Geoarchaeological prospection of the Rommertsdonk

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The river dune district in the western part of the river area in the Netherlands is an area of high archaeological potential. A prospection method by means of gouge-auger borings proved to be very successful in the discovery of four middle neolithic refuse layers on the Rommertsdonk, a river dune in the vicinity of the Hazendonk. This method permits a proper evaluation of the representativeness of the Hazendonk occupation chronology.

1. Introduction

1.1. An archaeological problem

To create a picture of the early and middle Neolithic human occupation of the Holocene sedimentation area of the western and central Netherlands, only three sites are at our disposal. The sites concerned, Swifterbant, Hazendonk and Bergschenhoek, were all excavated more than 15 years ago. Since then attention has focused mainly on the interpretation of the archaeological, zoological, paleobotanical and geological data of the sites. No serious attempts have been made to solve the crucial problem of how to increase the number of sites for a period lasting as long as two thousand years in an area covering as much as 40% of the surface of the Netherlands!

The Rhine-Meuse delta, is an area of high archaeological potential. The excavation of the Hazendonk (Louwe Kooijmans 1987), a neolithic site located on a river dune surrounded by extensive peatbogs, yielded as many as seven occupational phases between 5300 and 3750 BP. Large quantities of domestic refuse were found in layers starting on the dune slope extending for 10 m into the surrounding peat. The large number of occupational phases on the dune is attributed to its function as a high and dry base for gathering, hunting and fishing in the surrouding wetlands.

However, the Hazendonk is not the only high and dry place in the Rhine-Meuse delta east of the coastal barriers. More than a hundred river dunes (Verbraeck *et al.* 1974; Verbruggen in prep) have been discovered, every one of them with the same archaeological potential as the Hazendonk.

Keeping this large number of potential sites in mind, the representativeness of the Hazendonk is under discussion. In order to decide whether the Hazendonk chronology can serve as a model for early and middle Neolithic occupation of the Rhine-Meuse delta, new sites are urgently needed.

1.2. The geoarchaeological approach to the problem

In 1990 the Institute of Prehistory of Leiden University initiated the Donkenproject in order to verify the representativeness of the Hazendonk occupational chronology.

At least 20 river dunes west of Geldermalsen will be investigated for Neolithic occupation by means of handborings. During the excavation of the Hazendonk in 1976 the use of a gouge with a diameter of 3 cm proved to be very successful for following the refuse layers stratigraphically (Van Dijk *et al.* 1991). It will be clear from the diameter of the gouge that one can not rely on the chances of boring-up the finds themselves. However, pieces of charcoal of various sizes, charred bone often smaller than a pin-head and dune sand could easily be recognised in the peat layers. Especially the contrasting colours facilitated the recognition of the find-layers, the deep black of the charcoal and bright white of the bone in a matrix of brown peat. The experience gained by more than 400 borings along the borders of the Hazendonk laid the foundation of the Donkenproject.

The Rommertsdonk is only one of 20 investigated river dunes. It was selected for further research because of its proximity to the Hazendonk. It is located only 600 m away, facilitating a comparison of their occupational chronologies

1.3. Geological context

The Rommertsdonk is a small river dune situated in the centre of the peat district (see fig. 1). Several authors look upon this district as the central part of the Rhine-Meuse delta extending from Nijmegen in the east to the coastline in the west (Van Dijk *et al.* 1991; Louwe Kooijmans 1987; Törnqvist *et al.* 1993). Others (Hageman 1969; Zagwijn 1986) avoid the term delta and emphasize that the accumulation of peat and clay "took place under the direct influence of the relative sealevel movements but where marine or brackish sediments themselves are absent" (Hageman 1969, 377). The Rhine-Meuse delta is strictly

