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Bronze fibula with three pinned-on rings from Crustumerium, Monte Del Bufalo burial ground, Tomb 153 (photo G.J.M. van Oortmerssen, RUG/GIA).

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HEATHLAND AND THE PALYNOLOGY OF PREHISTORIC BARROWS
REFLECTIONS ON THE INTERRELATION BETWEEN SOIL FORMATION AND POLLEN INFILTRATION

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ABSTRACT: In the sandy areas of the Netherlands, heather (*Calluna vulgaris*) played an important role in the construction of prehistoric barrows, although, as will be shown in this paper, not in all periods as was recently asserted by Doorenbosch (2013). Since the mineralogical composition and the texture of the sandy deposits determine the vegetation and the occurrence of podzolization, no generalizations concerning the presence of heathland in relation to prehistoric barrows can be made. Post-depositional formation processes like podzolization and pollen infiltration should always be considered in relation to the nature of the subsoil.

KEYWORDS: Podzolization processes, heathland, prehistoric barrows, soil pollen.

1. INTRODUCTION

Palynology of old surface layers and sods in prehistoric barrows in the Netherlands, initiated by Professor A.E. van Giffen and for the first time systematically carried out by Waterbolk for his thesis (Waterbolk 1954), has been successfully applied whenever new or renewed research has taken place (Van Zeist 1955; Casparie & Groenman-van Waateringe 1980; Doorenbosch 2013). Why has this kind of research been so successful in the Netherlands, resulting in two dissertations specifically dealing with the palynology of barrows (Waterbolk 1954; Doorenbosch 2013) and one dealing partly with this subject (Van Zeist 1955), in contrast to other countries (Groenman-van Waateringe 2011)? The explanation lies in the soil conditions of the barrow sites and the associated vegetation. For the most part, the Dutch prehistoric barrows are to be found on poor sandy soils which supported a vegetation dominated by heather. The heath stretching around and over the barrows gave rise to an impenetrable iron-pan layer or illuvial horizon in the topsoil. In combination with the acidity of the soil, there was no question of any biological activity causing downward transportation of younger pollen into the old surface layer(s) beneath the barrow. The question, however, is, when did this domination of heather start? Did the acidification and iron-pan formation occur immediately upon the barrows' construction, and was this in time to prevent the downward movement of pollen grains in the centuries after this construction?

Over half a century of pedogenetic research has shown that podzolization in Pleistocene sandy deposits in northwestern Europe is marked by a great diversity across space and time, which is driven by numerous soil-forming factors and processes (Buurman 1984; Lundström *et al.* 2000; Blume *et al.* 2010; Duchaufour 2012). The main factors – in order of increasing dominance – are climate, hydrology, parent material and vegetation, whereby the last-named generally is strongly interwoven with human activity.

The influence of the climate mainly concerns the level of precipitation surplus. In Atlantic coastal regions and in uplands with an extreme precipitation surplus even sediments that are mineralogically very rich will readily podzolize. On the Pleistocene sandy soils of the Northwest-European Plain the situation is less extreme. Although the precipitation surplus varied with climatological fluctuations in the course of the Holocene (Dupont 1987), and would therefore have affected podzol formation to some extent, these fluctuations were insufficient to cause significant temporal and spatial variations in podzol soils (Buurman 1984).

By contrast, the local and regional hydrology of the sandy area in question was of much greater influence. Palynological and pedological research by Havinga of soil profiles buried under peat and other hydromorphous soil profiles showed that under the influence of high groundwater levels, brown forest soils in almost all cases degrade into podzols (Havinga 1963). In this way, well-developed podzol soils may have formed as early as the Early Holocene or even the Late Glacial. Such hydrologically induced – and therefore locally or micro-regionally determined – podzols should not of course be regarded as indicative of the general development of podzols on drier soils too, and the associated degradation of woodlands to heaths.

The most influential factor on the spatial and temporal variability of podzol soils in the sandy areas of the Netherlands was almost certainly the texture and mineralogy of the sandy deposits in question. The general line is that sandy soils with a mineralogically rich composition and/or high content of silt and lutum are far less prone to podzolization than are mineralogically poor soils and/or soils with a high content of sandy and gravelly constituents (Buurman 1984). In practice, this results in the following threefold division with regard to non-groundwater-affected soil profiles:

1. Mineralogically rich sandy soils that will hardly if at all podzolize, under any type of vegetation;
2. Sandy soils of moderate mineralogical composition that either will or will not degrade, depending on the type of vegetation;
3. Mineralogically poor sandy soils that will podzolize under any type of vegetation.

