ANALECTA PRAEHISTORICA LEIDENSIA

26

1993

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ANALECTA PRAEHISTORICA LEIDENSIA 26

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26

PUBLICATIONS OF THE INSTITUTE OF PREHISTORY
UNIVERSITY OF LEIDEN

THE END OF OUR THIRD DECADE

PAPERS WRITTEN ON THE OCCASION
OF THE 30TH ANNIVERSARY OF
THE INSTITUTE OF PREHISTORY, VOLUME II

EDITED BY CORRIE BAKELS

UNIVERSITY OF LEIDEN 1993

Redaction committee: L.P. Louwe Kooijmans/C.C. Bakels

Graphic design: H.A. de Lorm

Copy editor: M. Wanders - Van der Sanden

ISSN 0169-7447

ISBN 90-73368-08-1

Subscriptions to the series Analecta Praehistorica Leidensia and single volumes can be ordered exclusively at:

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2300 RA Leiden
The Netherlands.

contents

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An Early/Middle Bronze Age multiple burial at Wassenaar, the Netherlands

In April 1987 amateur archaeologists of the Wassenaar Historical Society found a Late Neolithic/Early Bronze Age settlement site when they were prospecting trenches recently dug in a development plan in their village.

The excavation of this settlement site by the Institute of Prehistory of Leiden University led to the discovery of a unique multiple burial of a slightly later date, i.e. from the transition from the Early to the Middle Bronze Age. This grave provided indications of a violent conflict of a scale hitherto totally unexpected in Dutch Bronze Age society. On further consideration, however, such conflicts most probably represented a structural aspect of the life of that society.

1. The location, geology

Wassenaar is situated in the coastal district of the Netherlands, just north of The Hague (fig. 1). Its subsoil consists of beach or barrier deposits in which long barrier ridges have been formed parallel to the coast. The sediments are covered with dune sands, in which, especially on the formerly dry barrier ridges, series of low dunes have been formed, which are known as the Older Dunes. These dune rows are separated from one another by wide, lower zones, representing former beach flats. This landscape was formed in the Early Subboreal, when considerable coastal aggradation took place and the coastline prograded seaward by several hundreds of metres each century (Jelgersma *et al.* 1970). The coastal district stood out as a wide, dry region between the North Sea in the west and the extensive intracoastal marshes and swamps of the Rhine/Meuse delta plain to the east. As such it will have been an attractive region for prehistoric settlement (fig. 2).

Traces of prehistoric occupation — settlement sites and isolated artefacts — are usually found on the dune rows, but the Wassenaar site surprisingly proved to be situated on a low, very small dune of only some 25 m across, lying in the middle of a beach flat along with some other similar small

Figure 1. Location of the site in the Weteringpark extension of Wassenaar.

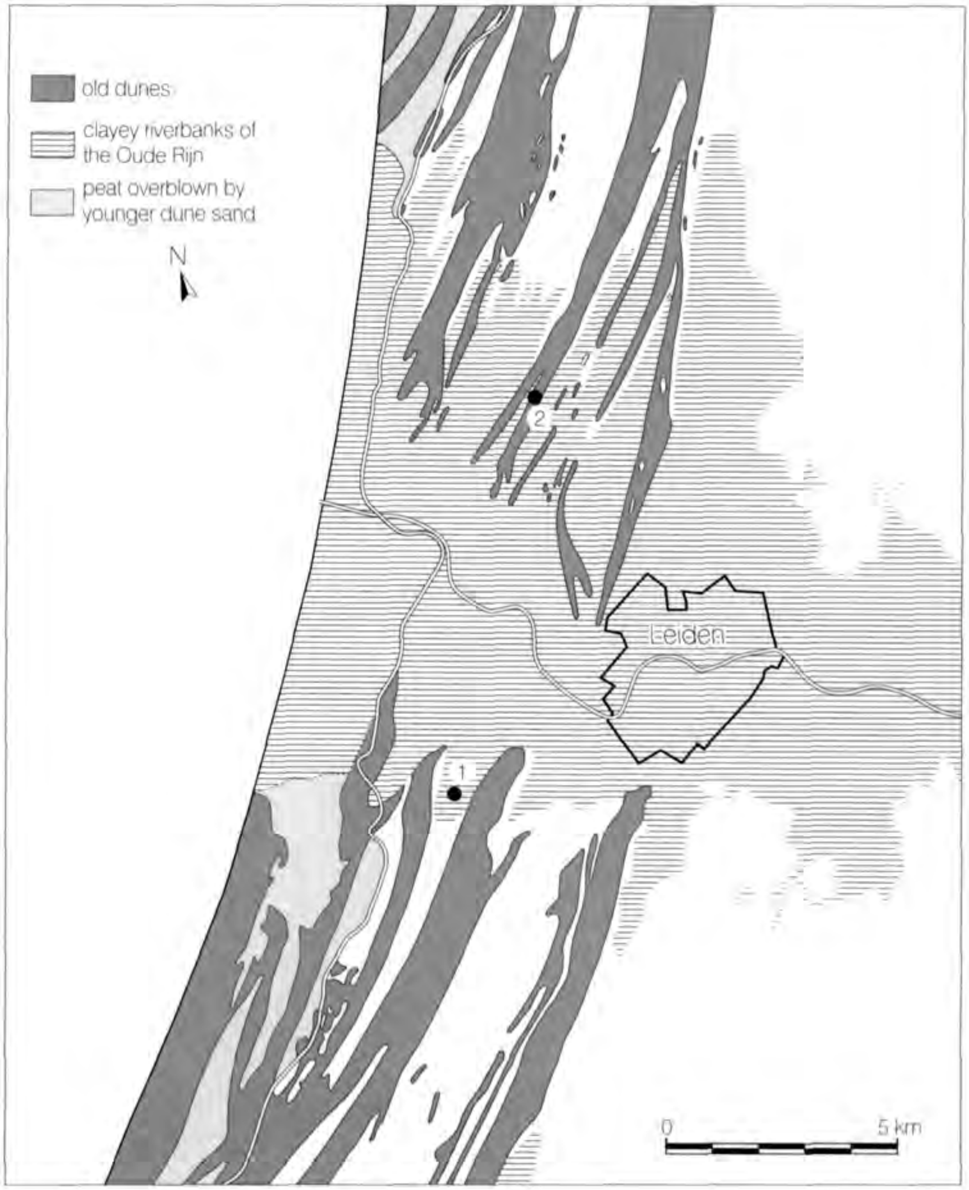

Figure 2. Geology of the coastal zone near Leiden, with the Subboreal coastal barrier system, covered by Older Dunes, and the location of the Wassenaar burial (1) and the Voorhout palstave hoard (2). Geology after Jelgersma *et al.* 1970.

dunes. The site lay in the northern part of the dune section between the estuaries of the Meuse and Rhine and close to the estuary of the Rhine and its tidal creek systems (figs 3, 4).

2. The excavation[1]

The excavation of the site by the Institute of Prehistory of Leiden University showed that all that remained of the settlement was a handful of flint fragments and pottery sherds, some of which had belonged to Early Barbed Wire Beakers, which are diagnostic for the very beginning of the Bronze Age, *c*. 3600 BP (figs 5, 6).

The only reason why these data merit mention in this journal, in spite of their great interest for the history of local and regional prehistoric occupation, is that they represent the context of the totally unexpected discovery, during the final cleaning of one of the sections, of the multiple burial of twelve individuals. Although the grave lay in the area of the development plan and its excavation implied delays in the building schedule, the excavators were able to successfully clean, record and lift the skeletal parts thanks to the cooperation of the contractor and the local authorities.

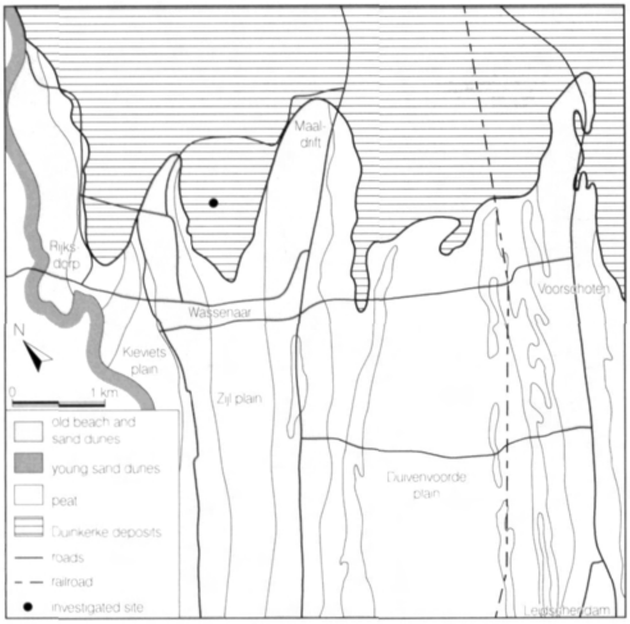

Figure 3. Location of the small dune in the beach flat between the northern ends of two main coastal barriers, close to the Rhine estuary. Detail of fig. 3. After Van de Plassche 1982.

2.1 The excavation methods

The excavation procedure had to be adapted to the bad state of preservation of the bone remains. It was decided to do as much of the cleaning and recording as possible in the field and to have a professional anthropologist make all the basic anthropological observations in the field so as to restrict the laboratory work to corrections and additional observations.

The grave was covered with a plastic tent as a safeguard against the rainy and stormy weather. The cleaning was done with wooden spatulas and soft brushes and the bone was kept wet with the aid of a plant spray and plastic sheets. The diggers worked from scaffolding, mostly lying on their bellies (fig. 7).

2.2 Recording

Drawings of each individual skeleton were made on a glass pane, scale 1:1 (fig. 8). These were redrawn on transparent sheets and subsequently mounted. The complete skeletons and details of each of the skeletons were photographed, as well as of some additional details. The field drawing was later adjusted on the basis of the field photographs and drawings made of scale photographs of the cleaned and preserved blocks. Anatomy-book drawings were used as reference material to overcome the difficulties of deformation and bad conservation. The drawings and anthropological descriptions finally obtained provided a good basis for observations on the complex process of deposition.

2.3 The lifting of the grave and its conservation

The skeletons were lifted in blocks of approx. 40 × 50 cm, which was an appropriate size for individual legs, trunks and pelvises. Use was made of thin sheets of gutter tin, supported by pieces of stiff chipboard. These were first used as gliders in pressing the sheets of tin beneath the skeletal parts, which had to be done in a perfect plane to avoid the risk of the blocks cracking later. The sheets of tin, now with the sand blocks on them, were then pulled back onto the stiff chipboard and lifted (fig. 9). All the blocks (about 40 in total) and the separately lifted long bones could be preserved thanks to the financial support of the municipality of Wassenaar and the province of South Holland. The reconstructed grave formed the centre of a small exhibition in Wassenaar from December 1989 until February 1990 and has been on view in the National Museum of Antiquities in Leiden since the autumn of 1990.

3. The grave, description and analysis

3.1 The grave pit

The twelve individuals had been buried in a quadrangular pit of a rather irregular shape with sides of approx. 210 and 230 cm. The sides were oriented roughly NNW-SSE and WSW-ENE. The bodies were all positioned parallel to the latter direction, five with their heads in the east, seven with

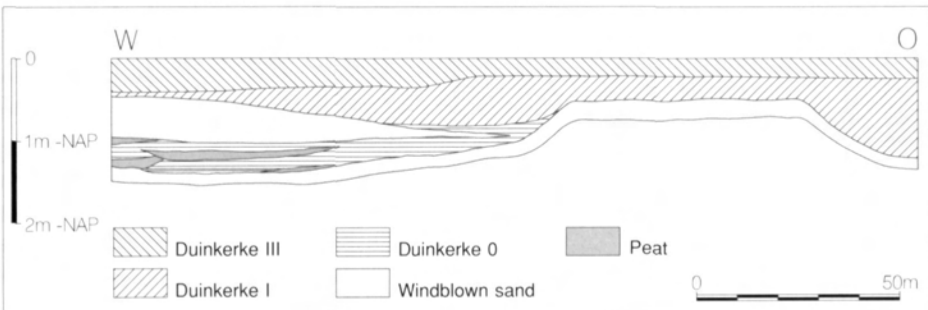

Figure 4. N-S cross-section of the small dune, after L. van der Valk.

Figure 5. Wassenaar-Weteringpark. Domestic Barbed Wire Beaker pottery, Early Bronze Age. Scale 1:2.

their heads in the west (figs 10, 11, 12, 13). The fill of the pit hardly differed from the surrounding dune sand, which is understandable when we consider the situation at the time of burial: the area was then covered with a young soil only, which means that the fill of the pit differed from the surrounding sand in terms of structure only and not in terms of texture or humic content.

What did make the burial pit stand out from the surrounding soil were the effects of percolation that had led to the formation of several bands of humic precipitation around the pit. They indicated the shape and maximum extent of the pit. The bottom of the pit (*i.e.* the level of the lower parts of the skeletons) will have been almost flat; it was situated at approx. -1.00 m NAP (NAP = Dutch OD).

It was difficult to make out the walls of the pit, but the pit appeared to be rather steep in the section. The depth could no longer be established as the original surface had been eroded. The remaining depth was approx. 40 cm, but it must be assumed that the pit was much deeper originally.

The grave lay to the NW of the small dune, more or less next to the concentration of beaker finds. The surface that contained the sherds had been eroded by the wind, which is why no direct spatial or stratigraphical relation could be established between the settlement and the grave. There proved to be a chronological difference of several centuries between the two finds; their co-occurrence must be attributable to the relatively prominent character of the small isolated dune in the surrounding landscape.

Figure 6. Wassenaar-Weteringpark. The extent of the small dune, excavation trenches and features.

3.2 Preservation

It is quite surprising that bone remains had been preserved in this matrix, at this location and at this depth. The dune sand is decalcified and the sand admits oxygen-rich water currents. The level of the floor of the burial pit (-1.00 m) is well above the former MSL of approx. -2.20 m (Van de Plassche 1982, 86). Since we cannot assume a local rise of groundwater in a small dune, situated on a beach flat close to an estuary, the bodies must have been buried well above the groundwater table (fig. 14). The rise in sea level will not have caused the local groundwater to reach the level of the bones until the (Late) Iron Age. Since then until the age of modern drainage the bones were submerged, the water stopping the process of decay. However, the skeletons were in a bad to very bad state of preservation and of some (No. 6) no more than a silhouette or soil discolouration remained. As the skeletons that had suffered most lay next to a subrecent ditch dug at a distance of only one metre from the southwestern corner of the grave, this must be the consequence of drainage in historical times.

3.3 Composition of the group

Thanks to the observations made in the field and the careful preparation of the lifted skeletal parts we have at least some basic anthropological information on the group.

The group was composed of twelve individuals, numbered 1 to 12. The age and sex of almost all the skeletons could be determined, in spite of the poor state of preservation (fig 15).

For details on these data and all additional observations, such as pathology and signs of violence, the reader is referred to the article by Maat and Smits (this volume).

Figure 7. Wassenaar-Weteringpark. Working conditions.

Figure 8. Wassenaar-Weteringpark. Making the full scale field drawing on glass.