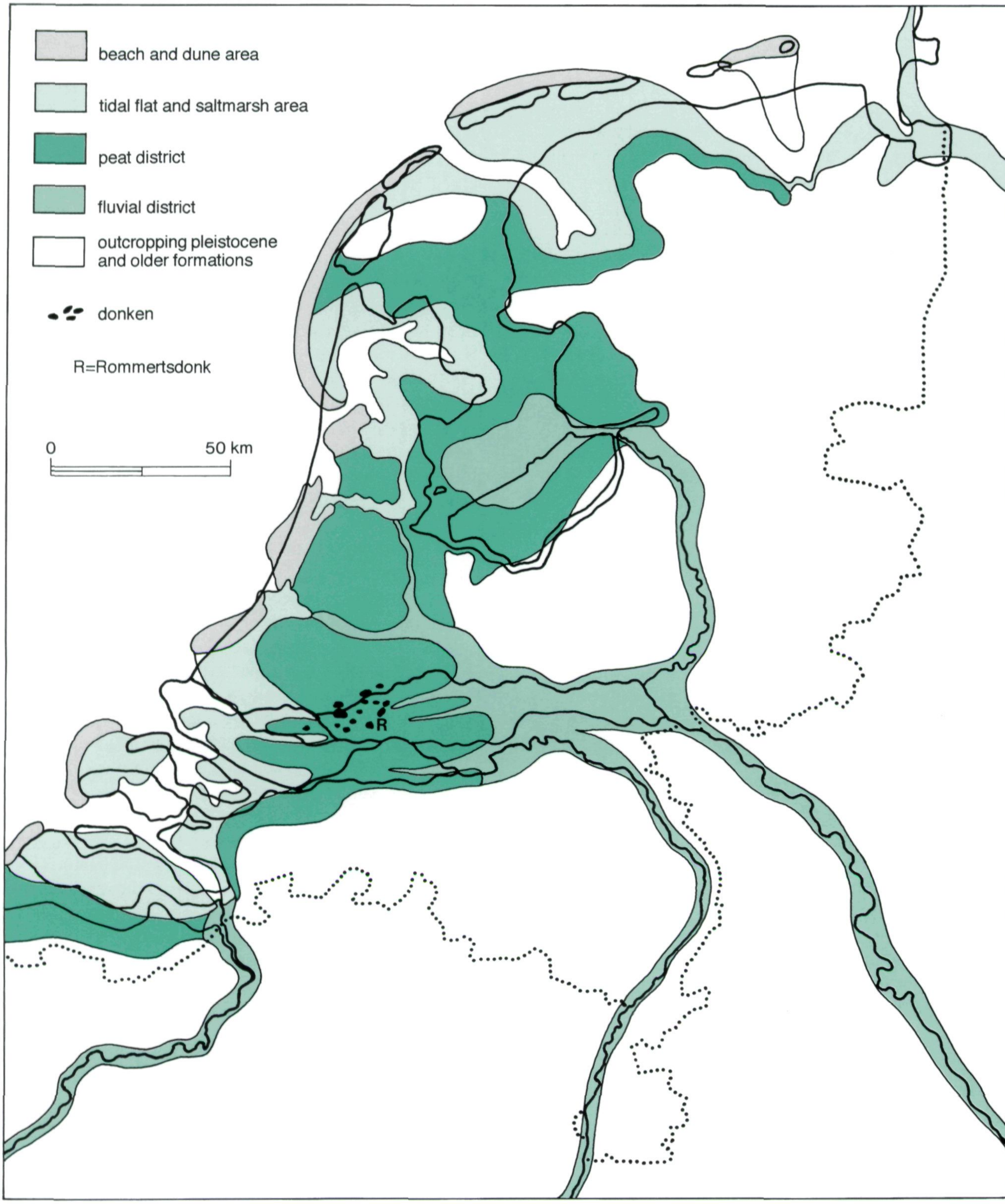


Figure 1. Holocene landscapes of the Netherlands and location of the Rommertsdonk

speaking not a delta. Not in a morphological sense because the "delta" is not a discrete shoreline protuberance. And not in a sedimentological sense as the central and western part of the "delta" have a perimarine and marine genesis respectively (see Bhattacharya/Walker 1992).

From an archaeological point of view the term delta has the advantage of being short and easy to combine with other words, such as "the delta neolithic". In my opinion there are no objections to the use of the term delta, as long as it is made clear that this delta consists of several distinctive landscapes (see Louwe Kooijmans 1987): a beach and dune district, tidal flats and lagoons, a peat district and a fluvial district (see fig. 1).

Although opinions differ on the use of the term delta, the above mentioned authors do agree on the overall determinant role of the relative sealevel rise in the Holocene development of this sedimentation area. Due to a relative sealevel rise of almost 15 m since 7500 BP, a thick sequence of peat and clay layers came into being in an ever changing landscape of lagoons, tidal flats and peat bogs. In the Rommertsdonk-Hazendonk area the peat and clay layers deposited on top of the pleistocene substratum attain a thickness of about 10 m.

The river dunes, locally known as donken, were formed during the Younger Dryas Stadial of the Weichselian (Verbraeck *et al.* 1974) on top of the floodplain of the then braided rivers Rhine and Meuse. However, it can not be excluded that the dunes remained active during the Preboreal and Boreal (Van der Woude 1981). The donken became submerged and fossilised due to extensive peat and clay accumulation under a rising water table, linked to the general sealevel rise. As more than 80 donken are located in the western part of river area, this region sometimes is referred to as the donken area.

The Rommertsdonk was discovered by R. Steenbeek in 1977 during geological fieldwork in the area surrounding the Hazendonk (Steenbeek 1977). Nowadays the Rommertsdonk is no longer surfacing, the dune top is located 1 m below the present-day surface. Only the undulations in the landscape reveal its presence.

The geological fieldwork provided data for a detailed reconstruction of the former Holocene landscapes of the Rommertsdonk-Hazendonk area (Van der Woude 1981). In the following, the paleoenvironmental evolution of the area as described by Van der Woude, is summarized.

From c. 7400 BP onwards extensive fluvial clay deposition in a so-called fluvio-lagoonal environment took place. This environment was characterised by permanent open-water surfaces criss-crossed by many river branches with wooded levees.

Around 6100 BP the fluvio-lagoonal environment gave way to extensive alder carr with numerous lakes in which organic accumulation occurred under very quiet conditions. Although much of the alder carr persisted for a period of 2000 years, the lakes expanded untill around 5300 BP also clay deposition took place. Figure 2 shows a landscape reconstruction of this so-called fluvio-lacustrine environment. In this reconstruction, based on hundreds of borings, the Hazendonk as well as the Rommertsdonk are visible amidst alder carr and shallow basins with subaquatic channels. Around 4800 BP the lakes reached their maximum extension. Closed alder carr and reed marshes precede a period of extensive fluvial deposition in, again, a fluvial lagoonal environment, which lasted until 3300 BP.

Closed alder carr returned and persisted at least till 2000 BP. A thin clay bed covers the sedimentary sequence.

The two millennia of alder carr (c. 6100 BP - c. 4100 BP) are of special interest to the Neolithic occupation history of the donken area, since almost all of the Hazendonk layers date to this period. As will be shown below also the four Rommertsdonk layers date to this period.

2. The prospection method

2.1. Basic concepts

The prospection method presented in this article focuses on the prospection of so-called archaeological layers, according to geological procedures. These procedures cover the method of data collection as well as the rules according to which the data should be described and classified (Hedberg 1976). The prospection method also includes mapping and dating of the archaeological layers.