2. *CALLUNA* AND THE PALYNOLOGY OF BARROWS IN THE HOLOCENE OF THE NETHERLANDS

A recently published thesis (Doorenbosch 2013) questions the history of the barrow landscape before the barrows were built. The author mentions six (not five) cases where it has been shown that heather vegetation existed some time before the barrows were built (Doorenbosch 2013: 234). The age of the barrows in these cases ranges from the Early Bronze Age to the Early Iron Age (Doorenbosch 2013: 185, 189, 192-193). In chapter 13, a summary and interpretation of the case studies, it is stated that "Barrows were numerous and plentiful from the earliest Neolithic period. All these barrows being built in heath paint a different picture of the landscape than a closed forest with some small, open spaces." (Doorenbosch 2013: 235). Doorenbosch claims that the latter was assumed by Waterbolk (1954) and later by Casparie & Groenman-van Waateringe (1980). In both publications, however, nothing was said about the extent of the open spaces. On the contrary, the conclusion by Casparie & Groenman-van Waateringe 1980: 61) was that the environment in the vicinity of the barrows varied from slightly degraded forest to extremely degraded, heath-rich vegetations, with all possible intermediate stages including abandoned settlement sites with regeneration into open woodland or heathland, however, never primeval forest. Pollen data from Neolithic barrows in fact seldom point to dense woodland, nor do they indicate open country, but they do show all stages in between (Groenman-van Waateringe 1986: 188-189).

Not only does Doorenbosch suppose that all barrows were built in heath, but as a consequence she maintains that these barrows were all built from (heather) sods. Having excavated many barrows from different prehistoric periods, Van Giffen (1930: 180-181[1]) concluded that in general Neolithic barrows were built of sand, and Bronze Age and younger barrows of sods. According to Van Zeist (1955: 33), no clear soil profile is present below Neolithic barrows and it is therefore often difficult to locate the exact position of the old surface. Waterbolk (1954: 121) calls this a woodland profile. By contrast, the subsoil beneath Bronze and Iron Age barrows nearly always shows a more or less well-developed podzol profile (Van Zeist 1955), also when *Calluna* percentages are low (Waterbolk 1954: 123). Hence the Neolithic barrows must have been constructed in a different environment, not in heathland, but in a half-open or wooded landscape (Van Giffen 1947: 513). This has consequences for the barrows themselves. Grass turves and heather sods are only to be sourced in open landscapes. Grasses growing in (open) woods are not of the turf-forming kind, so cutting turves in a wooded environment is not possible. The result will be a barrow consisting of slightly humic sand. Failure to consider the soil conditions underneath and within the barrows themselves in the way that Casparie & Groenman-van Waateringe (1980) did for each barrow, has thus led to the erroneous conclusion that all barrows were built on heath and constructed of sods (Doorenbosch 2013). Generalizations of the kind offered by Doorenbosch (2013), such as putting the thickness of sods at around 25 cm, even in cases where the excavation report explicitly stated that no sods were observed,[2] fail to do justice to the great local variety in the environment and vegetation that prevailed in prehistoric times.

The majority of Dutch burial mounds are constructed on geological deposits that are mineralogically neither extremely poor, nor extremely rich. In the northern Netherlands the subsoils are meltwater deposits from the Elster glaciation, the great majority of coversand soils date from the Weichselian glaciation, and river-dune sands from the Weichselian and Early Holocene. These deposits were originally often calcareous and in the course of the Boreal and Atlantic periods became largely overgrown with deciduous forest. The associated soil was generally a brown forest soil fairly deeply homogenized by tree roots and soil fauna with moder as the main type of humus. Because the top layer of such soils will gradually leach out with a slight accumulation of aluminium ions occurring in the subsoil, these brown forest soils are referred to in the international literature as brown podzolic soils (Duchaufour 2012). As long as the forest vegetation remained, this type of soil continued to

