Heide northward these Meuse sediments for the greater part were swept away by Rhine waters escaping to the west under the influence of the approaching inland ice in the Saalian Pleni-Glacial. The Rhine replaced the removed material by the Well Sands, which in all probability belong to the Krefeld Middle Terrace.
3. Subsequently, the Meuse incised itself in the combined sediments of the Lower Middle Terrace and the Krefeld Middle Terrace and partly replaced them by the sediments of the Lower Terrace (Kreftenheye Formation, mainly Weichselian Pleni-Glacial). In this time the Heerenven-Meuse eroded laterally the Krefeld Middle Terrace at its right bank.
4. In Weichselian late-glacial times a Meuse branch in the western part of the Meuse valley incised itself in the sediment of the Lower Terrace. The Heerenven-Meuse degenerated; during the last inundations it left a clay layer, intercalated with peat, on the non-eroded parts of this terrace.
5. In the Late Dryas time eolian sands, originating from the newly formed Meuse valley in the west, were blown eastward over the Lower Terrace and its clay/peat layer.
6. Mainly in the early Holocene, parabolic dunes developed from these eolian sands under the influence of the prevailing southwesterly winds and the recovering vegetation. In the hinterland of the dune ridges wind-blown basins were formed.
7. In most places the parabolic dunes were fixed by vegetation not earlier than they had reached and covered the western margins of the Krefeld Middle Terrace, viz. in late Boreal or early Atlantic times. The part of the Heerenven-Meuse that remained free of an eolian cover developed into the Heerenven lake.
8. Borne by the late Weichselian clay/peat layer a local ground water body developed in the eolian sands on the Lower Terrace. In late Holocene times, possibly under the

Fig. 4 (following pages)
Pollen-diagram of the bottom sediments of the Heerenven lake in the nature reserve De Hamert. Lithography: 178-235 cm below surface: peat; 235-265 cm detritus gyttja with fine-sandy admixture; 265-340 cm fine-sandy humic clay; 340-345 cm slightly humic fine sand; 345-370 cm fine-sandy clay-gyttja; 370-400 cm fluviatile sands. Key same as for Fig. 3.