3.4 ORDER OF DEPOSITION

The order in which the bodies had been deposited could be inferred from overlapping limbs; they proved to have been deposited from the north to the south, in an almost regular alternation of bodies on the two (west and east) sides of the burial pit. The assumption that Nos 3 and 9 were deposited first, after which the others were deposited from the centre to the north and the south leads to unsolvable problems in the northern part.

Some inconsistencies were observed: the left arm of No. 1 was found resting on the right arm of No. 2, the right arm of No. 10 on the left leg of No. 2. These inconsistencies can be explained by assuming that the two corpses were buried at exactly the same time or, even better, by assuming that some limbs, especially arms, were rearranged during the burial procedure. We must conclude, moreover, that no *rigor mortis* had as yet occurred. The relation between Nos 3 and 4 was remarkable: the left arm

Figure 9. Wassenaar-Weteringpark. The lifting of the skeletal parts in blocks.

Figure 10. Wassenaar-Weteringpark. The burial shortly after discovery, showing the N-S section.

of No. 3 was resting on the body of No. 4, but the general arrangement, that is, the "fit" of the bodies, makes it most plausible that No. 3 was deposited first. In other words, the arm must have been rearranged. However, the skull of No. 4 lay **on top of** the bent left arm of No. 3, out of articulation with the body, and it is most unlikely that this is due to post-depositional disturbance. Apparently No. 3 and No. 4 – whose head had been separated from the trunk – were deposited together, as a couple, as follows:

- body of No. 3
- body of No. 4
- rearrangement of left arm of No. 3
- head of No. 4.

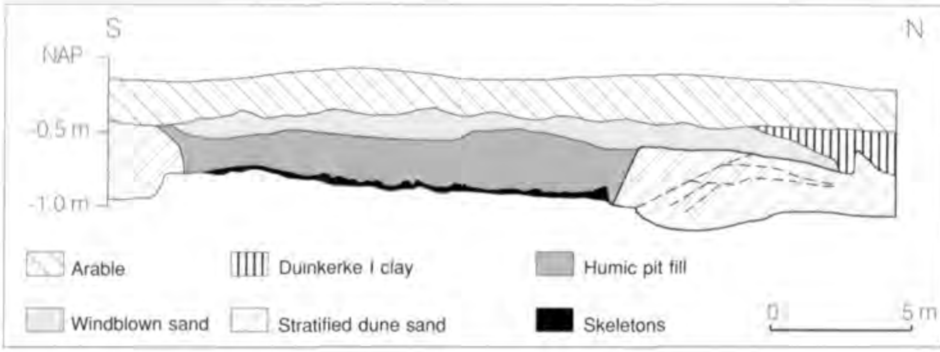

Figure 11. Wassenaar-Weteringpark. N-S section.

The three instances of coupled burials of two bodies on the same side of the burial pit have some characteristics in common. In all cases one of the deceased was (very) young, whereas the other was **not** one of the young adult males.

3.5 Disarticulations and missing parts

Most skeletons were well-articulated; disarticulations could be easily explained by post-depositional displacements, either as a natural consequence of the decay process of the bodies or due to bioturbation. The displacement of lower jaws and *patellae* and the disarrangement of hand and foot bones were to be expected in the loose sandy fill. The disturbance of the trunks of Nos 6, 7 and 8 may be attributable to burrowing animals or uprooted trees and the same may hold for the displacement of the right limbs of No. 1 and the right knee of No. 8. Some observations, however, cannot be explained in this way, in particular the position of the skull of No. 4, commented on above. The only possible explanation in this case is disarticulated deposition, implying either pre- or post-mortal decapitation. However, only the *cranium* was out of place. The *mandibula* was in a normal position relative to the cervical vertebrae. Something similar may hold for No. 8, but this could not be verified due to the poor state of preservation and the overall disturbance of this part of the grave.

In all cases the absence of particular skeletal parts was attributable to poor preservation conditions, post-depositional disturbance or the speed with which the remains had to be recovered.

3.6 Burial postures

At first sight, the burial postures appeared to reflect a rather careless and hasty form of deposition, but closer inspection revealed a certain regularity, possibly the result of distinct sex- and age-bound burial rules (fig. 16).

The only body in the grave which could be anthropobiologically identified as that of a woman (No. 11) was one of the only two (11 and 6) which had been buried face downwards. The two juveniles and the younger adolescent (Nos 4, 8 and 12) lay on their sides (two on their left sides, one on the right side) in a gently flexed posture. All the others had been buried on their backs, with varying arm and leg postures, and in these cases, too, some regularities can be observed. The tall, 15-year-old adolescent (No. 7)

Table 1. Wassenaar-Weteringpark, sex and age of the 12 individuals according to Smits and Maat, this volume, left in order of number, right in order of age estimation.

number	sex	age (year)	number	sex	age (year)
1	male	20-30	12	infans I	$1\frac{1}{2}$-2
2	male	30-40	4	infans I	3-$3\frac{1}{2}$
3	male	30-40	8	adolescent	± 10
4	infans I	3-$3\frac{1}{2}$	7	adolescent	15-16
5	male	30-40	11	female	± 18
6	(female)	>19	10	male	19-21
7	adolescent	15-16	6	(female)	>19
8	adolescent	± 10	9	male	>22
9	male	>22	1	male	20-30
10	male	19-21	2	male	30-40
11	female	± 18	3	male	30-40
12	infans I	$1\frac{1}{2}$-2	5	male	30-40

Table 2. Wassenaar-Weteringpark, sequence of deposition of the 12 bodies

sequence	west	east
1	12	.
1	11	.
2	.	1
3	10	.
4	.	2
5	9	.
6	8	.
7	.	3
7	.	4
8	7	.
9	.	5
10	6	.

Figure 12. Wassenaar-Weteringpark. Oblique view from the North.

was the only one with crossed lower legs. Four bodies (Nos 1, 2, 5 and 10) had one leg stretched and one bent, the foot placed against the tibia of the stretched leg. They were all young adult or adult males (*c.* 20-40 years of age). The legs of two bodies were both stretched (Nos 3 and 9). Both were male adults; one was the oldest individual (30-40 years old) in the grave, the other had been so poorly preserved that his age could no longer be accurately determined, but he had been at least 22 years old. No age- or sex-related rules could be inferred from the varying arm postures.

The overall arrangement of the bodies also reflected a certain regularity: central are the two stretched adult males, accompanied by juveniles, with (young) adults on either side and the women with the very young children at the edges. In view of the applied burial rules and the symmetrical arrangement of the bodies in the grave we may assume that No. 6 was a female, like No. 11, and that No. 9 was a relatively old adult.

The regularities described above could be interpreted as purely accidental; indeed, the evidence is too meagre to have any statistical significance. We may, however, safely assume that the bodies were **not thrown** into the grave but were **arranged** in a regular way in a burial procedure which provided sufficient opportunity for the observance of distinct sex- and age-related burial rules.

3.7 "Grave goods"

Very few **artefacts** were found in the burial pit and none of these may be considered grave **goods**.

A flint arrowhead found between the ribs of No. 10 represented important dating evidence and was also an indication of violence (fig. 17).

During post-excavational preservation two scraper-like flints were found under the lumbar vertebrae of No. 3. Microwear analysis by A.L. van Gijn showed that one of these (No. 514) had certainly been used as a scraper, possibly on skin, as suggested by the gloss pattern. They may have ended up under the body accidentally, but it is more likely that they were the personal possessions of the deceased; if so, they may indicate that the bodies were buried in their normal clothes.

Patches of charcoal, the remains of burnt pieces of wood, were observed in several places, especially next to Nos 1, 9 and 12. Very few sherds were found in the pit fill; they were all very small (less than 1 cm^2).

Figure 13. Wassenaar-Weteringpark. Oblique view from the East. Note the extremely bad conservation of individual 6 (left), close to the subrecent ditch fill. Note also the disarticulated skull off ind. 4 (foreground).

3.8 Cause of death

Very important and most interesting is the aforementioned small flint arrowhead that was found between the ribs of No. 10. Its position suggested that it had been shot into the body. Van Gijn observed impact fractures at the tip of the arrowhead but otherwise it had a fresh appearance and showed no traces of shafting (fig. 18). It is of course impossible to say when the impact fractures were formed; they may have been the result of earlier use. Nevertheless, we have interpreted this arrowhead as sound proof of a violent cause of death in the case of No. 10.

Since information on the cause of death is important for a social interpretation of this grave, careful attention was paid to possible marks of violence on the skeletal parts, which was not easy considering their poor state of preservation. A critical inspection revealed three blow marks, all without traces of healing, on the lower jaw of No. 2, on the right humerus of No. 3 and on the skull of No. 5. These marks were certainly not caused in modern cleaning; post-depositional causes were moreover very unlikely according to the physical anthropologists. An important question in this respect is how many traces of mortal violence are to be expected on skeletal remains, especially if they have been poorly preserved and are severely deformed, as in this case. A fourth indication of violence was the fact that the skull of the infans No. 4 had apparently been separated from the body at the moment of deposition. This disarticulation can hardly be attributed to post-depositional factors.

In view of all these observations, a violent conflict is the most likely cause of death. Other casualties, such as an epidemic disease, famine, flooding or shipwrecking, are less plausible causes.

3.9 Dating

The lack of grave goods meant that the remains had to be dated via typological comparison of the specific shape of the arrowhead found with individual No. 10 and via C14 analysis. The arrowhead did not resemble any of the fairly large number of arrowheads found in Bell Beaker graves in the Netherlands (Lanting/Van der Waals 1976). Barbed Wire Beaker graves have yielded hardly any grave goods and no arrowheads whatsoever (Lanting 1973). However, a

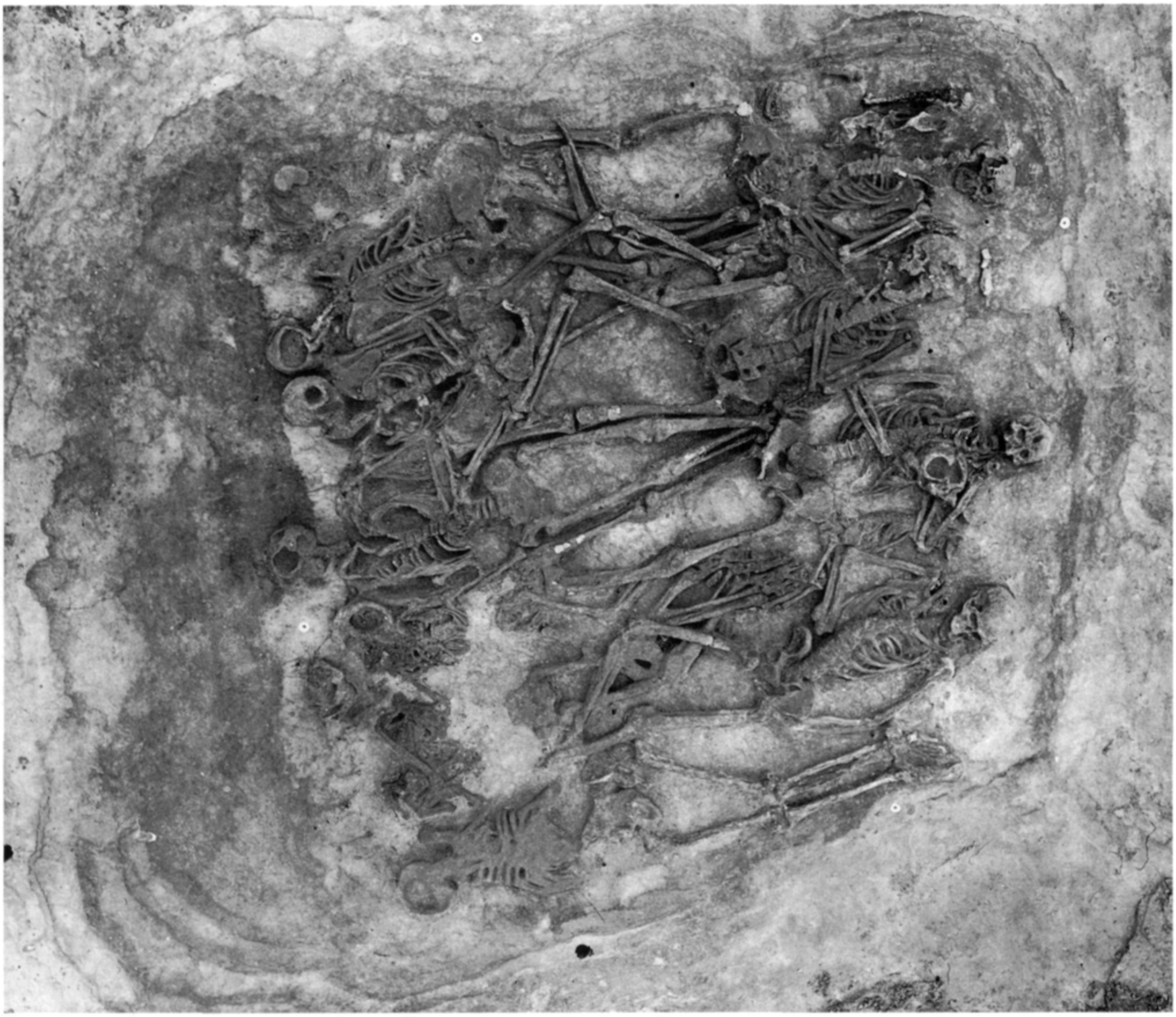

Figure 14. Wassenaar-Weteringpark. Vertical view. Note the humic infiltration bands around the grave.

fairly characteristic, rather sophisticated type of arrowhead with recurved barbs has been found in domestic assemblages. Close parallels have been found in an early Hilversum Culture pit fill at Vogelenzang near Haarlem (fig. 19), which are to be dated around 3400 BP (Groenman-van Waateringe 1961a). This date corresponds perfectly to two radiocarbon dates obtained from charcoal directly associated with the present burial:

Charcoal near pelvis of No. 9	GrN-14.949	3420 ± 80 BP
Charcoal from post (?) near No. 11	GrN-14.950	3380 ± 80 BP

These results yield a calibrated date of around 1700 cal. BC.

One of these samples was obtained from a number of concentrations of charcoal which were interpreted as the burnt edges of posts or beams that had disappeared altogether. The other sample was taken from the burnt remains of the end of a heavy upright post close to the head of individual No. 11, which may have marked the end of the grave. The relatively large standard deviation is attributable to the low carbon content of the samples.

This evidence soundly dates the grave to *c*. 3400 BP, 1700 cal. BC, around the transition from the Early to the Middle Bronze Age, which means that there is no direct connection between the grave and the settlement remains which first attracted attention to the site.

4. Context

4.1 Bronze Age occupation of the coastal region

How does the grave fit into the context of regional Bronze Age archaeology?

The Older Dune landscape developed and extended seawards during the Late Neolithic and the Bronze Age. As the coastline prograded, older dune rows gradually shifted further inland. At the same time the effect of the salt sea spray decreased and, as a result, the vegetation of the dunes changed from a halophytic vegetation, via typical dune brushwoods, into a deciduous forest, while the beach flats became rich natural meadowlands. This landscape will have been attractive for prehistoric settlement from its formation onwards. However, as a result of the subsequent rise in sea level, the beach flats were gradually submerged and changed into swamps and alder carrs. The region will have lost much of its former appeal when peat started to grow there, but where the dunes bordered zones of estuarine sedimentation, *i.e.* next to inlets and estuaries, high-water deposits compensated for the rise in the groundwater level; these deposits will have been covered with meadowland for a long time. The estuaries themselves moreover added to the diversity — and hence the attractiveness — of these zones.