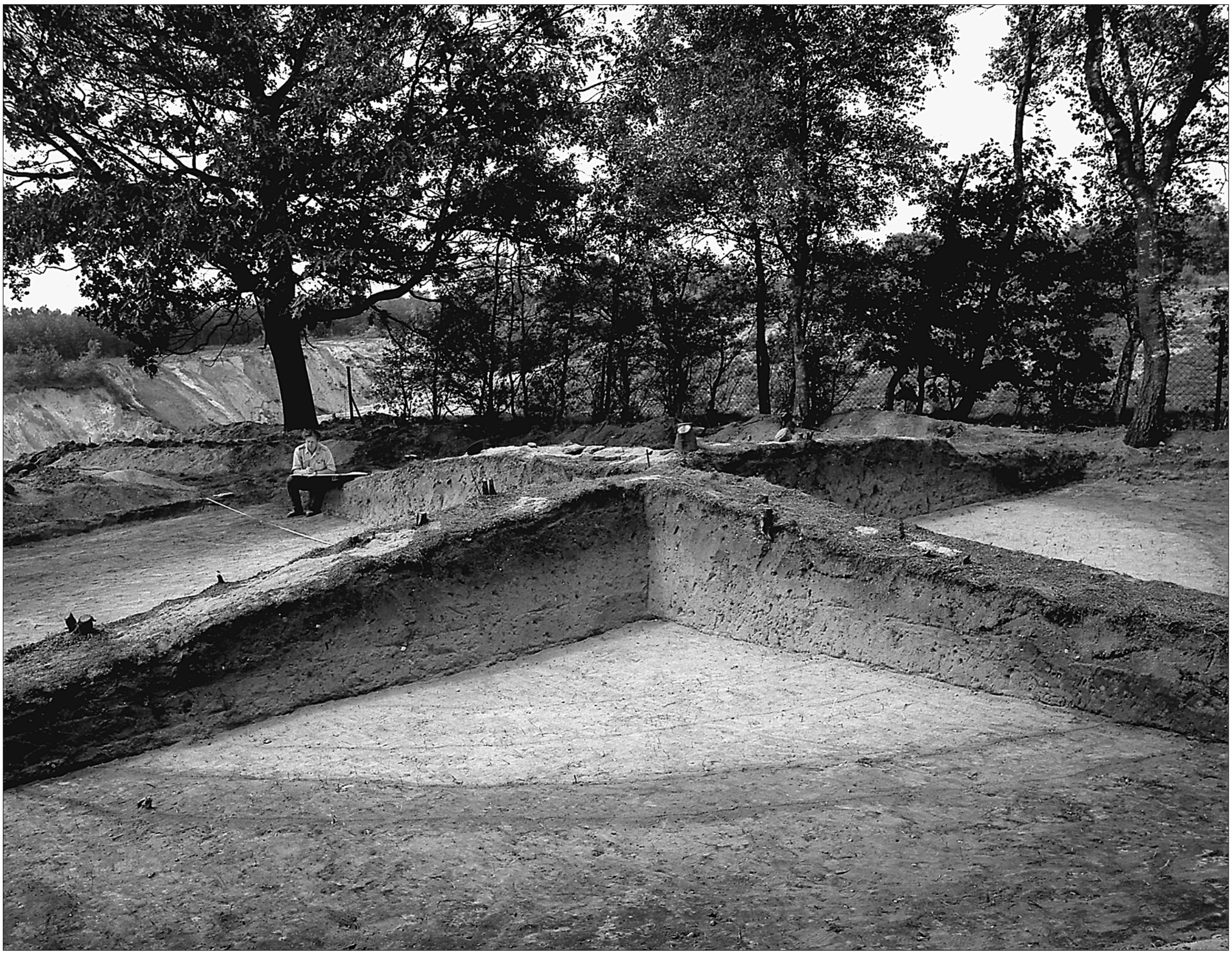

Fig. 1. Burial mound from the Late Neolithic and Early Bronze Age on mineralogically rich brown sands of the ice-pushed ridges in Lunteren (Veluwe, Central Netherlands). Both the original soil profile and the burial mound itself show a highly homogenized soil horizon of brown sand, with traces of secondary podzolization (brown podzolic) only in the top of the mound (Collection Cultural Heritage Agency, Amersfoort).

exist. When this forest vegetation was gradually cleared by human intervention in the Neolithic period and especially also in the Bronze and Iron Ages, and changed from semi-open parkland and grassy heaths into a landscape in many places dominated by heath, the net infiltration of rainwater to the subsoil increased and in the course of centuries degraded the old brown forest soil into a poor humic podzol. This process is known as 'secondary podzolization' (Duchaufour 2012). As a result, bioactivity would sharply decrease and, moreover, penetrate less deeply. Consequently, relics of the earlier brown forest soil still occur in the subsoil of many humic podzols at the BC horizon level. In other words: one can tell from the profile sequence of these soils that they were degraded only at a later stage (Havinga 1963; Spek 1996 and 2004).