Archaeologists tend to classify layers (sediments) containing artefacts according to cultural criteria, i.e. the artefact assemblage. Linking archaeological data to geological data requires compatible terminologies. To prevent any misinterpretation of the results of the prospection, the concept of the archaeological layer will be defined first.

An archaeological layer is a lithostratigraphic unit distinguishable in the field and defined on the basis of its lithological content, i.e. the archaeological indicators. The indicators used in this prospection method are: charcoal, (burnt) bone, ceramics, flint and river dune sand, embedded in a matrix of (clayey) peat or clay. The overall lithological homogeneity of the layers points to more or less constant physical conditions, during which the aggregates were laid down in one depositional event (see Klein 1987; Reineck/Singh 1980, 96). Of course, post-depositional processes, such as trampling, may have contributed to a great extent to this homogeneity.

It cannot be stressed enough that a single archaeological layer is not identical to a cultural layer, cultural phase or other terms based on interpretation rather than direct observation. The age of a great number of layers, together

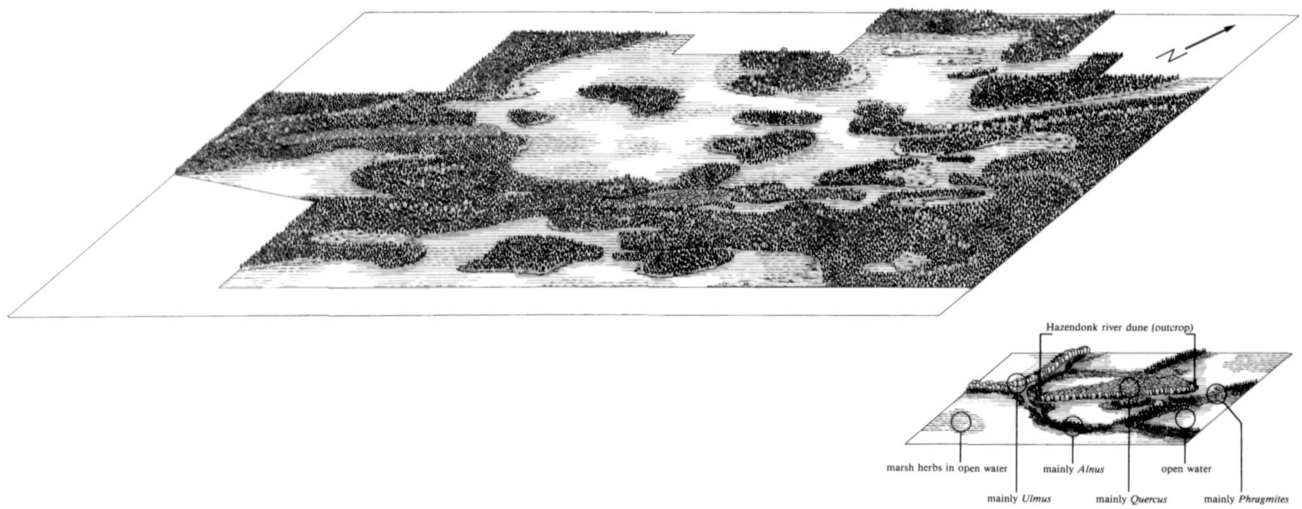


Figure 2. Fluvio-lacustrine environment of the Rommertsdonk-Hazendonk area, around 5300 BP. The Rommertsdonk is visible on the left-hand side of the reconstruction (after Van der Woude 1981).

with their cultural assignment, make up the database on the basis of which the true duration of prehistoric cultural phases can be established.

2.2. Dating of archaeological layers

In order to determine the chronostratigraphy of layers three courses are open to us.

First, we can date layers by dating the artefacts embedded in them. Since charcoal is one of the indicators on the basis of which layers are defined, it is pertinent to date the charcoal, by the radiocarbon method. The perfect conservation of the artefacts, even the most fragile fish remains, point to a contemporaneity of the artefacts and their age of deposition. Thus, the only age difference between the 14C age of the charcoal and the age of the depositional event may arise from the fact that it is not the age of the manufacture that is dated but the wood itself.

The second method for dating layers is based on their depth below NAP (Normal Amsterdam Level), in relation to the growth of carr peat on the slope of the donk. The concept of juncture-point is of crucial importance in this method. It is defined as the point (in cross section) where the top of the archaeological layer rests directly on the sloping river dune sand. Up slope the layer is no longer present, or the matrix has changed from peat or clay to dune sand. Down slope the layer is separated from the dune slope by a "sterile" peat layer. Since the top of the archaeological layer coincides with the peat surface at the moment the artefacts are deposited, dated initial peat growth on river dune slopes can be used to date the depositional event. Van Dijk *et al.* (1991) studied the Holocene water level development in the Netherlands' river area. For their reconstruction of the water level development, they constructed isochrones of initial peat formation on compaction-free river dune sand, in an east-west cross-section through the donken area. These isochrones offer a unique opportunity to date archaeological layers. Simply by plotting the altitude of the juncture-point of the layer at the correct place along the x-axis in the cross-section, the age can be obtained by interpolating between the isochrones. As the juncture-point of the top of the layer is used, the outcome most likely will date the end of the deposition of the artefacts just before peat growth restarted.

Dating the beginning of the depositional event using the lower boundary of the layer seems problematic. Trampling of the archaeological indicators into the soft peat, thereby lowering the lower boundary of the layer, will most certainly have occurred.