We have, however, nothing more than the odd site and a few rare finds to confirm the presumed continuous prehistoric use of the coastal dune landscape. This landscape — and the archaeological evidence buried in it — has to a large extent been destroyed by intensive land use in historical and modern times: the effects of the cultivation of bulbs, sand quarrying, road construction and building have been disastrous for prehistoric remains in this region. Many remains were destroyed before the days of active archaeological research. Since the end of the last century, however, some finds have been recovered in this area and over the past decades detailed observations have been made in archaeological surveys and excavations. Most instructive in this respect were the large-scale geological and archaeological observations made during the execution of the development project in the Velserbroekpolder in Haarlem, in which extensive sites of many hectares containing plough marks and house plans came to light (Bosman/Soonius 1990). These remains indicated the intensive use of at least those parts of the dune margins that were bordered by natural pastures on former salt marshes and suggested intensive land use on a larger scale in this period, especially in zones of ecological diversity.

Other Bronze Age settlement sites have since then been found at Velsen-Noordzeekanaal, Vogelenzang (Groenman-van Waateringe 1961a), Lisse, The Hague and Monster (Van Heeringen 1983; Louwe Kooijmans 1974, App. I), all of which were discovered during sand-digging operations, but no remains of Bronze Age sites have so far come to light in the direct surroundings of the Wassenaar grave. A Bell Beaker site has been found at less than 1 km to the east, but the closest domestic Middle Bronze Age remains were found 7 km to the southwest (Van Heeringen 1983, site 3). The well-known Middle Bronze Age hoard of Voorhout was discovered 8 km to the northeast of the grave, on the other side of the Rhine estuary. It is likely that the occupation sites were on the rows of dunes bordering the beach flat close by (Van Heeringen 1983).

Due to the extensive destruction of the archaeological remains, the poor state of preservation of the scarce finds and the fragmentary nature of our evidence it is very difficult to make specific statements on Bronze Age settlement densities and the intensity of land use, but we have the impression — and it cannot be more than that! — that the land was intensively used from the times of the Late Neolithic Vlaardingen Group onwards.

The evidence of Haarlem-Velserbroekpolder suggests that the very similar microregion in which the Wassenaar grave was situated was equally attractive and was hence populated by a similar number of people in Bronze Age times. The sea had retreated from this area several centuries before then and the beach flat must have been covered with wet natural meadowlands, the dunes on both sides having been wooded. The grave, however, had not been dug in or near a settlement site, but in what was apparently a field far away from the settlement itself, which must have been situated somewhere on the main dune ridges.

4.2 The grave in relation to Dutch Bronze Age burial traditions

Although the Wassenaar grave is clearly a special case, we must ask ourselves what Bronze Age burial traditions it reflects and to what extent. We must also consider its uniqueness and its position in our interpretation of the Dutch Bronze Age.

Early Bronze Age burial practice may be considered an archaeologically poorer continuation of the Beaker tradition: the deceased were still buried under barrows, but without the ring ditches containing closely set posts (Lanting 1973; Louwe Kooijmans 1974, 308, 318); the orientation of the grave was usually north-south instead of predominantly east-west, as it had been in the previous period. The burial posture changed from crouched to more gently flexed; the earliest instance of a stretched burial on the back, which was to become customary in the Middle Bronze Age, has been dated to 3660 ± 35 BP (St.-Walrick; Groenman-van Waateringe 1961b; Louwe Kooijmans 1974, 308). Grave goods are almost completely absent in Early Bronze Age graves.

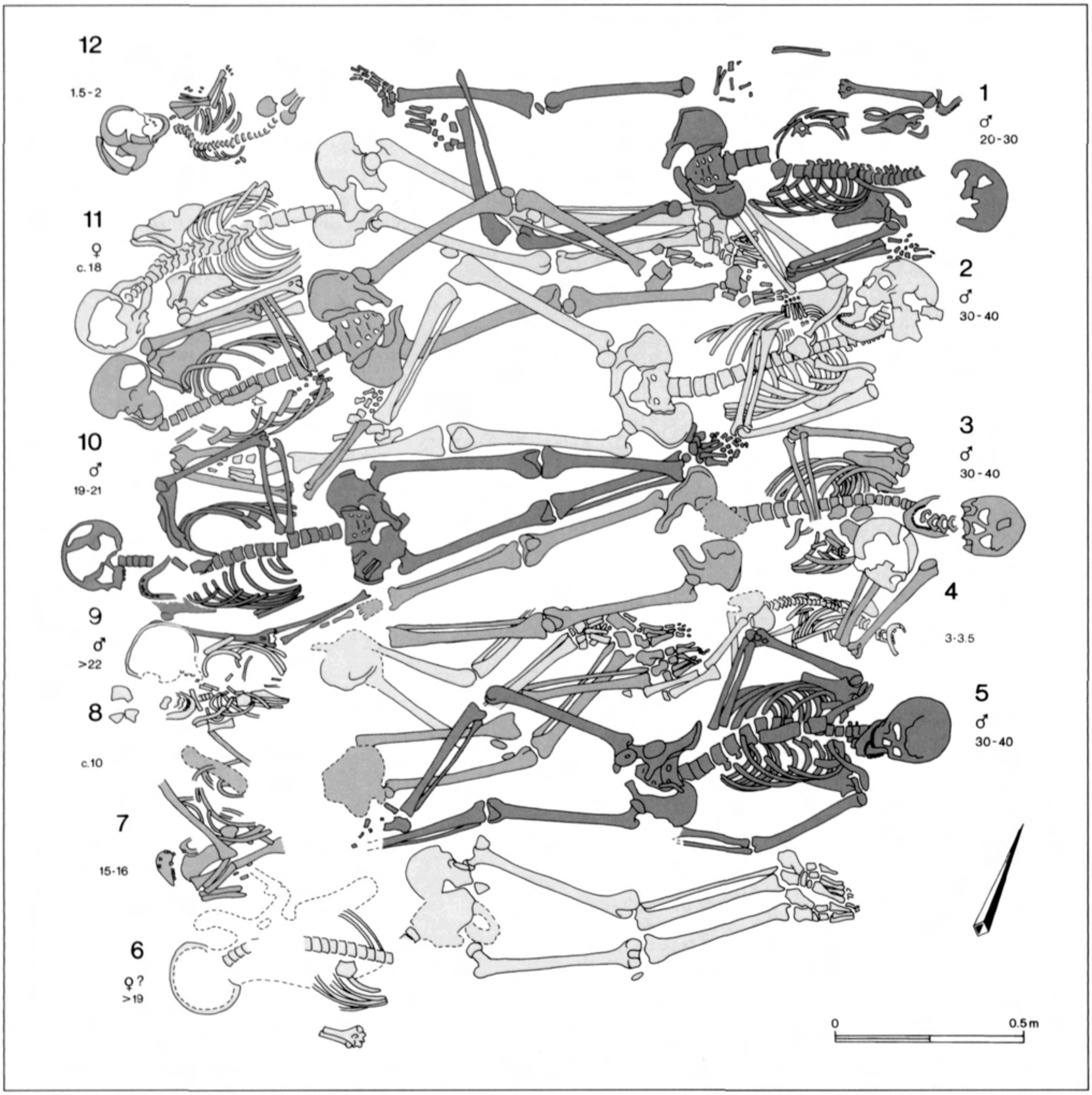

Figure 15. Wassenaar-Weteringpark. Plan of the multiple burial, with age and sexe of the individuals.

Halfway through the Early Bronze Age the practice of cremation and the burial of the remains in Hilversum urns under barrows surrounded by ditches and banks was introduced in the southern part of the Netherlands (especially North Brabant). This clearly indicates close connections with the urn burial traditions of south England (esp. the Wessex biconical urns). The development is now generally interpreted as an evolution, based on regular and intensive contacts, continuing those of Beaker times, and no longer as an indication of the arrival of British immigrants.

The practice of cremation was introduced in the northern part of the Netherlands (Drenthe) at the beginning of the Middle Bronze Age. It remained the common form of burial

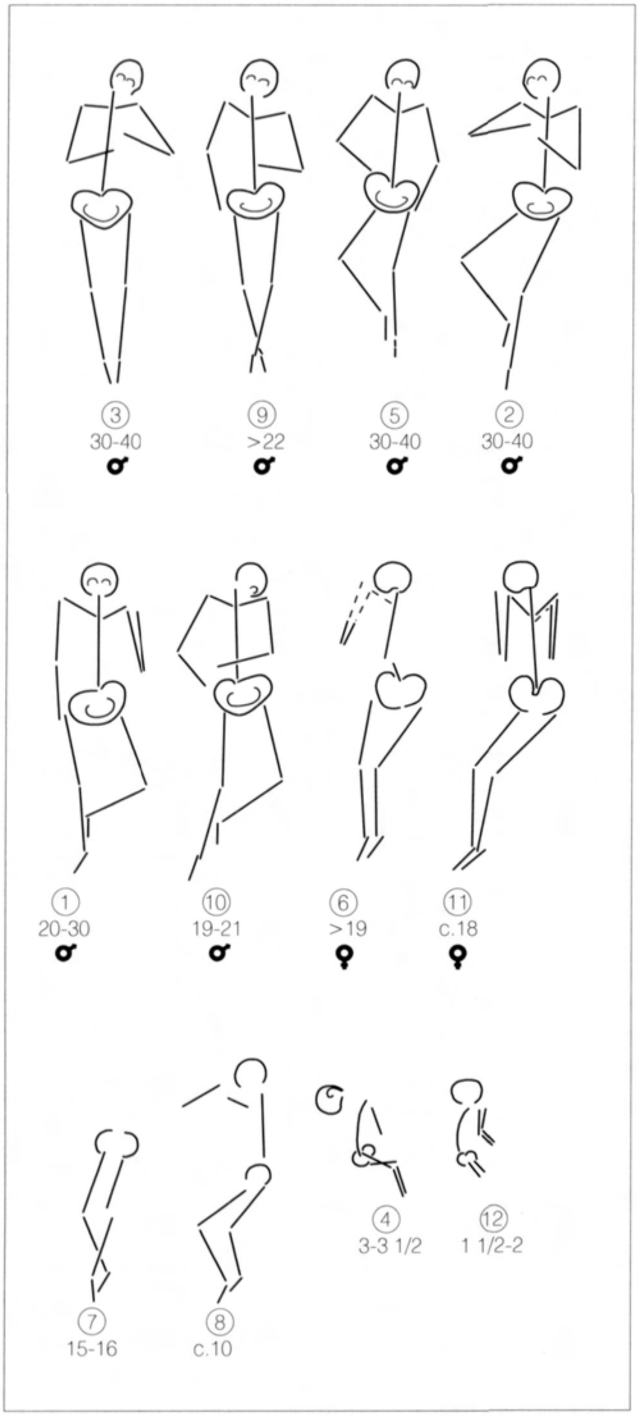

Figure 16. Wassenaar-Weteringpark. Burial postures.

throughout the first half of that period (MBA-A) and was replaced by inhumation of fully stretched corpses (preserved as silhouettes) in proper coffins in the second half of the Middle Bronze Age (MBA-B). The silhouettes provide very little information on body postures. No child postures or face-down postures have been identified. There where the silhouettes of legs could be made out both legs were stretched; no silhouettes with one bent leg have so far been identified (Lohof 1991). No multiple burials have been found, but we do know of some cases of closely grouped individual graves in a communal mortuary house, as at Zeijen, barrow 75 (Glasbergen 1954, part 2, 144). These were, however, individual graves and although they had been dug within a time range of a couple of years, most were probably NOT contemporary. This northern Dutch group represents the westernmost manifestation of a tradition that was common all over the North German Plain and the southern part of Scandinavia.

In the late part of the Early Bronze Age and the Middle Bronze Age there was therefore a marked difference in burial practices between the northern and southern parts of the Netherlands. There were, however, also similarities between the two areas: in both areas barrows were erected on heavily podzolized soils using sods cut from those soils; in both areas these barrows were surrounded by circles of postholes during the Middle Bronze Age and were used for later secondary burials, although different local burial practices were used: what have been called "tangential inhumations" have been found in the north and cremation-and-urn burials in the south. Moreover, stretched inhumation was occasionally practised in the south while cremation started to be introduced in the north. As the number of barrows found is rather small it is possible that only a part of the local population was buried under such structures.

Due to the lack of evidence the relation between the burial customs of the coastal district of the western Netherlands and the aforementioned two traditions is not clear. Sherds of Hilversum pots indicate connections with domestic sites in the southern part of the Netherlands. The lack of evidence on burial practices, in particular barrows, is first of all attributable to historical and (sub)recent landscape transformations and, secondly, to the formation of the Younger Dunes over parts of the Bronze Age occupation areas near the sea. The chance discovery of a group of at least three (probably more) Early/Middle Bronze Age barrows at Velsen-Hofgeesterweg, a few kilometres to the north of Haarlem, has provided at least some indications of coastal burial traditions. The barrows, which had been completely covered by drift sand, came to light during the digging of a trench for a pipeline in 1978 (Woltering 1979). One barrow (A) contained what was thought to have been a primary east-west burial of a crouched skeleton and six secondary inhumations, five of which at least were stretched. The bodies were oriented NW-SE and NE-SW. The barrow was surrounded by a ring ditch and a circle of postholes. Another barrow (C), which

Figure 17. Wassenaar-Weteringpark. Flint arrow head *in situ* between the ribs of ind. 10.

was surrounded by three ring ditches and five circles of postholes, contained four stratigraphically separated concentrations of cremation remains at the centre. Barrow B was surrounded by a double circle of postholes and a square ditch and contained cremation remains at the centre. Two kilometres to the south of this group, at Velserbroek, an exceptional grave was found on a small dune (Bosman/ Soonius 1990). It was oriented east-west and contained inhumation remains accompanied by two golden *Noppenringe* and a Scandinavian palstave. The stretched skeleton, which lay at a depth of -0.85 m NAP, had decayed almost completely. The deceased had been placed on a small platform inside a larger (90 × 280 cm) burial pit. No other graves of this type are known. This evidence suggests a rather wide diversity of burial customs, combining both northern and southern elements.

A similar picture, but based on a much larger collection of data from some 200 interments, has been obtained for the Middle Bronze Age occupation of Westfrisia (West Friesland), a region with close connections with the coastal dunes in Bronze Age times. The dunes will have been the first to have been occupied and long-distance contacts will have been maintained via these areas. In the groups of barrows, the cemetery of flat graves, the settlement burial and the human remains mixed with domestic refuse stretched inhumations dominated, but crouched burial in various postures and cremation were also practised. Interesting with respect to the adult-juvenile association in the Wassenaar grave is the case of the partial cremation of an adult female IN a burial pit and the subsequent burial of a 7-year-old juvenile, on its side in a crouched posture, in the same pit at Hoogkarspel (barrow 2; Bakker/Brandt 1966, 190; Brandt 1980, 59). The barrows were surrounded by varying structures, mainly ring ditches, but also square ditches, circles of pits and circles of post holes, although the latter were rarer, good timber being scarce in that area. A synthesis of this rich material is still lacking and is badly needed (Bakker 1974; Brandt 1980; Brandt/IJzereef 1980).