For the interpretation of soil and pollen profiles in burial mounds, knowledge of this secondary process of podzolization is of the utmost importance. Barrows from the Late Neolithic on these moderately eutrophic soils often reveal a buried moder podzol and generally also a fairly homogeneous yellow-brown, brown or red-brown body at the base (fig. 1). Samples taken from the old surface downwards beneath Neolithic barrows are devoid of any pollen at depths below c. 5 cm under the old surface, and might represent the pollen rain from shortly before the building of the mound. Older pollen from before the mound was built is not preserved, owing to bioturbation and faunal attack. Barrows from a later date (Bronze Age, Iron Age), on the other hand, increasingly have a humic podzol as a buried profile, and a mound in which turves with micropodzol features are visible (fig. 2). This, broadly speaking, reflects the long-term development both of the soils and the vegetation on these types of soil. Over the centuries a deep humic podzol developed in the tops of almost all these barrows and urnfield mounds from the Late Neolithic and Bronze and Iron Ages. Pollen analysis of a series of samples from the old surface downwards as performed by Doorenbosch (2013: 102-105, figs. 8.7 and 8.8) is only possible thanks to acidification, which causes ever shallower homogenization by soil fauna. Thus with diminishing depth of faunal attack on pollen, a kind of layered profile will evolve.

Fig. 2. Burial mound from the Middle Bronze Age on mineralogically poor cover sand in Alphen (North Brabant, South Netherlands). Both the original soil profile and the sods in the mound itself show clear characteristics of podzolization (humic podzol) (Collection Cultural Heritage Agency, Amersfoort).

3. THE LAARDER WASMEREN CASE: AN EXAMPLE OF PODZOLIZATION IN AN EXTREMELY POOR SANDY SOIL

Sandy soils which are extremely poor owing to their mineralogical composition and/or their limited content of silt and lutum, can degrade even at a very early stage after their deposition. These include the coversands and drift sands with low silt and lutum contents from the Holocene period (*cf*. Jongmans *et al.* 2013; Stouthamer *et al.* 2015). Because of the very low nutrient content and base saturation, the top layer of these deposits will podzolize rapidly in all cases, irrespective of the vegetation present. This process is referred to in pedology as ‘primary podzolization’ (Duchaufour 2012). Although a thin forest of birch, oak and possibly also pine might grow naturally on these soils, this type of vegetation can relatively easily develop naturally or through human intervention into a semi-open park forest or even heath vegetation. On a local scale, this may result in a deposit with a podzol soil beneath a heath vegetation even in the Early Holocene: a humic podzol with soil-profile sequence A-E-Bh-Bs-C, especially in areas influenced by shallow water tables. Any observation made under such relatively extreme and/or moist conditions does not warrant sweeping conclusions regarding the phytosociological development of heath vegetations on our dry sandy soils.

The supposed early development of heathland in the Netherlands is partly also based on recent OSL datings and pollen analyses from the Laarder Wasmeren site near Hilversum in the Gooi area (central Netherlands) (Sevink *et al*. 2013; Doorenbosch 2013).

This site, according to the abstract, is a “unique complex of multiphased Holocene drift sands and paleosols, with at least two lacustrine phases” (Sevink *et al*. 2013: 243). Research on the various sections involved palynology and OSL dating among other investigations. Two pollen diagrams (LWM II and V) have been published in detail (Doorenbosch 2013: 155-160).

In the publication by Sevink *et al*. (2013) the pollen data from three sections (LWM II, IV and VII) are presented as curves for trees, Poaceae, Ericaceae and other herbs. In the most complex section, four soil-formation phases (from bottom to top S-1-4) and three drift-sand phases (D-1-3) are distinguished. The oldest soil developed in coversand deposited during the Younger Dryas. The three drift-sand phases are separated by soils showing podzolization.