Archaeological layers can with the third method also be dated by dating the peat matrix. This method has the advantage of being able to date a layer in those cases where not enough charcoal is present. However, radiocarbon ages of peat samples can be less reliable. Rejuvenation of peat resulting from root contamination is a serious problem, whereas mechanical contamination of clayey peat may result in an ageing effect (Törnqvist 1992). Furthermore sampling and dating the peat around trampled charcoal will probably show a considerable difference in age between peat and charcoal. For example, assuming a sedimentation rate of 15 cm per 100 years, a lowering of the lower boundary with 15 cm (before compaction), will result in a date 100 years too old.

Concluding, it should be noted that there is a fair chance that dating the peat matrix instead of the artefacts themselves, causes more problems than it solves.

2.3. Field strategy

Prospection for archaeological layers begins in the field. The type of equipment, selecting the best locations to place the borings, as well as the choice of where to take the radiocarbon samples, all contribute to the success of the prospection method.

2.3.1. Equipment

The field data were all obtained with the use of handboring equipment. Gouge-augers, 1.5 m long with extension rods proved to be very useful in gouging the peat and clay layers in an undisturbed state. To achieve reliable depths of juncture-points, all borings were levelled relatively to NAP, with the aid of a Wild levelling instrument.

2.3.2. Location of the borings/boring density

As pointed out earlier the prospection focuses on the peat and clay layers surrounding the river dune, and not on the dune itself. On the steep dune slope denudation prevails, whereas on the surrounding peat the eroded artefacts and dune sand are (re)deposited. Except for some crushed charcoal, hardly any artefacts will be found directly on the donk. The deposition of artefacts on the peat offers a great advantage. As a result of the rapid sedimentation rate, the different archaeological layers are separated by sterile peat layers, instead of being deposited on top of each other. Thus every layer has its "own" artefact assemblage and its own juncture-point.

In figure 3 the location and distribution of the borings are shown. They are located in a narrow zone all round the donk and concentrated in rows perpendicular to the strike of the dune slope. The width of the zone around the dune is determined by the distance at which the artefacts were deposited on the peat (the width of the activity zone). The distance between the borings in a row varies from 1 to 5 m, whereas the distance between the rows preferably should not exceed 20 m. The rows enable the construction of cross-sections for unravelling the complex lithostratigraphy and for assessing the altitude of the juncture-point. The smaller the distance between the rows, the better the chances of finding layers of limited dimensions.

3. Results and discussion

3.1. The archaeological layers

On the basis of 135 borings, 4 archaeological layers were identified at a depth of between 2.6 and 5.1 meters below NAP. (see fig. 3). The layers were mapped in detail and dated by means of radiocarbon dating and the altitude of the juncture point. The layers together with their juncture points are depicted in figure 4.

All layers are basically similar. General characteristics are:

- charcoal particles ranging in size from < 1mm to 10 mm, burnt bone, and riverdune sand are present in every layer. Ceramics and small flint flakes were found in layer 3
- the layers have a matrix of (sometimes slightly clayey) unoxidised fen-wood peat. The layers exhibit a strong heterogeneity, which in itself constitutes a kind of unity when compared to the adjacent "sterile" peat layers. Thus the upper and lower boundary are defined by the uppermost and lowermost presence of the archaeological indicators.
- the layers have a clear juncture point on the dune slope and extend for 10 to 15 m into the surrounding peat. Except for some pulverised charcoal, no indicators were found on the slope of the donk itself.

3.2. Radiocarbon ages and calendar age ranges of the layers

Charcoal samples were obtained from layers 2, 3, and 4. To avoid contamination of the samples by pulverised (older) charcoal present on the dune slope, the cores were taken more than 2.5 m from the juncture-point of the respective layers. After sieving, only particles > 2.5 mm were selected.

To form an opinion about the representativeness of the Hazendonk occupational phases, the Rommertsdonk and Hazendonk 14C ages had to be correlated (tab. I).