Grave goods were rare all over the Netherlands in the Middle Bronze Age; the few that have been found consist mainly of small rings and an odd pin. Heavy implements like axes and swords are very rare, even though hundreds of barrows have been excavated. Remarkable exceptions are the rich Sögel grave of Drouwen and the Middle Bronze Age grave of Sleen (Butler 1969, 107 f.). Two graves in the western Netherlands are conspicuous for similar reasons: the Velserbroek grave mentioned above and one of the flat graves at Zwaagdijk, Westfrisia, in which an adult male was accompanied by an originally approximately 55-cm-long sword with a six-riveted hilt which is probably of Atlantic (Breton?) origin (Butler 1964; Modderman 1964). These graves reflect a martial aspect of Middle Bronze Age society that is of interest in the context of the Wassenaar grave.

In comparison with those of the northern and southern traditions, the burial customs of the coastal district — if we may indeed regard it as a separate unit — vary considerably in terms of the handling of the deceased, the posture of the bodies, their orientation, the type of burial monument and the surrounding structures. We may interpret this differentiation, at least partly, as a reflection of the varying social qualities of the deceased and hence as an indication of a socially differentiated society. But that is about all that can be said about this differentiation. The lack of grave goods and our ignorance of the correlation between archaeological and social variables precludes further conclusions.

The evidence of the Wassenaar grave fits in with Bronze Age burial traditions as far as the extended postures and the custom of inhumation are concerned, although the two were not to become common until a few centuries later. We know of only one other case of a child buried in the same posture as that of Wassenaar whereas skeletons with one bent leg have been found in no other graves whatsoever. The absence of cremation remains in a grave dating from phase MBA-A is very conspicuous. All in all this makes the Wassenaar grave a special case. Another unique feature of this burial is the peculiar way in which the individual bodies had been placed in the grave: the twelve deceased had not been simply buried together according to a general burial practice, but had been carefully deposited according to a special set of rules (specially designed for this occasion?). Ethno-archaeological observations may throw some light on this matter.

Figure 18. Wassenaar-Weteringpark. Flint arrow head from ind. 10. Scale 1:1.

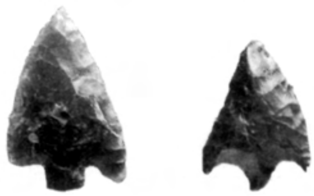

Figure 19. Vogelenzang. Two arrow heads from an early Hilversum Culture domestic complex. After Groenman-van Waateringe 1961a. Scale 1:1.

4.3 ETHNOARCHAEOLOGY

No exhaustive research has been done into ethnographic evidence on burial in relation to violence. Not being an anthropologist myself, I will restrict myself to interesting and possibly relevant quotations of Binford (1971, 221). He notes that "... many [ethnographic] investigators [list] as the basic components of the social personality, symbolized through differential burial treatment: age, sex, relative social status within a given social unit, and social affiliation in terms of multiple membership units within the society and/or membership in the society itself. Additionally it was frequently noted that peculiar circumstances surrounding the death of an individual may be perceived by the remaining members of a society as altering, in a substantial manner, the obligations of the survivors to acknowledge the social personality of the deceased. Such persons are instead treated as "members" of a post-mortem social unit and afforded mortuary ritual appropriate to such a membership group. ... Deaths occurring simultaneously as a result of epidemics or massacres might be treated corporately, with mass graves, by virtue of their "unusual" coincidence."

Binford (1971, 220) cites several specific ethnographic cases but if we restrict ourselves to his ethnographic sample (p. 228-233), the "cause of death" appears to be expressed in only 8 out of 40 cases. This is done especially by settled agriculturists and pastoralists (7 out of 17 cases). It is reflected not so much in the furnishings of the grave, but in its location (three cases) and in the handling of the body and its disposition (two cases each). Sex is never and age infrequently expressed in body posture in this sample. However, the representativeness of Binford's sample — and hence his quantitative interpretations — may be disputed.

From an ethnographic point of view, the way in which the Wassenaar group was handled after its collective violent death is not uncommon. The separate location and the specific burial rules match the data of Binford's sample very well. The attitudes of Dutch Bronze Age groups towards such casualties may have been quite similar to those of recent agriculturalist groups.

5. Conclusion

5.1 WHAT HAPPENED AT WASSENAAR?

The evidence and discussion above lead to the following conclusions.

The coastal Older Dune landscape was most probably intensively used in the Bronze Age. The microregion to the south of the Rhine estuary will have been attractive because of its ecological diversity. We furthermore have sound evidence from the Wassenaar grave for a violent armed conflict around 3400 BP, 1700 cal. BC. The majority of the victims of this conflict were males of warrior age, but children and women were also killed.

Shortly after the onslaught the victims were buried on a small dune, in the middle of the natural pastures of a wide beach flat. This location is not likely to have been a settlement site; the settlements were most probably situated on one of the main dune rows, close to the arable. We assume that this conspicuous location was purposely selected for this extraordinary grave. The use of particular burial rules and the personal attention paid to the dead suggest that they were buried by captive or escaped kinsmen.

5.2 A MORE VIOLENT DUTCH MIDDLE BRONZE AGE

This conclusion gives rise to a number of questions.

In the first place, the Wassenaar grave stands out as unique in three respects: the collective aspect, the signs of violence and the combination of the two. In these respects it is singular for the Dutch Bronze Age, and indeed for Dutch prehistory as a whole and — as far as I know — for the Bronze Age of the whole of northwest Europe. Is this grave to be regarded as an entirely unique feature or does it represent a class of burial that is rare or has a low chance of discovery, or perhaps both?

The second question is: to what extent does this new evidence alter the traditional view of the Dutch Bronze Age?

Thirdly, how are we to specify this type of armed conflict or "war"? Information on the different types of war (and their varying archaeological visibility) in (sub)recent societies with roughly similar organisations is instructive in this respect. I intend to discuss this topic in a separate paper and to extend on tribal warfare in European prehistory in that context.

Features like the Wassenaar grave, situated in an open field without any durable markers, have a very low chance of discovery and hence a poor archaeological visibility. Once bone remains have decayed — as is usually the case in the Netherlands — such burial pits are not noticed by workmen or dragline drivers. On the other hand, in spite of the systematic prospection of digging operations and the intensive archaeological research that has been carried out over the past decades, no comparable burials have been found, not even in Westfrisia, where extensive reallotment operations have been prospected, large-scale settlement excavations have been carried out and many well-preserved bone remains have been found. It may be argued that the use of special burial rules at Wassenaar implies a certain "tradition", in the sense of a regular custom. Our impression is that the Wassenaar grave does not reflect a singular event, but represents a first indication of an aspect of Bronze Age society that is poorly reflected in the archaeological record. We should at any rate examine the consequences of this hypothesis.

Violence of the kind reflected in the Wassenaar grave is totally at variance with the picture of a peaceful agrarian society that has so far emerged for the Dutch Bronze Age from evidence from settlements, graves and hoards: a quite Utopian, if not naive, view of the past.

Most of the evidence from settlements has recently been collected (Fokkens/Roymans 1991). People lived in small, undefended agrarian settlements, in three-aisled farms comprising a living area and a byre. The farms varied in length, most measuring between 20 and 30 m, a few having lengths of up to 60 m (Angelsloo: Van der Waals/Butler 1974). The settlement structure appears to have varied, too: there were isolated farms (Elp: Waterbolk 1964), small open clusters (Texel: Woltering 1975), settlements consisting of one large farm surrounded by outhouses (Zijderveld: Hulst 1991) and concentrations of at least ten, perhaps even more, farms arranged in a long row between arable and pastureland (Westfrisia, Bovenkarspel: IJzereef 1981). The abundant evidence for cattle stalling, the specific site locations and zoological and botanical evidence present a picture of self-sufficient farmers with a balanced true mixed-farming subsistence strategy, with the emphasis on cattle, wheat and barley. The settlements were situated between arable and natural pastureland and mobility seems to have been restricted to small-scale transhumance, as for instance in the case of the initial colonization of Westfrisia. There is no reason to assume the exchange of staple crops between neighbouring communities on any scale. In view of the evidence for a violent conflict we may now speculate about the role of horses, represented for the first time in very low frequencies in the bone spectra found at the sites of these communities.

No evidence for site hierarchy has so far been obtained and it is unlikely that any will emerge in the future. The *inter*site differentiation appears to reflect regional variation rather than hierarchy. *Intra*site differentiation is mainly expressed in the lengths of the farms, in particular in the large number of farm plans in Westfrisia, whose lengths ranged from 15 to 30 m. Such differences in lengths imply great differences — of up to a factor of three — in the number of cattle kept, that is, if we assume a living area of standard dimensions, and hence a differentiation in wealth, possibly implying a hierarchical society. There is no settlement evidence for a household of a person with some central function or power. The settlement evidence therefore indicates a tribal society rather than a chiefdom.

Social differentiation is apparent in grave goods on a very modest scale, as already mentioned above. The warrior graves of the Early and Middle Bronze Age can be counted on the fingers of one hand, whereas hundreds of barrows, most containing several burials, have been excavated. The greatest differences are in the burial monuments themselves: the labour invested in the construction or extension of the barrow and in the circles of postholes surrounding them.

The number of hoards that have found in the Netherlands is also very small. Hoards of weapons containing swords and/or spearheads, such as that of Overloon (Butler 1959), are remarkably rare. The archaeological reflection of Early and Middle Bronze Age society hence lacks distinct social hierarchy and shows hardly any signs of martiality. Nobody has ever seriously questioned whether this is a true, representative reflection of that society. The apparent poverty of the Dutch Bronze Age was initially attributed to the scarcity of bronze, which had to be imported over long distances. However, the evidence for a flourishing agrarian society that has since then been obtained in large-scale settlement research has made this argument untenable. All that can be said now is that the Bronze Age inhabitants of the Netherlands were already quite economically minded and did not "waste" their bronze in burial customs. At the same time they obscured their social differentiation and organisation for later archaeologists. On the face of it, however, we do not have the impression that the social organisation of the Bronze Age was any more sophisticated than that of, for instance, the evolved Limburg Bandkeramik. It is best to see it as a ranked organisation of a tribal community than as a stratified chiefdom.

The peaceful, rather idyllic picture of the Dutch Bronze Age has now been severely disrupted by the Wassenaar evidence. Apparently violent conflicts took place, in which not only males, but also females and children were killed, although the Wassenaar sex ratio does suggest that women were spared to a certain extent; they may have been abducted rather than killed.

I wondered whether the shock that this new evidence has caused among archaeologists is possibly attributable to naivety and whether, in spite of the lack of evidence, armed conflicts in fact formed a normal part of the social life of societies like the Bronze Age one described above. With this hypothesis in mind I started a general survey of multiple burials with indications of violence from the Central and Western European pre-urnfield period. I found a small, but widely spread, amount of evidence from Bandkeramik times onwards. A survey of ethnographic and anthropological sources showed that, first of all, violent conflict is the rule rather than the exception in all societies. Secondly, in many tribal societies warfare is endemic, either as raids or in a more ritualised form, and, thirdly, these tribal types of warfare do generally not leave conspicuous archaeological traces: they do not involve defensive structures, specialised weapons and armour, large-scale destruction, specialised warrior groups, etc. In view of these observations it seems permissable to use the little Neolithic evidence available and the even smaller amount of Early and Middle Bronze Age evidence to assume that armed conflicts or tribal warfare were endemic throughout the Neolithic and the Bronze Age. This form of warfare was the logical basis for the more visible forms of warfare of the more complex societies of later prehistory. I plan to discuss the results of this study in a separate paper in the near future.

Acknowledgements

I would like to thank Erik Jungerius for his assistance in the field, Liesbeth Smits for her physical-anthropological study and Pieter van de Velde for his critical reading of my article and the discussions we had.

notes

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An Early / Middle Bronze Age common grave at Wassenaar, the Netherlands. The physical anthropological results

The physical anthropological study of skeletal remains from a common grave at Wassenaar has provided demographic and palaeopathological information on the Bronze Age group of people who had been buried in the grave.

The group consisted of men, women and children who had been interred according to different burial practises.

Bone lesions indicating a violent death were found only on skeletons of male individuals.

1. Introduction

In April 1987 a grave dating from the Early/Middle Bronze Age was excavated by archaeologists from Leiden University. The grave contained the skeletons of 12 individuals, one of which had a flint arrowhead between the ribs. See the plan of the grave (figs 1, 2).

Skeletons from this period are seldom recovered in the Netherlands because of the poor local preservation conditions for bone. Our skeletal remains were also in a very bad condition. Especially in the southwestern part of the grave the state of preservation was so poor that it was virtually impossible to identify the individual bones of the upper parts of the skeletons (Nos 6, 7, 8). Moreover, the skeletons deteriorated rapidly on exposure during excavation.

Because of this and the risk of the loss of valuable information during transport, the physical anthropological research was carried out in the grave where possible. This included sex and age determinations and the measurement of long bones and of the total skeleton length of the individuals *in situ*. The skulls were not measured because of the postmortem deformation due to the pressure of the soil.

As it was impossible to lift the bones individually, the skeletons were removed in their entirety, together with the underlying soil. Further cleaning and preservation took place in the laboratory.

Eventually the various parts were fitted together, like a jigsaw puzzle (see fig. 3), for exhibition purposes.

The communal character of the burial and the discovery of a flint arrowhead between the ribs of one of the skeletons determined the main objective of our study, *i.e.* to determine whether the demographic and palaeopathological data obtained for the group could shed any light on the event which had taken place so long ago.

2. Materials and Methods

The individuals had been buried in a grave of approx. 230 × 210 cm, oriented NNW-SSE (see fig. 1). The orientation of the skeletons in the grave was roughly WSW-ENE. Five individuals (Nos 1, 2, 3, 4, 5) were positioned with their heads in the east and seven individuals (Nos 6, 7, 8, 9, 10, 11, 12) with their heads in the west. Six (Nos 1, 2, 3, 5, 9, 10) had been interred on their dorsal and two (Nos 6, 11) on their ventral sides. The legs of the latter were bent slightly to the left. Four others (Nos 4, 7, 8, 12) were positioned on their sides, two on their left sides and two turned slightly on their right sides.

On the whole, the skeletons were still well articulated. Disarticulations and missing parts were attributable to post-depositional displacements, either as a natural consequence of decay or due to bioturbation. In one case only, *i.e.* that of individual No. 4 (a child), was the skull out of position (see fig. 1).

Due to the poor condition of the bones and the request for the use of the reconstructed skeletons for an exhibition we were unable to perform detailed examinations.

2.1 Age assessment

The age of the children and juveniles was inferred from the mineralization and eruption status of the deciduous and permanent teeth (after Ubelaker 1984) and from the closure of the epiphyses of the postcranial skeleton (after Krogman/Iscan 1986). The length of the long bones was also considered, although it is a less reliable age indicator as it should be regarded in relation to the adult stature of a reference population (Trotter/Gleser 1952, 1958). In one case only, i.e. that of the poorly preserved skeleton of individual No. 8, was the length of a long bone the sole age indicator available (reference material: Maresh 1955).