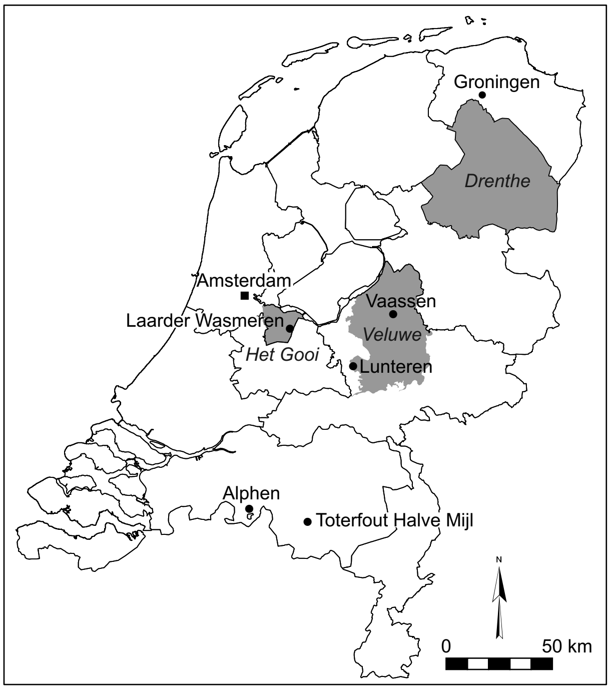

Fig. 3. Location of sites mentioned in text (map E. Bolhuis, RUG/GIA).

The fairly high Ericaceae percentages in the Early Holocene are known from other sites as well (Van Geel & Bos 2007; Van Mourik *et al.* 2012: esp. 85, fig. 9). In the latter publication, the curve for Ericaceae in the pollen diagram of Schaijksche Heide is more or less identical to that in the LWM II diagram (Doorenbosch 2013: fig. 10.3a). Both curves show high percentages for Ericaceae, *viz. Calluna vulgaris*, in the coversand.

As the podzol profiles of the Laarder Wasmeren sequences will have been strongly affected by the high water table, their dating should not be seen as proof of remarkably early podzolization in the Netherlands in general, but as evidence of soil formation processes induced by local conditions. If we examine the formation of the pollen layering in these sequences, the pollen content of each new layer will have been a mixture of older pollen from the vegetation of the underlying soil, *i.e.* from the vegetation covered by the newly deposited drift-sand layer, of pollen present in the drift-sand material itself, and of younger pollen that has moved downwards by bioturbation and percolation from the vegetation on the overlying soil (Koster 1978: 115-116; Van Mourik *et al.* 2012: 85). Hence the interpretation of the pollen diagrams is extremely complicated, since they do not necessarily represent the vegetation at the time of deposition and soil formation.

The youngest drift-sand phase (D-3) is OSL-dated to around 3000 BC. However, in the detailed pollen diagram of LWM II by Doorenbosch (2013: fig. 10.3a), slightly below two OSL samples of the major drift-sand phase D-3 (dated to 5410 ± 320 BP and 4710 ± 250 BP), pollen of hornbeam (*Carpinus*) is found, and the first large increase of *Calluna vulgaris*. Since hornbeam does not regularly occur in most Dutch pollen diagrams and never in burial mounds before the Late Bronze Age, it is clear that the OSL dates the drift-sand deposit, but not necessarily the pollen in it. Thus the high values for *Calluna vulgaris* in the top of the diagram, starting shortly before the first occurrence of *Carpinus,* most probably date from the Late Bronze Age/Iron Age as can be expected and is known from many other sites across the country (*e.g.* Koster 1978: 117; Elerie *et al.* 1993: 194). It is even likely that the extremely high values for *Calluna* can be explained by downward movement of medieval pollen.

4. PODZOLIZATION ON MINERALOGICALLY RICH SANDY SOILS

Sandy soils which, because of their mineralogically rich composition and/or their relatively high content of silt and lutum, are so eutrophic that they will barely degrade under any kind of vegetation, are found in certain sandy regions of the Netherlands. These include the boulder-clay plateaus from the Saalian glaciation in the northern and eastern Netherlands (the Drenthe Formation; Gieten Member), the brown sands of the ice-pushed ridges of the Rhine-Meuse system from the Saalian glaciation (Urk Formation) and the mostly silt- and lutum-rich coversand deposits from the Weichselian glaciation (Boxtel Formation).