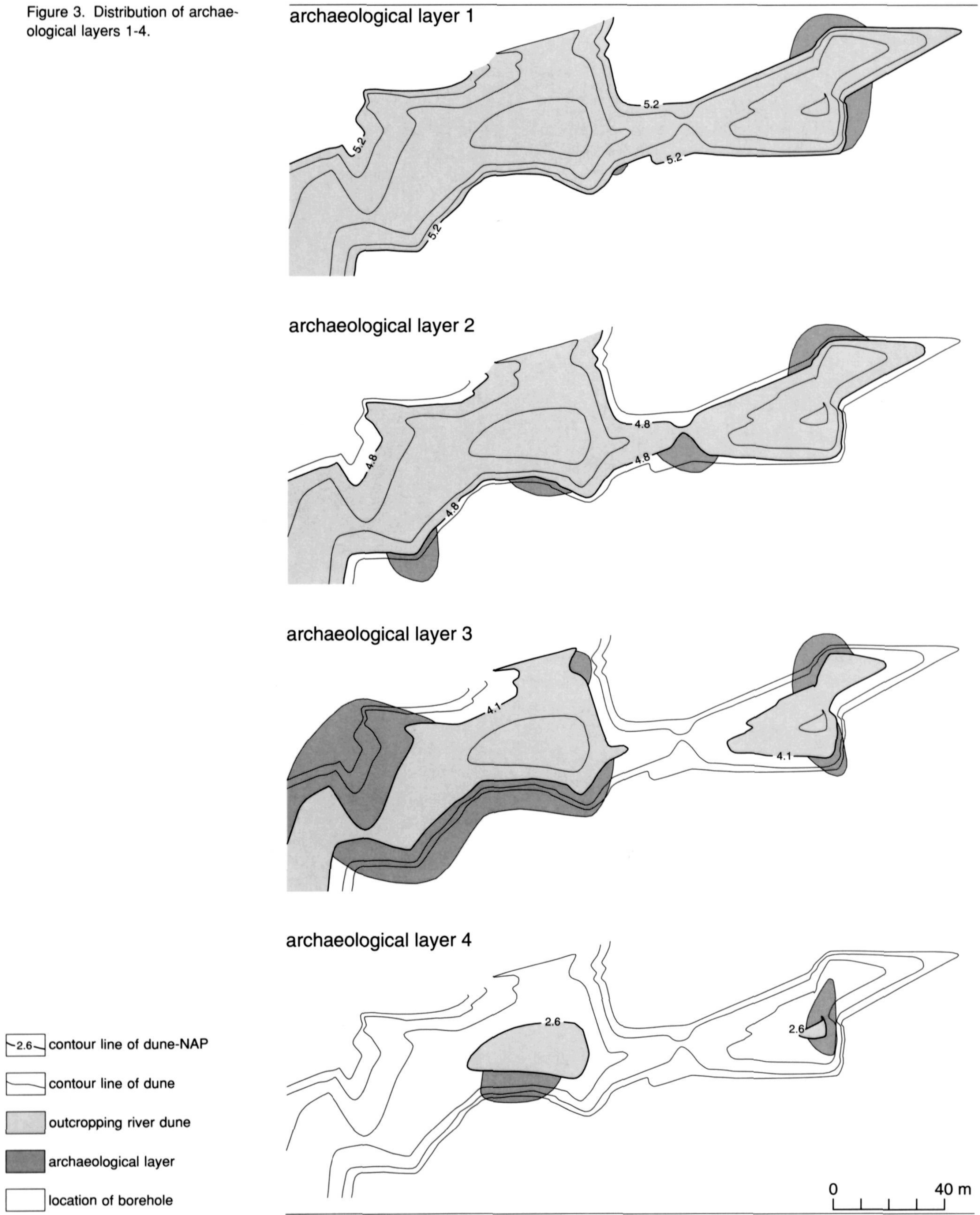
So far only a few Hazendonk 14C dates have been published (Louwe Kooijmans 1974). For no other reason than that these samples were peat samples obtained from pollencores, and therefore do not necessarily date the archaeological layer, they were not deemed to be relevant. Fortunately a well documented set of 24 unpublished 14C ages were found in the archives of the National Museum of Antiquities at Leiden. From this data set 16 charcoal/ charred wood samples were selected.

Because of the inconstancy of the atmospheric 14C content, all dates were converted to calendar age ranges.

The calibration program Cal 15 (Van der Plicht 1993; Van der Plicht/Mook 1989) was used to convert the 14C ages.

First the sample time width was estimated at at least 60 years. This figure is based on the thickness (age) of the branches normally used in campfires for food processing. Furthermore the possibility cannot be excluded that the layers represent an interval of time themselves due to either multiple occupational phases of short duration or one longterm occupational phase. Then a smoothing of the

Figure 3. Distribution of archaeological layers 1-4.