The age of the adults was more difficult to assess. The complex method of age diagnosis based on the degree of fusion of the internal sutures, the structure of the cancellous

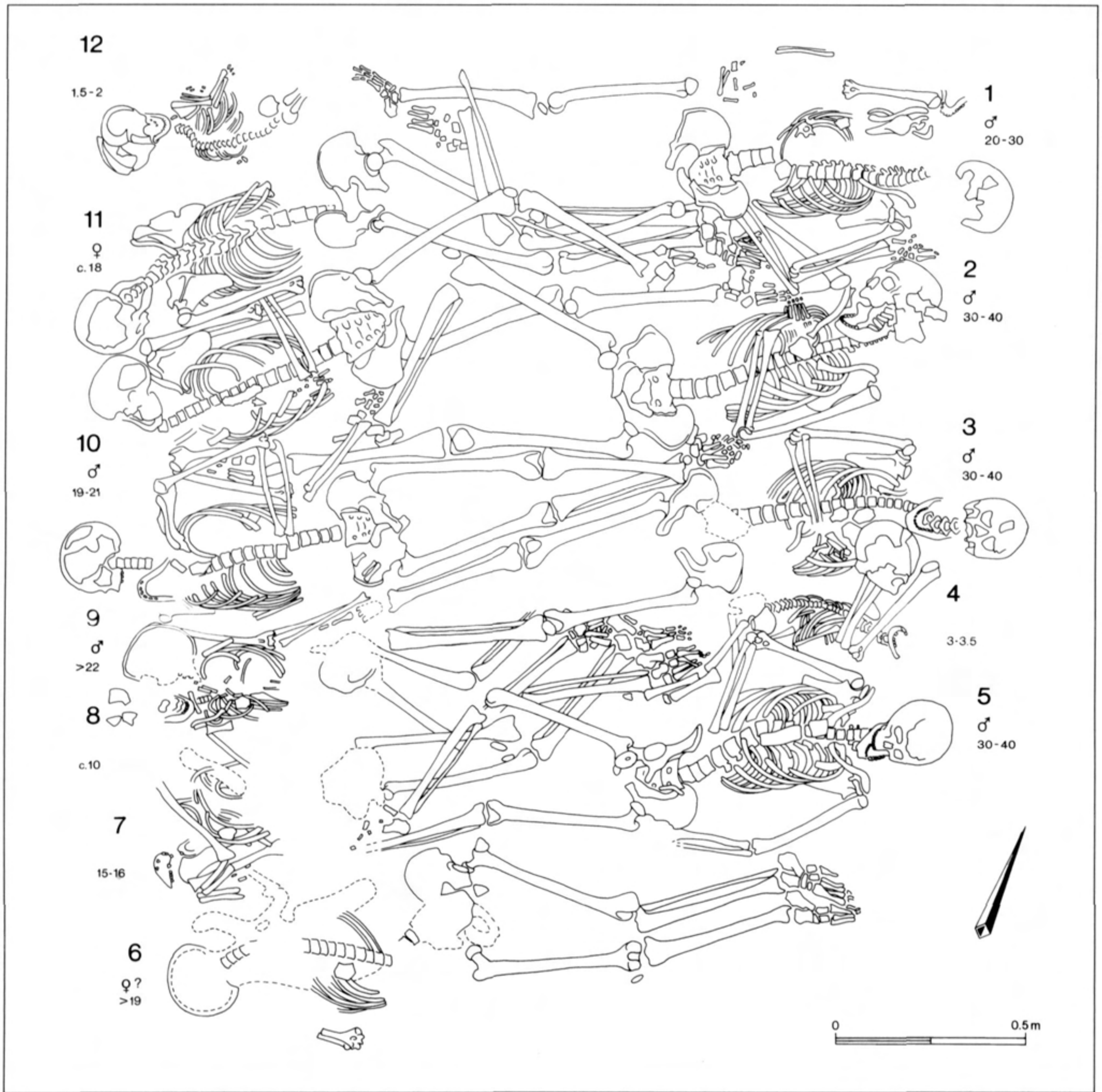

Figure 1. The grave.

bone of the proximal epiphyses of the femur and humerus and the appearance of the pubic symphysis (Workshop of European Anthropologists 1980) could not be used here as it would have been too destructive. The only indicators that could be used were the degree of fusion of the external sutures (Rösing 1977) and the degree of attrition of the teeth.

We took the degree of attrition of the teeth as our main age indicator. Attrition phases after Brothwell (1981) were numerically scored according to the method proposed by Maat and Van de Velde (1987). The ages thus derived are considered normal for pre-medieval populations (Brothwell 1981). The individual rate of attrition can be established by comparing the degree of attrition of the first and second molars of the permanent teeth. The first molar erupts six years before the second one, which means that the difference in attrition between the two also covers a period of six years. The attrition rate of a population is defined as the mean value of all individual attrition rates.

2.2 Sex determination

The sex of the individuals was determined on the basis of non-metrical morphological characteristics of the skull and the pelvis. They were scored according to the criteria indicated by the Workshop of European Anthropologists (1980).

The scores were -2, -1, 0, +1, +2, which stand for super-female, female, indifferent, male and super-male, respectively. Some sex characteristics are more discriminative than others and a different weight is therefore attached to each characteristic. The degree of sexualisation is the mean weighed outcome of all the observed characteristics. A negative value indicates a feminine and a positive value a masculine development. Only the adults were studied in this way.

2.3 Stature

The lengths of the long bones and the total length of the skeleton, from the upper part of the skull to the most distal point of the tuber calcanei, were measured *in situ*. The bone lengths were checked after the bones had been cleaned in the laboratory. The statures were calculated according to the method proposed by Trotter and Gleser (1952, 1958).

3. Results

3.1 Demographic data

The group consisted of six men, two women and four children. One individual (No. 6) in the southwestern corner of the grave was too incomplete to allow sex determination. Its sex had to be inferred from the position of the body within the grave and relative to the other bodies (see the discussion below).

There were two children in the age category 0-6 years (Infans I), one child in the age category 7-14 years (Infans II) and one of 15-16 years (Juvenil).

The ages of the adults were inferred from the individual degrees of attrition as described above. The attrition rate of the group as a whole was approx. 0.6 (n=4, mean = 0.58, s.d.= 0.14). The attrition rate of one of the women (No. 11) was twice as high as the average rate of the males (Nos 2, 3, 5). After relating individual degrees of attrition to the degree of fusion of epiphyses and sutures we established a sequence of estimated ages at death (see tab. 1).

All the adults had died before the age of forty. In the case of two individuals, Nos 6 and 9, the degree of

Table 1. Total count of individuals recovered from Wassenaar.
* = estimated age at death after seriation of molar attrition.
** = corrected for age.

Individual	Age(years)*	Sex	Stature(cm)**	Pathology
1	20-30*	male	167	
2	30-40*	male	182**	cutting blow
3	30-40*	male	176**	cutting blow
4	3-3.5	-		
5	30-40*	male	169**	cutting blow
6	>19	female?	170	
7	15-16	-	ca.170	
8	ca.10	-		
9	>22	male	176	
10	19-21*	male	177	arrowhead
11	ca.18	female	182	
12	1.5-2	-		

epiphysial fusion indicated that they were adults but it was impossible to arrive at a more precise assessment of their age as no teeth were available.

3.2 Stature

The average adult male stature of this group was 174.8 cm. It should be noted that individual No. 7, aged 15, already had a stature of approx. 170 cm and that individual No. 11, aged 18, had a stature of 182 cm!

3.3 Traumatology

An arrowhead (see fig. 2) was found between the ribs of individual No. 10, a young man of about 19-21 years of age.

Individual No. 2, a man of about 30-40 years of age, had a wedge-shaped injury on the left side of his lower jaw, the thin end pointing towards the front of his jaw (see fig. 3).

Individual No. 5, a man of 30-40 years of age, had the same kind of injury on his forehead (frontal bone).

A third, similar injury, was observed on the posterior part of the right upper arm of individual No. 3, also a man of 30-40 years of age.

No bone reaction (growth/healing) was observed at all these injuries.

A remarkable case was that of individual No. 4, a child of approx. 3 years of age, whose head was found on top of the left side of the chest of the nearest individual (No. 3). The lower jaw was still in a natural anatomical position in front of the cervical vertebrae. No injuries were observed.

3.4 Discussion

All the identified males were lying on their backs, at the centre of the grave. The only morphologically identified

Figure 2. The arrowhead *in situ*.

female, No. 11, lay at the far end of the grave, in the northwestern corner; individual No. 6 lay in the southwestern corner. Individuals Nos 6 and 11 had both been interred face downwards, with their legs in the same positions. If we may draw any conclusions from the relative positions of these individuals in the grave (see Louwe Kooijmans, this volume) then we may conclude that No. 6 was probably a female, too. That would imply that the men and women had been interred differently. All four subadults had been buried more or less on their sides. Sex-related differences in burial practises could indicate differences in the roles of men and women in the social organisation.

Another indicator of social organisation could be the dental attrition rate. It was quite clear that the attrition rate of the female (No. 11) was twice as high as the average rate of the males (Nos 2, 3, 5). Such a difference could be the result of culturally defined habits. Perhaps men and boys were offered the best food whereas women and girls had to make do with the leftovers, containing more grit (Wells 1975). Another possibility is that certain cultural activities in which the teeth were used as a tool were carried out by women (Molnar 1972).

We must of course bear in mind that we are discussing the attrition rate of only one woman; her teeth may have had a different enamel thickness (Molleson/Cohen 1990).

As adult stature is not only dependent on genetic factors but also on general welfare, nutrition and hygiene, it varies for different populations in time and space (Roede/Van Wieringen 1985). Deficiencies in diet and diseases can retard growth, whereas prolonged favourable conditions can result in a considerable increase in length after several generations. The average calculated stature of the males of this group is quite tall compared with that of males of historical times in the Netherlands: approx. 166 cm in the 17th and 18th centuries AD and 165 cm in the first quarter of the 19th century AD (Maat 1993). Due to improved socio-economic conditions the average stature of the Dutch male population even increased to 178 cm in 1965 and 182 cm in 1980 (Roede/Van Wieringen 1985). In view of these considerations, the adult stature of the excavated men of the Wassenaar group seems to indicate a rather healthy lifestyle.

Tall statures were rather common in the Bronze Age (Van den Broeke 1992; Dienst Gem Arch. Velsen 1989; Louwe Kooijmans 1973; Modderman 1964; Verwers 1966); measurements obtained for other skeletons (through calculation or by measuring the skeletons *in situ*) range from 169 to 187 cm.

The demographic composition of the group and the recorded palaeopathological changes were our main source of information in reconstructing what may have happened at Wassenaar.

Was there an armed conflict between warriors or an economically motivated raid on the inhabitants of a rural settlement (see Louwe Kooijmans, this volume)? A communal burial alone does not constitute conclusive evidence for a violent cause of death. Other factors, such as

Figure 3. Individual No.2 with the wedge-shaped injury on the left side of the lower jaw.

a serious infectious disease or ritual depositions (Cunliffe 1993), may also explain why several persons died within a short span of time. It should also be kept in mind that bone remains do not always reveal the cause of death.

The composition of the group in terms of sex and age, and in particular the presence of women and children, precludes the possibility of a conflict between groups of warriors. However, the group is not entirely representative of a domestic community either, as it lacks old people and includes only two women.

Material objects like the flint arrowhead found between the ribs of male No. 10 are clear indications of the cause of death. No more objects of this kind were found, but the injuries on the bones of the males Nos 2, 3 and 5 have been interpreted as cutting blows. The injury on the upper arm of male No. 3, for instance, may easily have been inflicted as he was attempting to ward off an attack.

The absence of any signs of bone reaction at these lesions proves that the wounds had not healed. It implies that the injuries were caused shortly before or at the time of death. A remarkable fact is that all these injuries were found on males only!

Other examples of injuries caused by projectiles, such as arrowheads, or hand-held weapons, such as swords or axes, are well-known in European prehistory. For example, in the case of the Neolithic grave containing the skeletons of a man, a woman and two children discovered at Fengate (Pryor 1976) an arrowhead that was found between the ribs of the man indicated the cause of his death. Another Neolithic grave containing the skeleton of a man who had been hit by several arrowheads was discovered at Stonehenge (Atkinson/Evans 1978). Both of the skulls of the two male individuals buried in the Neolithic grave at Sant Quirze del Valles had been mutilated and a flint arrowhead projected from the vertebra of one of the two (Campillo *et al.* 1993). Six individuals found in a Neolithic mass grave at 'San Juan ante portam Latina' showed injuries caused by flint arrowheads (Etxeberria *et al.* 1991). A more detailed and extensive description of similar cases is given in the article by Louwe Kooijmans (this volume).

Missing parts of skeletons and disarticulations may also indicate a violent death. This brings to mind the position of the skull of child No. 4. If the position in which the head was found is the result of human intervention, it implies a highly complex form of *deliberate pre-* or *post mortem* decapitation, which is not understandable from an anatomical point of view as the lower jaw was still in place. It is more likely that the head was moved after interment. However, post-depositional processes cannot have been responsible for this kind of displacement. Some unknown post-depositional process must have taken place (see Louwe Kooijmans, this volume). Something similar may hold for individual No. 8, but poor preservation conditions and the disturbance of this part of the grave made it impossible to verify whether that was the case.

The other individuals showed no signs of violence. This may be due to the total absence of violence, to the disappearance of indications of soft tissue injuries or to the bad state of preservation of the bone.

We have only circumstantial evidence suggesting that they died a violent death along with the others.

4. Conclusion

The skeletal remains of the Early/Middle Bronze Age group found at Wassenaar showed that it had consisted of men, women and children. The group may have lived in a settlement on one of the dune ridges in the vicinity (see Louwe Kooijmans, this volume). The average age at death was rather young as there were no individuals above the age of 40. Their stature suggested that they had lived under favourable socio-economic conditions. The differences in the burial practices used and in the molar attrition rates may reflect a cultural sex-based differentiation in status. An arrowhead found between the ribs of a young man and several traumatologic injuries on the bones of other males constitute strong evidence for a COMMON violent death.

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Once again Toterfout-Halve Mijl

A reanalysis of the former investigation of the Bronze Age barrow cemetery at Toterfout-Halve Mijl has yielded new insights. The aim of the research was to arrive at an interpretation in social terms of the burial evidence of the barrow cluster. Three qualitative variables and the sex and age of the deceased were compared with the main variable the diameter of the mound. New insights in the burial gift pattern were revealed by the physical-anthropological research of the cremation remains

1. Introduction

One of the tasks involved in my research project 'Middle Bronze Age societies in the south of the Low Countries'[1] was the gathering of data on the barrows in the southern part of the Netherlands and northern Belgium. The cluster of barrows of Toterfout-Halve Mijl (Veldhoven, Dutch province of North Brabant) (fig. 1) was taken as a first case study. The aim of the research was to arrive at an interpretation in social terms of the burial evidence of this cluster. The cluster was chosen because its excavation, by W. Glasbergen, had been meticulously conducted and published (Glasbergen 1954). There is currently a trend in Dutch archaeology to interpret burial evidence in terms of social organisation. The reason for this is that of all the remains of prehistoric material culture, those relating to the treatment of the deceased constitute highly concrete evidence for conscious prehistoric behaviour. The way in which the deceased were treated can tell us something about a prehistoric society's views on death. The key question in burial research is to what extent the differences observable in burial evidence reflect social differences within a society. Although it is very difficult to infer direct links, it is worthwhile to determine the variability in burial rites. A quantitative ranking in burial evidence resulting from such an analysis can be used as an indication of the minimum vertical differentiation in the social structure (O'Shea 1984, 18).