In the course of the Early Holocene, these rich deposits generally became covered with deciduous forests consisting mainly of oak and common lime, and carried deeply rooted and biologically extremely active soils, with mull as the most important type of humus (Stockmarr 1975). The combination of very high base saturation in soils of this kind and strong bioturbation by soil fauna and tree roots resulted in deeply homogenized soils with a strong mineral erosion, causing these soils in the course of the Early Holocene to develop into deep brown soils. Over the centuries these acquired some podzol-like characteristics only in the uppermost 10-15 cm (brown podzolic). Without groundwater interference, these brown soils were able to survive for millennia, regardless of their vegetation. True podzols were never formed here. On these soils, forest vegetation often survived well into the historical period. Heaths developed here only under extremely high anthropogenic pressure and at a very late stage in history, in particular as a result of the intensive sheep-grazing and turf-cutting that took place in the Netherlands from the end of the Middle Ages onwards (Spek 2004). This explains why on the ice-pushed soils of, for example, the Gooi and Veluwe regions and also on the boulder-clay plateaus of Drenthe, substantial areas with brown soils and brown podzolic soils are found that are barely if at all podzolized.

Barrows on these kinds of eutrophic soils generally cover a buried profile with the characteristics of a brown podzolic soil (Waterbolk 1964). The mounds were generally constructed from loose sand and humus from the contemporary forest soil, so that during present-day borehole surveys they reveal a relatively homogeneous brown, yellow-brown or red-brown profile, occasionally containing some small iron veins but virtually never amorphous bands of leached-in humus or other podzol features. As to the pollen composition, these kinds of brown sandy burial mounds would originally have reflected the woodland environment in which most of them were constructed. However, because of the substantial bioactivity in such barrows plus the absence of blocking podzol layers, pollen that in later periods settled on the surface of these mounds would penetrate relatively freely to the deeper layers of the mound through bioturbation and percolation.

Analysis of Neolithic and Bronze Age barrows in Schleswig-Holstein, northwestern Germany (Groenman-van Waateringe 2011), lying on a SW-NE oriented moraine and consisting of sandy-clayey to rich loamy material, shows quite a different picture compared to most of the Dutch barrows. Of the 40 sampled barrows, the pollen of 16 was fully counted, and only four of these lacked clear evidence of contamination such as pollen of walnut (*Juglans*), rye (*Secale*), buckwheat (*Fagopyrum*) and maize (*Zea mays*). In this area rye cannot be expected in the diagrams before the Late Iron Age/ Roman period, walnut not before the Roman period. Buckwheat does not occur before the early Medieval period and probably even later in northwestern Germany, and large-scale cultivation of maize did not take place before the 20th century. The remaining 24 barrow samples either did not contain enough pollen or it was clear at an early stage of counting that they were contaminated. In effect all samples must have been contaminated with much younger pollen, including the four lacking the above-mentioned tree and crops, because apart from those obviously recent species the pollen assemblages in these four samples were quite similar to the others.

5. HEATHER GROWTH ON BARROWS: PRESERVER OF POLLEN IN OLD SURFACES?

To answer this question, i.e. to understand the role heather growth played in the preservation of pollen in old surfaces underlying burial mounds, we need to look closely at each of the three above-mentioned types of soil profile.

1. The original pollen content of the old surface of mineralogically rich soils (boulder clay, and sandy soils of ice-pushed ridges), which had never been podzolized, was either not preserved or was contaminated with younger pollen because of the ongoing biological activity in these soils.
2. The pollen content of the old surface beneath burial mounds on mineralogically poor soils will give a good impression of the landscape at the time of the mound's construction. In these barrows, with podzolization from the outset and an impenetrable iron-pan layer, practically no biological activity or percolation of pollen took place.
3. The preservation of pollen in the old surface beneath burial mounds on moderately mineral-rich soils is dependent on when the podzolization started, the height of the original mound and the spot where the pollen samples were taken.

The downward movement of pollen in poor sandy soils is found to be c. 10 cm in 300 years (Dimbleby 1985: 3). Studies of the poor sandy soils of the Veluwe region, central Netherlands, point in the same direction (Groenman-van Waateringe 1986 and 2012).