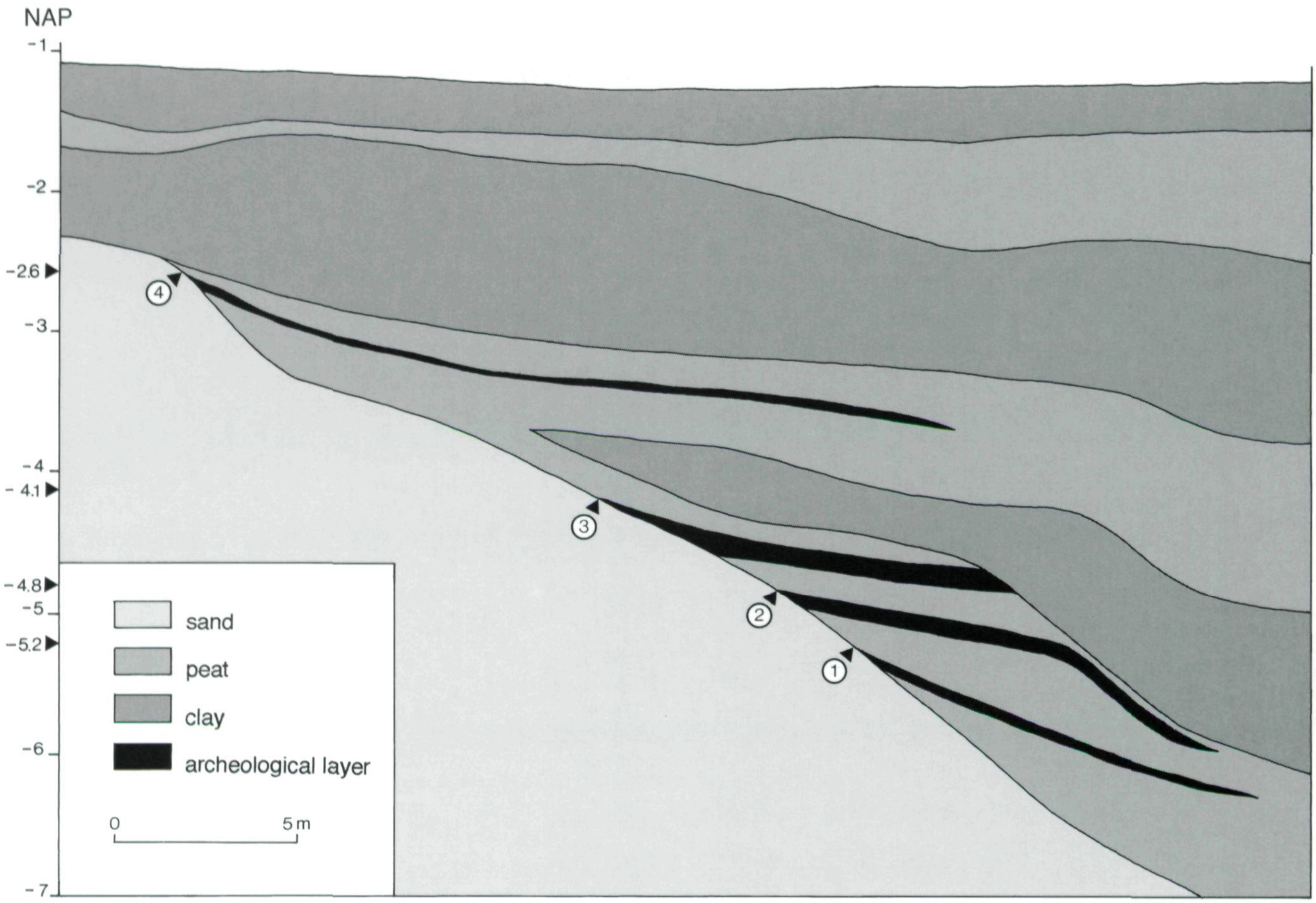


Figure 4. Schematic cross section showing the Rommertsdonk with covering peat and clay layers. Archaeological layers are numbered from bottom to top.

calibration curve was performed to suit sample time width (Mook 1983). The smoothing calculation is one of the standard options of Cal 15. And lastly for the (actual) calibration the two standard deviation (2 sigma) confidence interval was chosen. The calibration yielded calendar age ranges spanning 200 to 300 years.

Table I and figure 6 present the calendar age ranges and related information of the Rommertsdonk and Hazendonk 14C ages.

However, the interpretation of the dating results in terms of contemporaneity of occupational phases, is far from easy. When the calendar age ranges are compared a number of questions arise. Firstly, how do we have to interpret the age differences between 2 or more calendar age ranges of one single layer (for example the Hazendonk 1 layer)? Does it reflect the nature of the radiocarbon dating method, i.e. the Gaussian probability distribution of the radioactive decay measurement? Could the different ranges date the beginning and end of one occupational phase? Or is it the result of (different percentages of) wood of various ages present in the charcoal samples. Probably all factors will affect the 14C age to some degree. Secondly, when comparing the Rommertsdonk and Hazendonk age ranges, does a partial overlap of age ranges mean that the occupational phases are comtemporaneous? For instance, is Rommertsdonk layer 3 contemporaneous with Hazendonk 1, Hazendonk 2 or with neither of them.

A solution to the above problems could be to use the probability distributions of the calendar age ranges, calculated by the Cal 15 calibration program. When the peak in the probability distribution with the highest probability is selected then comparing calibrated age ranges simply amounts to a comparison of the calendar ages of the peaks. However, selecting the highest peak means the preclusion of a large part of the calendar age range, and this will seriously affect the outcome of the comparison.

3.3. Reducing the calendar age ranges

In this paragraph an explanation will be given of the method of reducing the calendar age ranges by using the

Table 1. 14C ages of Rommertsdonk and Hazendonk archaeological layers. Reduced calendar age ranges date the top of archaeological layers

Layer	Sample No.	GrN	Age (conv. C-14 y BP)	Reduced cal. age range
Rom. 4		19080	4425 ±35	3290..2990
Rom. 3		19079	5130 ±60	4000..3880
Rom. 2		19078	5390 ±60	4290..4170
Rom. 1				4460..4340
Haz. VL 2b	9	8233	4000 ±25	2570..2470
Haz. VL 2b	7 b	9132	4015 ±30	
Haz. VL 2b	8 c2	9133	4010 ±35	
Haz. VL 1b	11	9135	4435 ±50	3260..2960
Haz. VL 1b	12 c	9136	4445 ±35	
Haz. VL 1b	12 d	8234	4505 ±40	
Haz. VL 1b	10	9134	4535 ±40	
Haz. VL 1b	13	9137	4450 ±40	
Haz. 3	20	8236	4735 ±35	
Haz. 3	19 a	9193	4810 ±35	3670..3610
Haz. 3	18	9192	4830 ±40	
Haz. 3	17 b	9191	4870 ±55	
Haz. 2	23	8330	5020 ±30	3910..3790
Haz. 2	24	8237	5090 ±40	
Haz. 1	26 a	8331	5165 ±30	4020..3690
Haz. 1	26 c	9196	5265 ±60	

isochrones of peat formation on river dunes (see fig. 5). The actual reduction comprises three successive steps:

1. As stated earlier, isochrones of peat formation on riverdunes offer an opportunity of dating archaeological layers. The other way around, dated archaeological layers can be used to date initial peat growth. In other words, the time-depth points of peat growth and archaeological layers are interchangeable. The first step involves the creation of a large data set of calendar age ranges: a combination of the peat data of Van Dijk *et al.* (1991) and the archaeological data of Verbruggen (in prep.).
2. The second step involves the construction of the isochrones through interpolation of the calendar age ranges. In fact, drawing the isochrones means determining the most probable part of the age range. It will be clear that the larger the number of age ranges on which the isochrones are based, the smaller the margins for the isochrones will be.
3. Finally, the reduced age range is calculated by adding the margins of error to the age of the most probable part of the age range (see above). The margin of error is related to the rate of the water level rise and the margin of error of the altitude of the juncture point of the archaeological layer. It is estimated to range from 60 yrs for the period before 3800 cal BC to 200 yrs for the period after 3000 cal BC. As a result the reduction of the age range varies from 0 to c. 200 yrs.