An example of an interpretation of burial evidence in terms of social organisation is the study by E.H. Lohof (1991). Lohof tried to demonstrate a vertical stratification in the burial evidence of the northeast part of the Netherlands on the basis of a number of qualitative variables. One of the main criteria he used in his study was the 'labour input', by which he understands all the archaeologically visible efforts required to bury a deceased person. The volume of the mound is one of the most important variables. Although there is always the risk that the overall amount of labour invested in a burial rite may not correspond to the labour investment that is measurable in an archaeological context (O'Shea 1984, 11), a mound covering a grave may be regarded as an important measurable and quantifiable element of burial evidence.

In his study Lohof compared the diameter of the mound[2] with a number of qualitative variables, such as the presence of grave goods, the treatment of the deceased, the presence of a cist or a stone slab covering the grave, the orientation of the grave and the presence of a mortuary structure. He then found that the barrows in the northern part of the Netherlands could be hierarchically grouped. One group, consisting of 'top mounds', dates from the Early Bronze Age to the end of the Middle Bronze Age B (Lohof 1991, 249-252).

Another of Lohof's research aims was to demonstrate hereditary status. His assumption was that the criteria age, sex and personal achievements determined whether or not a person was buried in a barrow. His research consequently evolved around the presence of primary child burials beneath large mounds. According to Lohof's assumption, children could not have status positions higher than those of adults because of their young age and lack of personal achievements. Lohof's analysis showed that primary child burials do occur in the northern part of the Netherlands, but not beneath large mounds. This led him to the conclusion that in his area of research hereditary status cannot be demonstrated on the basis of the labour invested in the burial rite.

Although the amount of evidence from Toterfout-Halve Mijl is dangerously small, an attempt has nevertheless been made to make statements on the social organisation on the basis of the evidence of burial rites obtained from the cemetery. A number of variables were selected from Lohof's study that show a correlation with the basic variable of the diameter of the mound, namely the presence of grave goods, the presence of a mortuary house, the

Figure 1. An overview of the Bronze Age cemetery of Toterfout-Halve Mijl (from Glasbergen 1954).

treatment of the deceased and the age class/sex ratio. These variables have been compared with the diameter of the mound. The age class/sex ratio will be included in the discussion of the first three variables below.

2. A brief description of the cemetery

The cemetery lies between the hamlets of Toterfout and Halve Mijl in the municipality of Veldhoven (province of North Brabant) (fig. 1). The cluster of barrows, with a length of two kilometres, lies on an east-west oriented coversand ridge. In the last century a local archaeologist, the well-known Petrus Norbertus Panken (1819-1904), dug up many barrows in this area.[3] In most of the barrows that he 'investigated' he found small amounts of charcoal. In only three did he find any cremation remains (Glasbergen 1954, 16).

After just under a century of undisturbed peace, the area containing the cemetery threatened to be disturbed by extensive large-scale moor reclamations and the digging and agricultural activities of the local occupants. The Biologisch-Archeologisch Instituut (BAI) (Institute for Biology and Archaeology) of Groningen then decided to excavate the cluster of barrows in its entirety. In the period 1948-1951 the cluster consisted of thirty-eight barrows. Thirty-four of these barrows were excavated.

Three separate groups of barrows were distinguished in the cemetery:

1. an eastern group near Toterfout;
2. a central group on the Groote Aard;
3. a western group to the south of the hamlet of Halve Mijl.

One barrow (no. 4) lies to the north of the central group.

In the middle of the 19th century there were some pools and a rivulet to the north and south of the coversand ridge. That environmental situation probably closely resembled that at the time of the Bronze Age occupation. The area is under cultivation today and the pools have been drained by the deepening and canalization of the rivulet 'De Bruggenrijt'.

3. New evidence

One of the problems in barrow research is that a barrow may be the result of several raising or burial phases, which may be spaced between a few days and several hundred years apart. Such a raising or burial phase is generally referred to as a 'mound period' .[4] That term will be used as a working unit in the following analysis. In total, thirty-four barrows were investigated at Toterfout-Halve Mijl. Twenty-four barrows comprised one mound period and nine barrows consisted of two mound periods. One barrow comprised three mound periods. That means that a total of forty-four mound periods were excavated. They were found to contain fifty-one graves, which yielded the remains of forty-seven bodies, five mound periods did not contain human remains.

Some of these mound periods have been dated with the aid of the C14 method (see the dates given in 1 and 2 sigma in fig. 2). Two mounds were found to date from the Early Bronze Age (EBA 2000-1800 cal. BC)[5], nine from the Middle Bronze Age A (MBA A 1800-1500 cal. BC) and four from the Middle Bronze Age B (MBA B 1500-

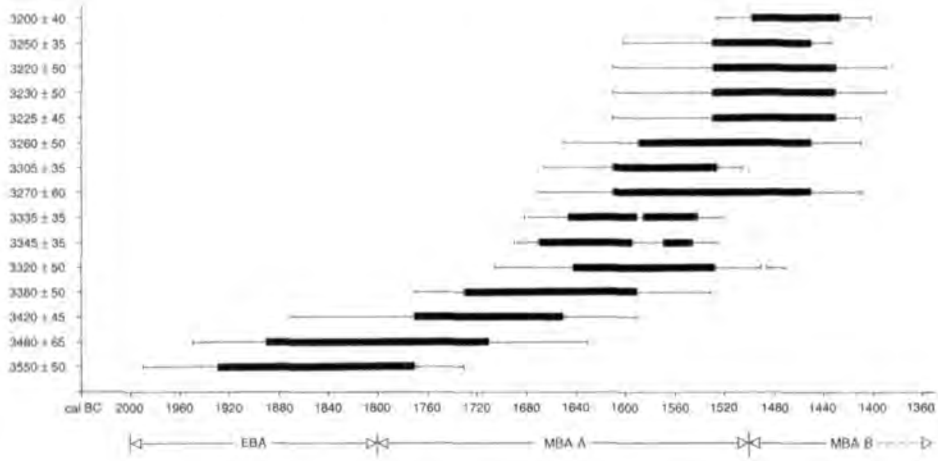

Figure 2. Table of radiocarbon dates (Lanting/ Mook 1977).

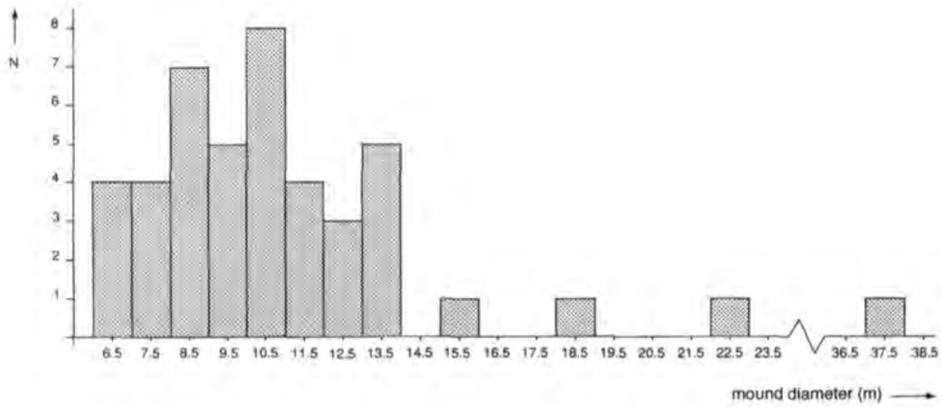

Figure 3. Histogram showing the diametre classes.

1100 cal. BC).[6] On the basis of these dates it is estimated that the cemetery was used for between 460 and 720 years. In the further analysis a period of use of 600 years will be assumed.

The diameters of the mounds were measured so as to enable comparison of the labour invested in the individual mound periods. The maximum width of the peripheral structure was measured. The diameters of the individual mound periods vary from 6 to 37.4 m (fig. 3).

Two main classes of mounds can be distinguished. The first consists of mounds with small diameters, of 6 to 14 metres. This class comprises 91% of all the mound periods (n=40). The second class comprises mounds with diameters of 14 metres or more. A conspicuous feature of the four mound periods of this last class is that they are all surrounded by ring ditches and all have early dates. The forty other barrows are surrounded by rings of postholes.

Waterbolk determined the relative chronology of the cemetery on the basis of the results of his palynological research. There proved to be a spatial chronological distribution: the older mounds were all in the eastern cluster and the younger mounds in the central and western clusters. This was corroborated by the C14 dates.

There also proved to be a spatial difference in the sizes of the mound periods: the larger mounds lay on the eastern part of the coversand ridge, the smaller ones on the western part.

The cemetery of Toterfout-Halve Mijl was found to contain 25 primary burials, 19 of which were cremation burials, the other six being inhumations. The 26 secondary burials comprised 21 cremation burials and one inhumation. In total the cemetery contained 47 cremation burials (85%) and seven inhumations (15%). The majority of the burials were single burials: one corpse per grave. Three were multiple burials. Multiple burials can be explained by

Table 1. The results of the physical-anthropological research by E. Smits.
p = primary burial, s= secondary burial.

Mound period	Find No.	Diameter	P/S	Determination	Treatment of the deceased	Grave gifts
1	1	37.4	s	indeterminated	cremation: remains in urn on surface	-
1	1aI	37.4	p	♂, 22-40 y	cremation: remains scattered on surface	bone pin
1	1aII	37.4	p	♂ ?, 20-40 y + ♀ ??, 12-24 y	cremation: remains scattered on surface	-
1	3 = 1bI	37.4	p	♂ ??, 15-18 y	cremation: remains scattered on surface	-
1	3 = 1bII	37.4	p	♀ ??, 15-20 y	cremation: remains scattered on surface	-
1	4 = 1c	37.4	s	♂, 22-40 y	cremation: remains in pit	bronze discolouration
1	5 = 1d	37.4	s	♀, 22-30 y	cremation: remains in burial pit	bronze discolouration
1	7 = 1f	37.4	s	child, 7-12 y	cremation: remains in tree-trunk (1.52 m)	-
1B	60a	22.3	s	♀, 22-40 y	cremation: remains in urn in pit	bronze discolouration
1B	61a	22.3	s	♀ ?, 22-40 y	cremation: remains in urn in pit	bone pin
1B	62a	22.3	s	♀, 40-60 y	cremation: remains in urn in pit	bronze discolouration
1B	63	22.3	s	child, 8-12 y	cremation: remains in burial pit	pierced phalanx + antler + bronze discolouration
1B	65a	22.3	s	♀, 20-40 y	cremation: remains in urn in pit	bronze discolouration
1B	74	22.3	p	♂, 30-40 y	cremation: remains in urn in burial pit	-
1B	76	22.3	s	♀ ?, 30-60 y	cremation: remains in tree-trunk	-
2	35a	18.4	p	indeterminated	cremation: remains in burial pit	-
4	88	13.0	p	♀, 30-60 y	cremation: remains in tree-trunk	-
5.I	44	10.2	p	child, 2 y ± 8 months	cremation: remains in burial pit	pierced decorated bone fragment + antler
5.I	47	10.2	s	child, 4 y ± 12 months	cremation: remains on surface	-
5.II	39	12.0	s	child, 0-3 y	cremation: remains in burial pit	phalanx brown bear + antler
8.I	48	10.9	p	♀ ??, 18-40 y	cremation: remains in burial pit	-
8a	27	6.4	s	juvenile ?	cremation: remains in posthole	-
8a	28	6.4	s	< 7 y ?	cremation: remains in posthole	-
8a	29	6.4	s	indeterminated	cremation: remains in posthole	-
8a	30	6.4	s	child, 12-15 y	cremation: remains on surface	-
8a	31	6.4	s	child, 7-8 y ± 24 months	cremation: remains in posthole	-
8a	32	6.4	s	child, 7-14 y	cremation: remains in posthole	-
8a	33	6.4	s	indeterminated	cremation: remains in posthole	-
8a	34	6.4	p	child, 2-4 y	cremation: remains in burial pit	-
8a	35	6.4	s	(?)♀, 22-40 y	context unknown	-
10	50	8.9	p	♀ ?, 20-40 y + 7 y ± 24 months	cremation: remains in burial pit	earthenware pot
10	50a	8.9	p	♀, 20-40 y	cremation: remains in burial pit	-
11.I	53	7.8	s	human ?	cremation: remains in posthole	-
14	70	12.7	p	♀, > 35 y	cremation: remains in burial pit	-
16.I	59	6.0	p	adult	cremation: remains in burial pit	-
17.I	14	8.6	p	♂ ?, > 20 y	cremation: remains in burial pit	-
18	13	9.1	p	♂, 30-60 y	cremation: remains in burial pit	-
19.I	16	9.1	p	adult ?	cremation: remains in burial pit	-

Figure 4. Photographs showing the brown bear phalanx, the drilled phalanx and an antler fragment.

assuming that the persons in the grave all died at the same time. Mound No. 1 contained a multiple burial of five individuals.

The cremation remains that were found in the various mound periods were analyzed by Krumbein in 1951 (Glasbergen 1954, 126-128). This German family doctor was one of the pioneers of physical-anthropological research. As our knowledge in this field has greatly increased over the past forty years, it was decided to reanalyse the cremation remains of Toterfout-Halve Mijl.

E. Smits of the Institute for Pre- and Protohistory in Amsterdam analyzed 40 assemblages of cremated remains (tab. 1). There proved to be a great discrepancy between her results and those of Krumbein. Smits arrived at a more specific age class division. In some cases cremation remains that had initially been identified as the remains of a multiple burial of an adult and an Infans I proved to represent the remains of a single burial of one adult. This reduced the number of graves containing the remains of children (Infans I and II) from fifteen to eleven.

A remarkable discovery was the green discolouration that was observed on six assemblages of cremation remains (tab. 2). This phenomenon had already been observed before by German researchers (Kühl 1987). They found that this green discolouration is the result of the oxidation of bronze objects which accompanied the deceased on the pyre. The high temperature of the pyre (approx. 850°C) softened the bronze and caused a chemical reaction to take place on the remaining bones (Kühl 1987, 94). The position of the green discolouration is a strong indication of the original position of the bronze objects.

The green discolourations observed at Toterfout-Halve Mijl were on diaphysis fragments (bracelet?), on fragments of vertebrae, on skull fragments and on a fragment of a rib (fibula?). The green discolouration on the os frontale may be the result of the burning of a bronze decorative element of some headdress. In northwest Germany most cases of green discolouration on the *os frontale* concerned the remains of adults but at Toterfout-Halve Mijl the bronze oxide was observed on the bones of a child of 8-12 years old. Although this bronze oxide was observed on six assemblages of cremation remains, no bronze was found during the excavation. This must mean that the bronze objects were recovered from the cooled ashes and reused, which would imply that the original number of grave goods that accompanied the deceased at Toterfout-Halve Mijl was greater than that found during the excavation. The German researchers also found that the percentage of graves that originally contained bronze objects was twice as high as initially believed (Kühl 1987, 97).

The green discolourations proved to be limited to the cremated remains of the secondary graves of two mounds. These mounds, *i.e.* tumuli 1 and 1B, are not only the largest of the cluster, but also the oldest.