The height of the barrows as given in various publications is not necessarily their original height. With the exception of the Vaassen barrows 1 and 3 and several barrows in the west group of Toterfout-Halve Mijl,[3] the height of the barrows in Doorenbosch' study (2013) at the time of sampling still was 50 cm or more. This means that the barrow may have been covered by a protective heathland vegetation and associated iron pan well before any pollen from the vegetation on top of the barrows could have reached the underlying old surface. The exact place of sampling, however, is of the utmost importance: preferably right underneath the highest point. Samples from beneath lower parts of the burial mound are more likely to be contaminated, as may be the case when the mound has been reduced in height since its building. Pollen analyses of megalithic tombs (*hunebedden*) sometimes show rather high *Calluna* percentages (Casparie & Groenman-van Waateringe 1980), but one may doubt whether all these analyses are reliable, since in most cases the original mound covering the megalithic tomb no longer exists and only small remnants remained for sampling. For this reason one cannot be sure that no contamination with younger pollen had occurred (Groenman-van Waateringe 2015).

In those cases outside the Netherlands where pollen analysis of barrows has been successful, this is always on soils similar to the Dutch ones, on mineralogically poor or moderately poor sandy soils. Examples are found in England (Dimbleby 1985), Belgium (Waterbolk 1954: 112; Van Zeist 1963; Groenman-van Waateringe 1977), Germany (Averdieck 1981; Groenman-van Waateringe 1979), and Denmark (Odgaard & Rostholm 1987; Andersen 1995).

A new methodology might offer a more reliable outcome than pollen analysis alone can do. Biomarker and pollen analysis of a drift-sand section with three successive humic layers, OSL-dated to around 270 BC, 1300 AD and recent times, has shown that the high percentages for Ericacaea in the pollen data did not match with high biomarker data for *Calluna* in the lowermost humic layer (Van Mourik & Jansen 2013). Hence biomarker data based on the analysis of organic matter of leaves and roots preserved in soils may better represent the local vegetation than can pollen (younger or older, and probably extraneous). Low values for Ericaceae pollen are to be expected together with low values for biomarker data. By contrast, high values for Ericaceae pollen without the same for the biomarker data means that the Ericaceae were of little importance in the contemporary vegetation at that particular site.

6. CONCLUSION

The mineralogical composition and the texture of the various topsoil deposits in the Netherlands have strongly determined the age and morphology of podzol profiles. Categorization into three different mineralogical and textural classes enhances our understanding of the potential age and the formation processes of both soil and pollen profiles under and within burial mounds. Generalizations concerning the vegetation prior to the building of the mounds are unwarranted. Past depositional formation processes, including bioturbation and percolation of pollen into deeper layers, may obscure the picture of the original vegetation.

Heather without doubt played an important role in the surroundings of (part) of the prehistoric barrows, but certainly not in all. Because of the local circumstances the Laarder Wasmeren site cannot serve as a model exemplifying the early spreading of heathland. The place of sampling is also of the utmost importance. In view of the often observed disturbance at the centre of barrows, sampling at the highest point is not always possible. Sampling must therefore take place as close to the centre as possible, and if sods in the barrow are sampled, then the lowermost ones are preferable.

Given the pedogenesis of mineral deposits, the barrow landscape of our ancestors must have been marked by much greater variety than Doorenbosch (2013) suggests in her thesis.

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NOTES

1 'Beiden gemein [megalithic barrows and beaker barrows] ist der Aufbau aus weiszem oder wenigstens ziemlich reinem Sand auf einer ähnlichen Sohle' (Van Giffen 1930: 180). 'Im Gegensatz zu den steinzeitlichen sind die bronzezeitlichen und späteren Denkmäler aus Plaggen oder wenigstens stark humosen Sand errichtet worden, während auch ihre Grundflächen humusreiche Infiltrationen aufweisen.' (Van Giffen 1930: 181).

2 E.g. Toterfout –Halve Mijl, tumulus 4 (Glasbergen 1954: 44). Sod thicknesses given for barrows Vaassen 1 and 3 (mound no longer existing), Ermelo I, Renkum 1 and 4 are unjust, since no sods were found. The supposed suitable thickness of 25 cm is rather arbitrary, based on three barrows (Vaassen 2, Echoput 1 and 2). The sod thickness in the Oss Zevenbergen barrows are given on p. 122 as between 20 and 35 cm (Doorenbosch 2013). However, in table 12.2, 223 nine thicknesses are given, ranging from 10-20 cm, five of these being 13 cm. This makes most of the calculations of open spaces around barrows as given by Doorenbosch questionable.

3 According to Glasbergen (1954: 23) 'this small barrow had probably been much diminished by sod cutting'. From another barrow (22) remained only the periphery. Besides sod cutting damaging by ploughing, levelling etc. took their toll on the height of the barrows in this cemetery.