de HAMERT HEERENVEN
CM. BELOW WATER SURFACE
QUERCETUM MIXTUM
T.F.U.
Q.
GRAMINEAE
ARTEMISIA
COMP.LIG.
COMP.TUB.
CHENOPOD.
HELIANTHEM.
HIPPOPH.
PLANTAGO
RUMEX
SANGUIS OFF.
THALICTRUM
ERICALES
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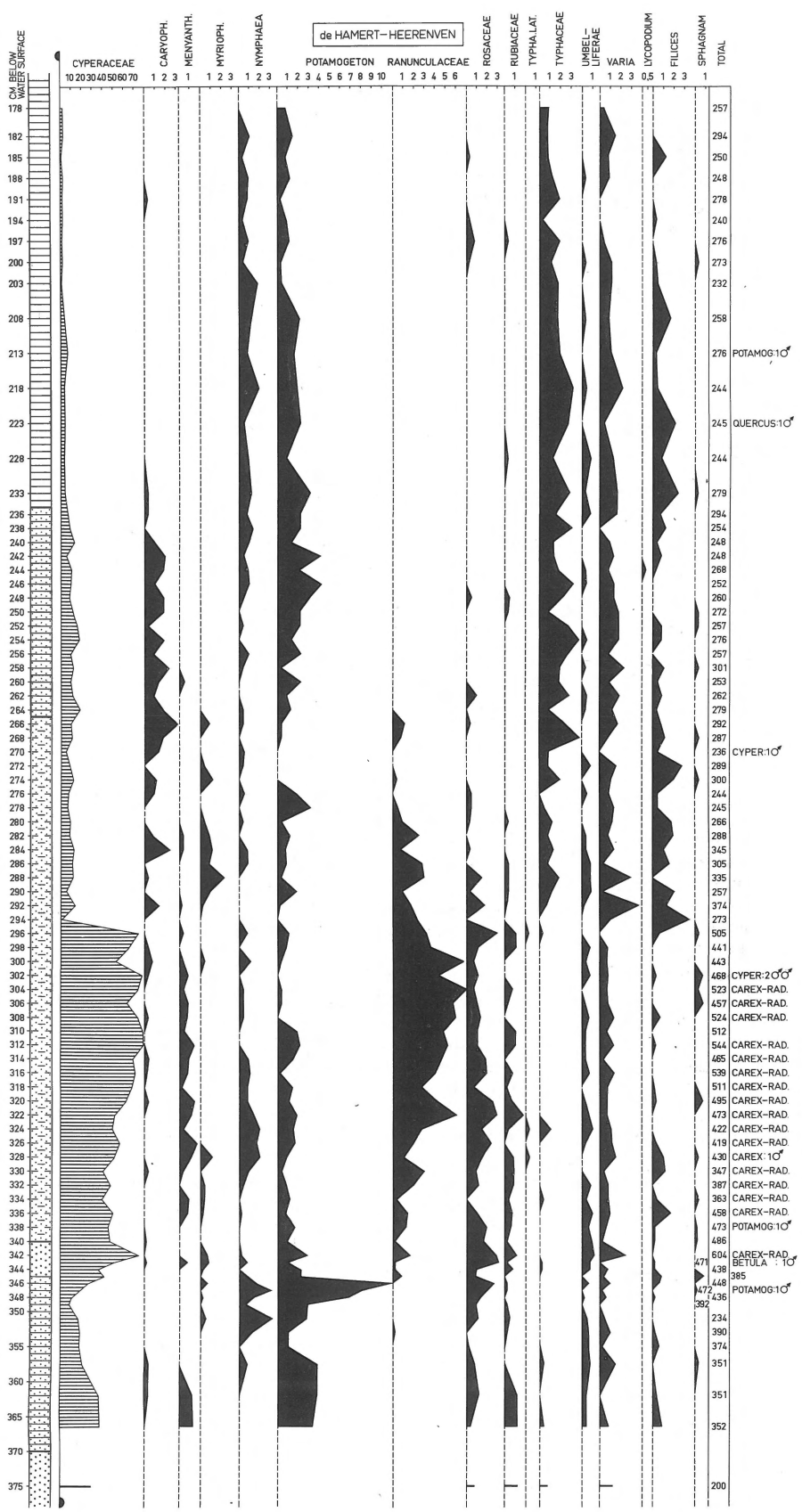
de HAMERT–HEERENVEN
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CYPERACEAE
CARYOPH.
MENYANTH.
MYRIOPH.
NYMPHAEA
POTAMOGETON
RANUNCULACEAE
ROSACEAE
RUBIACEAE
TYPHA LAT.
TYPHACEAE
UMBEL-LIFERAE
VARIA
LYCOPODIUM
FILICES
SPHAGNAM
TOTAL
POTAMOG:1♂
QUERCUS:1♂
CYPER:1♂
CYPER:2♂♂
CAREX-RAD.
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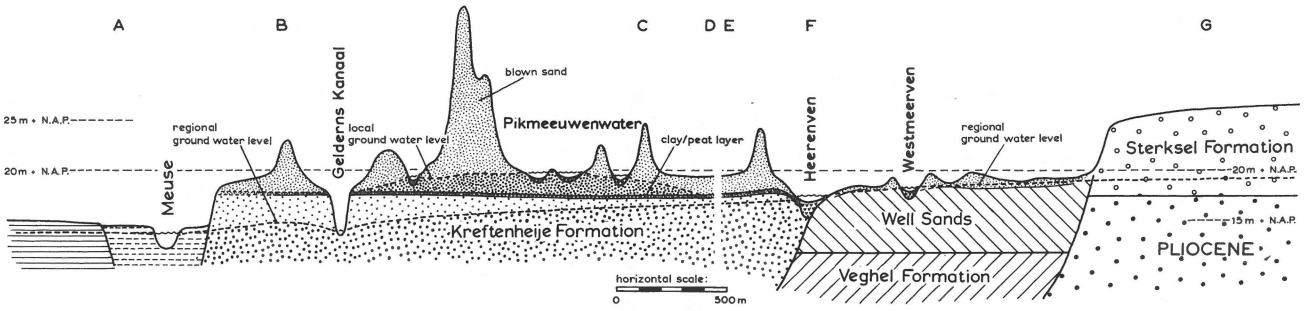

Fig. 5
Geological section through the area of the nature reserve De Hamert (cf. Fig. 2).

influence of forest clearings by man, the water body expanded and inundated the wind-blown terrain depressions in the hinterland of the parabolic dunes (origin of the Pikmeeuwenwater lake complex).

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