In conclusion, determining the most probable part of the calendar age ranges through the construction of isochrones of initial peat formation, means selecting the age which has the best goodness of fit with all other age ranges of the data set.

3.4. Comparison of the reduced calendar age ranges

Figure 6 (black bars) shows the reduced age ranges of the Hazendonk and Rommertsdonk layers. The reduction of the ranges by 50% up to 3800 cal BC provides a proper evaluation of the representativeness of the Hazendonk.

For Rommertsdonk layer 1, there is no equivalent on the Hazendonk.

Rommertsdonk layer 2 shows a considerable overlap with the oldest calendar age range of Hazendonk 1. However, the reduced age ranges show no overlap. Thus for Rommertsdonk layer 2 there is no equivalent on the Hazendonk either.

The reduced age range of Rommertsdonk layer 3 partly overlaps with Hazendonk 1 as well as with Hazendonk 2. Since the reduced age ranges date the end of the occupational phase (see section 2.2), the contemporaneity of Rommertsdonk layer 1 with Hazendonk 1 or 2 or neither of them, depends on the duration of the respective occupational phases. As stated before, age differences between some radiocarbon ages of a single layer, provide insufficient argument for assessing the duration of the

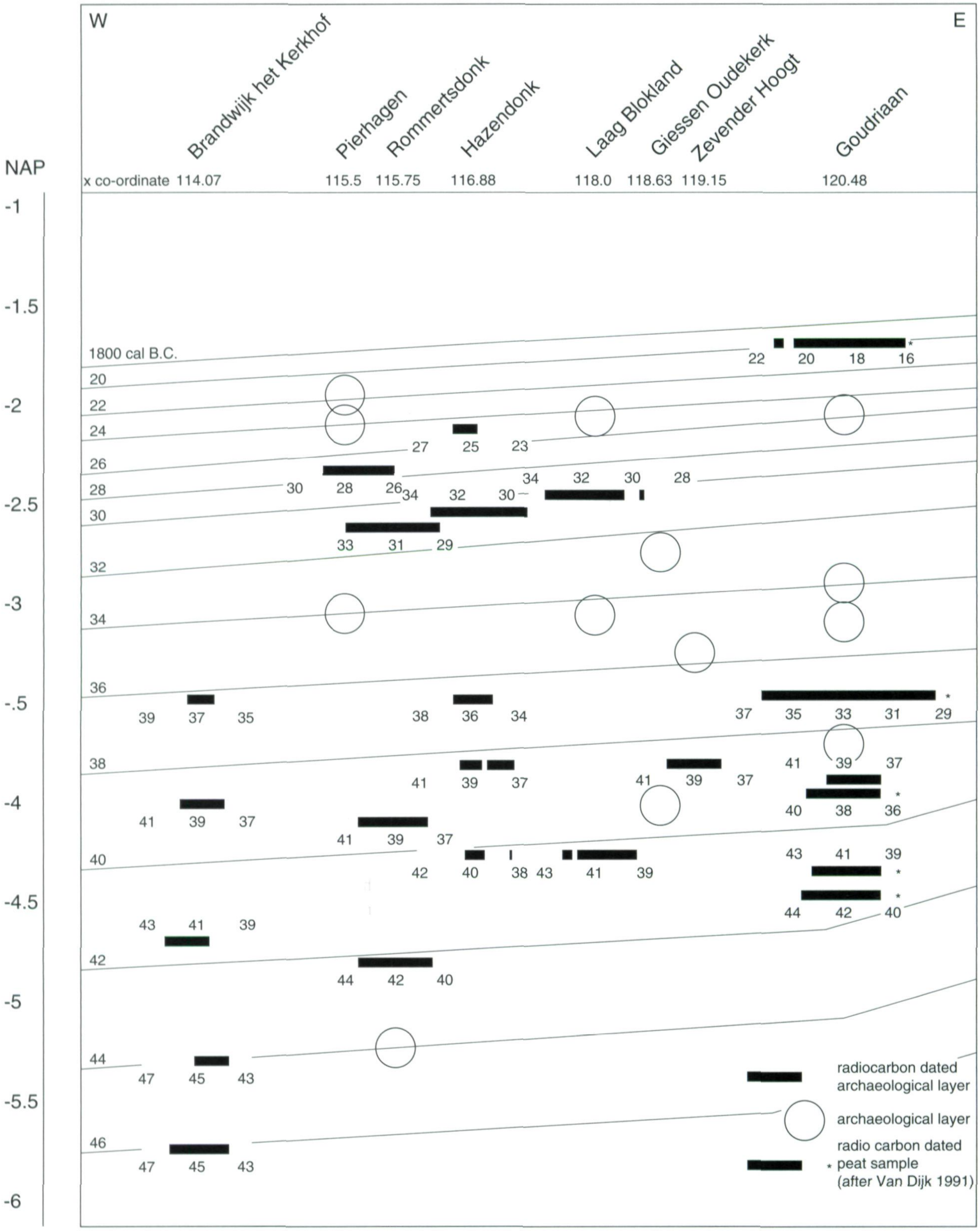


Figure 5. Isochrones of peat formation based on calendar age ranges of radiocarbon dated archaeological layers and peat samples.