In addition to human bones, the cremation remains also included remains of animals. In three cases the remains of children were found to be mixed with fragments of antler. Two of these children had moreover been buried accompanied by a pastern: one concerned a brown bear and the other a pierced pastern of an unidentified animal species. (fig. 4).

Animal bones found in burial contexts are usually interpreted as the remains of a meal for the deceased. Bear phalanges or deer antler encountered in graves are however

Table 2. Precise position of the green discolouration, P= primary burial, S= secondary burial.

mound period	find number	P/S	result of determination	position of green discolouration
1	4=1	s	? ♂, 23-40 y	fragment of vertebral body
1	5=1	s	♀, 23-30 y	fragment of vertebra and on a fragment of an arm or a leg
1B	60a	s	♀, 23-40 y	fragment of a rib
1B	62a	s	♀, 40-60 y	fragment of a diaphysis (arm/leg) and on a knee joint
1B	63	s	child, 8-12 y	on the forehead (midway above the eyes)
1B	65a	s	♀, 20-40 y	on vertebra fragments, arm/leg and skull

more likely to have had a symbolic significance. Claws and canine teeth of the brown bear, *Ursus arctos* L. appear rarely in prehistoric graves. Most claw finds occur in an Iron Age or Roman period grave context, where they are drilled through and therefore used as a pendant (Schönfelder 1994, 221). This use is a strong indication that the teeth and paws, the deadly weapons of the brown bear had magic qualities. According to Ranke the bear symbolised power in the Germanic world (Ranke 1985, 47).

German literature mentions examples of bears' phalanges found in rich male graves from the Iron Age (Lehmkuhl 1987, 109). In cases in which several bear's phalanges have been found in a grave it is believed that the corpse was wrapped in a bear's hide (Holck 1986). The Bronze Age child's grave at Toterfout-Halve Mijl contained only one phalanx, which had not been pierced; it may possibly have been kept in a small purse carried around the neck. Bronze Age bear phalanges are very rare. It is striking that the few known cases were found in the graves of young children (Kühl 1981; Teichert 1990). In the Bronze Age maybe the magic quality of the bear amulet was not a symbol of power as in later periods but more a protective sign exclusively intended for children.

Only few other cases of antlers grave goods are known; occasionally antler fragments are found in Iron Age graves (Kühl 1984, 212).

Since the reanalysis by E. Smits we know the age and/or sex of 35 individuals.

The division according to age shows that all age classes are represented with the exception of that of Senil.
In addition to the six relatively well-defined age classes, three less specific groups of 'adult' (n=2)', 'juvenile' (n=1)' and 'indeterminate (n=4)' remains have been distinguished. The classes of children younger than 14 (Infans I and II) and adults of between 22 and 40 (Adult) have the highest percentages. Two assemblages of the remains of children younger than 7 (n=5) were recovered from primary burials, three from secondary burials (tab. 2). The cremation remains recovered from the secondary tree-trunk coffin of mound period 1 proved to be those of a child aged between seven and twelve. The length of the tree-trunk coffin (1.52 m) was in accordance with the height of a child of that age.
In view of the small length of the tree-trunk coffin, one of the inhumation burials is probably also that of a child.[7]

The results of the sex determination of the cremated remains show that males, females and children were buried in both primary and secondary graves (tab. 3). Men were buried predominantly in primary graves. Women and children were buried in secondary graves more frequently than men. A striking fact is that more than twice as many women as men were buried. Children (aged less than seven) were buried in all types of graves, both single and multiple and both primary and secondary. The division according to sex shows that the number of secondary child burials is three times the number of primary ones. Single primary child burials were only encountered there where the secondary burials were also child graves. This was observed twice. Mound periods 5.1 and 8a contained two primary child burials of very young children (younger than four years old). The cremated remains of the secondary burials contained in this mound proved to be of children too.

4. Comparison of the diameter of the mound with the three qualitative variables

4.1 The relation between the diameter of the mound and grave goods

The deceased that were buried in the cemetery of Toterfout-Halve Mijl were accompanied by only few grave goods, unlike those whose remains were found in the northern part of the Netherlands.[8]

Table 3. Division of burials according to age class.

class	age (year)	primary position	secondary position	number	%
Infans I	< 7	2	3	5	16
Infans II	7-14	1	5	6	19
Juvenil	14-22	3	–	3	9
Adult	22-40	8	6	14	44
Matur	40-60	2	2	4	12
Senil	> 60	–	–	–	-
total		16	16	32	100
juvenile		–	1	1	
adult		2	–	2	
indeterminate		1	3	4	

Table 4. Division of burials according to sex.

sex	primary position	secondary position	number	%
child/juvenile	3	10	13	41
male	5	1	6	19
female	6	7	13	41
total	14	18	32	101

Eleven graves (three primary and eight secondary) yielded grave goods or indications of the former presence of grave goods (tab. 5). Of the deceased who were buried in the primary graves one had been accompanied by an earthenware pot and two by bone artefacts. Six graves contained strong indications of bronze grave, or at least pyre goods. The mound periods with the largest diameters and the earliest dates, *i.e.* 1 and 1B, contained the most grave goods (fig. 5). For the northern part of the Netherlands Lohof found a clear correlation between the diameter of the mound period and the number of grave goods in the Middle Bronze Age periods A and B (Lohof 1991, 125, 192).

4.2 THE RELATION BETWEEN THE DIAMETER OF THE MOUND AND THE PRESENCE OF A MORTUARY HOUSE

The cemetery of Toterfout-Halve Mijl contained the remains of several mortuary houses: configurations of four or more postholes around a grave (tab. 6). The posts that stood in these holes probably supported a roof. The remains of ten such structures were found at Toterfout-Halve Mijl. Nine of these were elongated structures of small, thin posts.[9] The tenth mortuary house was more soundly founded on thicker posts.

Three of the ten mortuary houses were not associated with a visible grave. They probably covered inhumation burials on the original ground surface. One double mortuary house was found associated with a multiple burial. One mortuary house was associated with a patch of charcoal. The posts of the other five mortuary houses surrounded cremation graves.

Several interpretations of the function of these four-post structures are to be found in the literature. Because of their flimsy structure, Glasbergen believed that they were temporary buildings. In his opinion, mortuary houses had a protective function; the posts served to support only a small roof to protect the deceased for the period between burial and the construction of the burial mound.

Van Vilsteren (Van Vilsteren 1988, 6) has suggested a different interpretation. If there is a clear correlation between the presence of four-post structures and cremation remains then, according to Van Vilsteren, these structures should not be interpreted as mortuary houses or little temples, but as the remains of pyres. Wahl (1982, 40) has described experiments with different wooden pyre structures. His results can tell us whether the structures whose remains were found at Toterfout-Halve Mijl may have been pyres, *i.e.* whether they may have contained sufficient wood to cremate a body. The amount of wood

Table 5. Distribution of the grave goods.
P = primary position, S = secondary position, y = year, m= month.

mound period	find number	diameter (m)	P/S	burial	grave goods
1	1al	37.4	p	? ♂, 23-40 y	bone pin
1	4=1c	37.4	s	? ♂, 23-40 y	bronze discolouration
1	5=1d	37.4	s	♀, 23-40 y	bronze discolouration
1B	60a	22.3	s	♀, 23-40 y	bronze discolouration
1B	61a	22.3	s	♂, 23-40 y	bone pin
1B	62a	22.3	s	♀, 40-60 y	bronze discolouration
1B	63	22.3	s	child, 8-12 y	bronze + antler + pierced pastern
1B	65a	22.3	s	♀, 20-40 y	bronze discolouration
5.I	44	10.2	p	child, 2 y ± 8 m	antler + decorated bone
5.II	39	12.0	s	child, 0-3 y	brown bear phalanx + antler
10	50	8.9	p	♀ ?, 20-40 y + child, 7 y ± 24 m	earthenware pot

Table 6. Distribution of the mortuary houses.
y= year, m= month, P= primary position, S= secondary position.

mound period	find number	diameter	P/S	burial
1B	74	22.3	p	♀, 30-40 y
5.1	44	10.2	p	child, 2 y ± 8 m
8.1	48	10.9	p	♀, 18-40 y
10	50, 50a	8.9	p	2× ♀ ?, 20-40 y + child, 7 y ± 24 months, ♀, 20-40 y
11.I	-	7.8	p	no grave
14	70	12.7	p	♀ ? > 35 y
15	-	10.1	p	patch of charcoal
19.1	-	9.1	p	adult?
21	-	13.0	p	no grave
27	-	7.3	p	no grave

required for a pyre depends on several factors. A first important factor is the construction method used: the pieces of wood can be either randomly stacked or arranged in a grid structure. The amount of wood required also depends on the posture of the corpse: more wood is required to burn an extended corpse than to burn a corpse lying with its knees bent, placed in a sitting posture or held upright with the aid of a post. It could be argued that the four small postholes found at Toterfout-Halve Mijl confined the limits of a randomly stacked pyre. In that case the elongated shape of the structures suggests that the deceased were burned with extended limbs. If the pyre is assumed to have been 1.5 m high, then it may have contained approximately 1.5 to 2.2 m^3 wood. According to Wahl, such an amount of wood is sufficient to cremate a corpse (Wahl 1982, 40).

An argument against the interpretation of mortuary structures as the remains of pyres is the absence of large amounts of charcoal beneath the mounds. The small amounts of charcoal found in the cemetery of Toterfout-Halve Mijl make it highly unlikely that the structures of that cemetery were pyres.

In comparison with the northeast part of the Netherlands the number of mortuary houses of Toterfout-Halve Mijl is exceptionally high. The 365 mound periods that have been investigated in the north contained as many mortuary houses as the barrows at Toterfout-Halve Mijl (Lohof 1991, 68, 124, 141).

Another difference is that most mortuary houses in the northern part of the Netherlands are associated with multiple central burials, one of which burials at least is an inhumation. According to Lohof the mortuary house covered (and protected) the central inhumation until the other corpses that were also to be buried in the grave had been cremated. Lohof therefore also assumes a temporary, protective function, although the structure of the mortuary houses of the northern part of the Netherlands does not

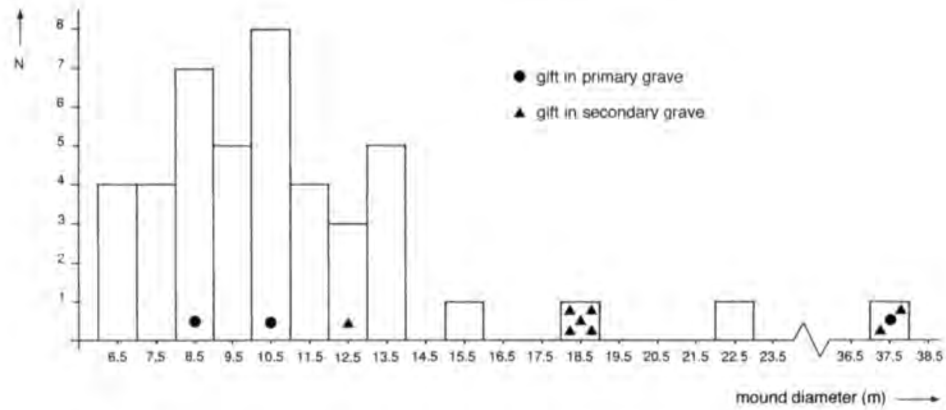

Figure 5. Histogram showing the grave goods in relation to the mound diameters.

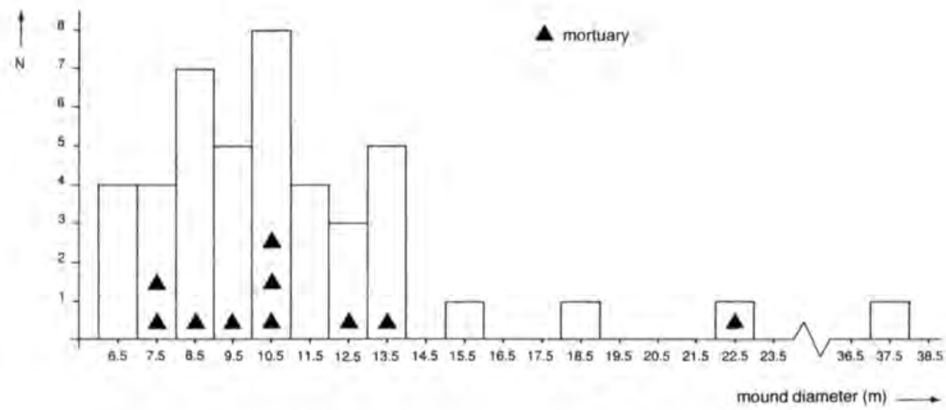

Figure 6. Histogram showing the mortuary houses in relation to the mound diameters.

suggest such a function: they were all built from thick posts, some of which were founded 60 cm deep.[10] The fact that in some of these cases the remains of the posts could be traced several decimeters into the body of the mound makes it very likely that the posts were not removed before the erection of the mound (Lohof 1991, 122). At Toterfout-Halve Mijl the posts had been removed before the erection of the mound. The sods that had been used to construct the mound lay on top of the postholes (Glasbergen 1954, 142).

Mortuary houses were found over graves of men, women and children and also over multiple graves. Apparently the burial rite that (probably) involved the erection of the mortuary house was not sex- or age-related.

There is no correlation between the diameter of the mound and the presence of a mortuary house at Toterfout-Halve Mijl: mortuary houses were encountered in both large and small mounds (fig. 6). There does not appear to be a direct connection between mortuary houses and rank or status in the northern part of the Netherlands either, although mortuary houses do seem to be more common in mound periods with small diameters than in those with larger ones. The same seems to hold for the cluster of barrows at Toterfout-Halve Mijl.

4.3 The relation between the diameter of the mound and differences in the treatment of the deceased

It is difficult to quantify the difference in the treatment of the deceased between primary cremation and inhumation. From an objective point of view, cremation is more labour-intensive than inhumation. We know of ethnographic examples where inhumation is reserved for higher social ranks and cremation for lower ones (Lohof 1991, 27). But examples of the opposite are also known. The treatment of the deceased is so closely tied up with ideology that it is not possible to compare the different burial practices simply

Table 7. Treatment of the deceased.

Treatment of the deceased	primary	secondary	total
cremation; remains in urn/scattered in burial pit[1]	15	4	19
cremation; remains in urn/scattered in pit	1	7	8
cremation; remains in urn/scattered on surface	6	4	10
cremation; remains in tree-trunk coffin	-	2	2
cremation; remains scattered in posthole	-	7[2]	7
inhumation on original ground surface	5	-	5
inhumation in tree-trunk coffin	1	1	2
total	28	25	53

[1] A distinction has been made between a 'burial pit' (rectangular, with the length being at least twice the width) and a 'pit' (oval to round).
[2] As the cremated remains were recovered from the fills of the postholes of the peripheral structure, this form of burial is considered secondary in this table.

on the basis of the amount of labour invested. It is a qualitative difference. The link with the social rank of the deceased can only be inferred from the overall combination of variables of the grave.

There are a number of remarkable factors (tab. 7): in the first place, only few inhumations were found. The sandy soil of the site had not favoured the preservation of archaeologically visible traces of inhumations. In five cases, *i.e.* those in which a mound period without a grave was found, Glasbergen assumed that a body had been buried on the original ground surface. In view of the small number of male burials (n=5), we may probably assume that inhumation on the original ground surface was a form of burial reserved for men.