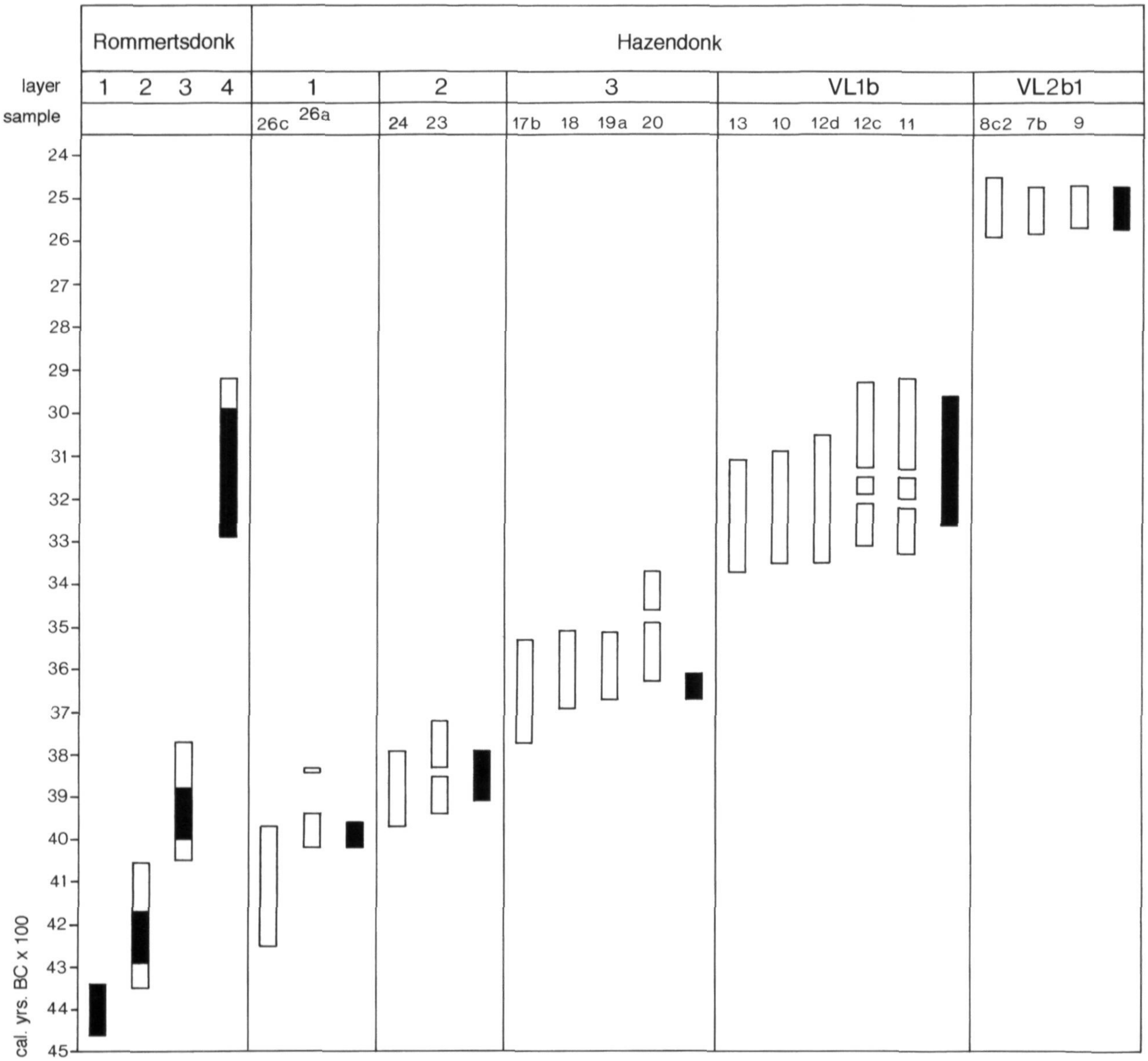


Figure 6. Reduced calendar age ranges of the Hazendonk and Rommertsdonk archaeological layers.

occupational phases. Consequently, the above problem remains unsolved here.

For Rommertsdonk layer 4, no reduction of the age range could be achieved, due to the slow rate of peat accumulation in this period. Since the calendar age range overlaps completely with the Hazendonk VL 1b phase, there is a fair chance that the layers are contemporaneous.

Finally, no equivalents were found on the Rommertsdonk for the Hazendonk 3 and Hazendonk VL 2 layers.

To sum up, of the four archaeological layers of the Rommertsdonk, one is probably contemporaneous, one is possibly contemporaneous and two are by no means contemporaneous with Hazendonk layers. Furthermore, the Hazendonk 3 and VL 2 layers have no counterparts on the Rommertsdonk.

4. Conclusion

The main reasons for carrying out this study were:

- to increase the number of Early and Middle Neolithic sites in the donken district.
- to develop a method for the prospection of refuse layers buried up to 6 m below the present day surface.
- to evaluate the Hazendonk chronology.

The discovery, mapping and dating of four Neolithic refuse layers clearly shows the efficiency and advantages of a prospection by means of hand borings.

A comparison of the reduced calendar age ranges of the Rommertsdonk and Hazendonk layers leads to the following conclusions:

- the Hazendonk chronology is not representative for the respective layers.
- in general, the Hazendonk can serve as a model for a phased Early and Middle Neolithic occupation chronology of the donken district.

Comparing two chronologies in order to decide which one can serve as a model for a large area, can be seen as a useful exercise. The comparison should be considered as a "half-time score".

Expectations are that the donken project will result in a data base of more than 50 refuse layers, on the basis of which the Neolithic occupation chronology of the entire donken district can be drawn up.

5. Acknowledgements

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