The second remarkable factor is the absence of evidence for inhumations in burial pits in comparison with the many cases of cremation remains found in burial pits.

A very unusual form of burial is that of the deposition of cremation remains in a posthole. Glasbergen's site plans and descriptions do not tell us exactly how the cremation remains had been buried in the ring of postholes. The remains were recovered from the fills of the postholes, where they had probably lain against the wooden posts (Glasbergen 1954, 56).[11] It is not clear whether the cremation remains were buried before or after the erection of the posts and, in the latter case, whether or not the posts were temporarily removed from the postholes. In the case of tumulus 11 the cremation remains had been deposited in a pit before the post was placed in it. E. Smits' reanalysis has shown that this particular form of burial was not reserved for specific parts of the skeleton. In one mound, tumulus 8a.I, this form of burial was encountered six times. Five of these six assemblages of cremated remains have been identified as those of children (Infans I and II). The primary grave in this small mound with its diameter of 6.4 m contained the remains of a young child. The deposition of cremation remains in a posthole was probably a form of burial exclusively intended for children.

Remarkable burial evidence was also observed in mound 1B. To the southeast of the central burial of a man aged 30-40 were four secondary burials beneath the ring bank. These urn burials contained the cremated remains of adult women. The position of the opening of the urn differed per burial: in one case the urn had been placed upright (like that of the primary burial), in two cases the opening was directed away from the primary burial and in one case it was directed towards the primary burial.

It is difficult to determine the overall time span and the order of the burials of mounds 8a and 1B. Research into burial rites in Yorkshire showed that the deceased had been buried according to certain rules (Mizoguchi 1993). It would seem that some kind of 'rules' were also applied in the case of the burials in the two Dutch mounds. The different categories of deceased had been deposited according to some standard. In mound 1B the remains of adult women had been buried in urns, the position of the urn possibly expressing some form of kinship; in mound 8a only children had been buried in postholes.

Mizoguchi has suggested that the specific recollection of the position, sex and age of the previous burials may have played an important role at the time of a new burial. From ethnographic examples we know that specific knowledge may be the 'property' of a specific interest group: the exclusive possession of such knowledge confirms the ties between the members of a group and legitimises and naturalises their specific relations with the members of the other groups of the community.

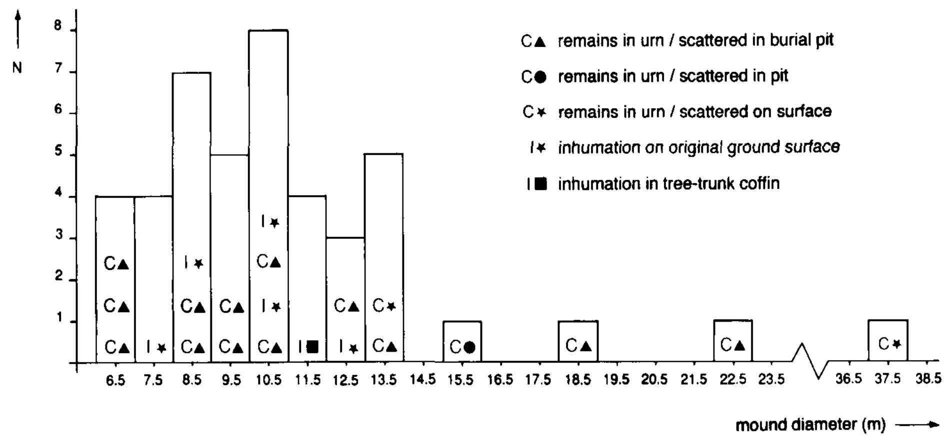

Figure 7. Histogram showing the treatment of the primary deceased in relation to mound diameters.

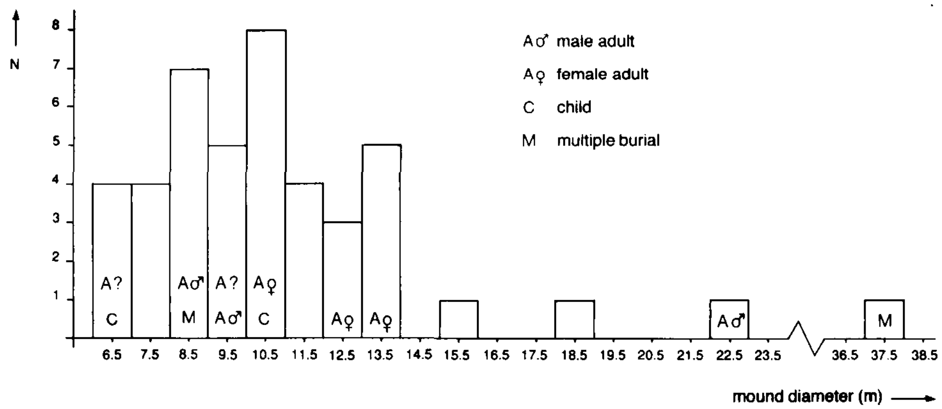

Figure 8. Histogram showing the ages of the deceased buried in the primary graves in relation to the diameter classes.

The comparison of the treatment of the deceased with the diameter shows that cremation remains were buried in burial pits in mounds of both small and large diameter classes (fig. 7). Inhumation on the original ground surface was observed only under mound periods with small diameters. Because of the small numbers of burials found, no statements can be made about the other forms of burial.

4.4 THE RELATION BETWEEN THE DIAMETER OF THE MOUND AND THE AGE/SEX RATIO

Adult males and females and children had all been buried in both primary and secondary graves, beneath mounds of different sizes (fig. 8). The right to be buried in a primary grave beneath a mound was apparently not dependent on age, because children younger than four years old were also buried in graves at the centre of mounds. The two primary single child graves were found in the smaller mound periods. This evidence is in accordance with that obtained in the northern part of the Netherlands (Lohof 1991, 256). A trend appears to be observable in the small amount of evidence available and that is that children were buried in smaller mounds and adults in larger ones, thus a weak indicator of age classes has been found.

5. The Toterfout community

The 600 years of use and the total number of 44 mound periods suggest that the cemetery contains the deceased of a small group of people.

Determining the size of a group of people on the basis of burial evidence is a risky business. There are often many uncertainties. It is for example difficult to say whether the total number of mounds found (38) is the same as the original number. From the Middle Bronze Age period B until the arrival of Panken the area between the two hamlets was probably an extensive moor. No activities took place here in protohistoric times. The first disturbances were those caused by Panken in 1845. It is difficult to estimate the impact of his activities. We know for sure that he set his spade into at least seventeen mounds, but none of the mounds disappeared completely as a result of his activities (Glasbergen 1954, 16). The greatest disturbances were caused during and just after World War II, when farmers in the area buried cattle in the mounds and dug sand from them. No mounds disappeared completely due to these activities either. We may therefore assume a total of 62 deceased[12] buried in mounds in determining the size of the group.

What we do not know for certain either is what percentage this number of 62 deceased is of the total number of deceased of the Toterfout community. A total of 62 deceased in 600 years implies one death every ten years, which would indicate a population of only two individuals. Such a small population cannot independently survive. According to the present views, Middle Bronze Age societies lived in small settlements comprising two or three farms (Roymans/Fokkens 1991, 11). These households may have constituted a social group of about twenty individuals. The average life expectancy in the Bronze Age is believed to have been between 25 and 30 years (Acsádi/Nemeskéri 1970). The six centuries of use can be divided into 20 to 24 generations, which would imply a population of between 400 and 480 individuals. The actual number of 62 deceased found in the cemetery is only a small percentage of the calculated population. It would mean that only 13 to 16% of the overall population was buried in a mound context. This assumed percentage is in accordance with the percentage assumed by Lohof for the Early Bronze Age (Lohof 1991, 225).

The population buried some of its dead in mounds which were erected in a fairly concentrated cluster. The settlement was probably situated somewhere near the cemetery, although hardly any evidence for a Bronze Age settlement site has been found. Middle Neolithic occupation remains have been found in some places (Van Beek 1977, 43; Glasbergen 1954, 98; De Laet 1974, 288; Verwers 1990, 33). From the palynological research we moreover know that cereals were cultivated in the vicinity of the mounds (Glasbergen 1954, 178). The fences whose remains were found beneath mounds 12 and 18 probably marked the limits of farmyards or fields.

6. Conclusion

The cemetery of Toterfout-Halve Mijl contained little evidence in terms of labour input for social hierarchy. The comparisons of the diameter of the mound with other qualitative variables, *i.e.* the grave goods, mortuary houses and the treatment of the deceased, revealed four mound periods which differ clearly from the others: periods 1, 1B, 5.1 and 10. Mound periods 1 and 1B contained many burials accompanied by grave goods. Both mound periods had large diameters, namely of 37.4 and 22.4 m, respectively. The diameters of the two other mound periods, 5.1 and 10, were not very large: 10.2 and 8.9 m, respectively. The main differences between the two pairs of mounds are not so much differences in the qualitative variables but rather differences in the volume of the mound, the number of burials and the dates. These differences may be attributable to changes in the burial rites during the Bronze Age. There are indications suggesting that the burial practices in the early phase of the cemetery in particular were more clearly intended to express kinship ties. The evidence of mound periods 1B and 8a suggests the use of certain 'rules': specific knowledge about the deceased was probably the 'property' of a specific kinship group.

Throughout the entire Bronze Age only a small percentage of the overall population was buried in mounds. Lohof assumes that that percentage was at most 15% in the Early Bronze Age (Lohof 1994, 113). As far as the Toterfout evidence is concerned this seems a realistic figure. The 62 deceased found in the cemetery amount to 13 to 16% of the total number of between 400 and 480 deceased.

The deceased who were buried in mounds probably belonged to a group with a high status or rank: the erection of a mound, whether it was small or large, involved much effort. There is no evidence for any hierarchy within that high-ranking group. The deceased who were buried in the cemetery did not belong to some specific age or sex category: children, women and men were all buried in mounds. They constitute a regular representation of a society.

What is remarkable is the percentage of children buried in the cemetery of Toterfout-Halve Mijl, which appears to be exceptionally low. Ethnographic studies have shown that the mortality rate for babies and infants in primitive societies may be as high as 50-60%. Lohof arrived at a child mortality rate of 19% for the Middle Bronze Age period B in the northern part of the Netherlands (Lohof 1991, 254). It would seem that babies and infants are very much underrepresented in the overall evidence of Toterfout. The deceased of this age category were probably disposed of in some other manner than through burial in a mound. Where the other 85% of the Toterfout population has been buried is not clear. Corpses may have been disposed of in many different ways which are not visible in the archaeological record. Hardly any traces of inhumations or cremated remains scattered in flat graves are preserved in areas of dry sandy soils. Flat graves have only been found at Cuyk; they date from the Middle Bronze Age (Bogaers

1966). Sometimes human remains are recovered from contexts other than mounds, such as those recovered from ditches between settlement refuse in Westfrisia (Brandt/IJzereef 1980, 55). The Wassenaar grave is also an example of a different form of burial (Louwe Kooijmans this volume).

It is likely that the Toterfout group lived somewhere near the cemetery. The three households buried a select number of their deceased on the sand ridge. In the earliest phase of the cemetery the deceased were buried in mounds surrounded by banks (1 and 1B). The large number of secondary burials indicate that these mounds were used for a long time. In the Middle Bronze Age periods A and B the cemetery slowly expanded, from the east to the west, to ultimately comprise almost forty mounds. It would seem that a relatively larger number of mounds was erected in the final phase. By then the burial rite appears to have focused on individual burials and no longer on burials in which a kinship group's specific knowledge of previous burials still played a crucial part, as in the earlier phase. The individual burial tradition of the late phase of the Middle Bronze Age was probably continued in the burial rite of the urnfields.

Further research into the barrows of the southern part of the Netherlands and northern Belgium may show whether the Toterfout evidence presents an exceptional or a normal picture of Middle Bronze Age society.

Acknowledgements

I am grateful to E. Smits (IPP) for recovering and analyzing the cremation remains. Without her careful observations the small but important details would not have been revealed. Thanks also to E. Malipaard (IPP) for the determination of animal remains, to M. Gerretsen and C. Ruffin for their help collecting the mound data and to Susan Mellor for the translation of the text.

notes

1 Theunissen (in prep.): Midden-Bronstijdsamenlevingen in het zuiden van de Lage Landen. Een herwaardering van het begrip 'Hilversum-cultuur'. Research sponsored by a grant from the Netherlands Organization for Scientific Research (NWO; file number 280-151-060).

2 Lohof's analysis is based on the diameter of the mound instead of the volume of a mound period (see note 4) because it is often no longer possible to determine the original height of a mound. If it is assumed that there was a fixed relation between the original height of a mound period and its diameter then the diameter is a more reliable criterion for comparing mound periods on the basis of labour input than the volume (Lohof 1991, 62).

3 The consequences of his activities are still visible in Glasbergen's site plans.

4 A 'mound period' is not a unit of time but a synonym for a mound 'burial event'.

5 No corded ware was found in the cemetery.

6 The cemetery was dated using the calibrated dates and the chronology of the Dutch prehistory as presented in "De prehistorie van Nederland" (Van den Broeke *et al.*, in prep.).

7 The tree-trunk coffin was 87 cm long.

8 An urn, *i.e.* a pot containing cremation remains, is not considered a grave good in the analysis.

9 The average diameter of the postholes was 8 cm. Their depths varied from 4 to 53 cm.

10 Probably measured from the excavation surface.

11 Another possibility is that the cremation remains were buried after the posts had rotted (Glasbergen 1954, 94).

12 The 34 excavated mounds contained the remains of 47 deceased. At least nine mounds were not excavated. It is estimated that these uninvestigated mounds contained 15 burials.

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Dwelling on peat; fissures as a recurrent feature of prehistoric structures built on peat in the Western Netherlands

This article presents a discussion of a recurrent phenomenon in settlements on peat in the Western Netherlands which has received little attention so far: the presence of fissures through the peat along the longitudinal and usually central axis of prehistoric dwellings. These fissures show a characteristic asymmetrical shape and a fill which consists of often well preserved anthropogenic floor layers and occupation debris. The data stem from several habitation sites, all located on meso- to oligotrophic peat in the Southern area of Midden-Delfland and dated to the Middle Iron Age to the Roman period. Most structures within these sites were badly disturbed by geological processes that took place during the Late Iron Age and possibly during the Roman period.

A review of the literature revealed that such fissures occur regularly in other peat sites in the Western Netherlands, also on sites with no post-depositional disturbance. In this article it is argued that fissuring took place at least partly during and because of habitation. The pressure exerted by the buildings themselves and by the many floorlayers caused compression and cracking of the soft and instable subsurface. As the pressures of the wooden building frames are down- and outwards across the structure, this will result in fissures along its long axis. In Midden-Delfland, these disturbances were aggravated by post-occupational processes. The latter caused subsurface disintegration and erosion of the softer peat layers below the occupied areas, which in turn resulted in the further sagging and breaking up of the habitation remains to various degrees.

1. Introduction

Within the framework of large scale environmental reconstructions in the polders of Midden-Delfland, designated as a 'green zone', a number of archaeological sites were and are being excavated prior to destruction. Some sites were known from a survey (Bult 1983); others were discovered while being destroyed during reconstruction works (Abbink 1993; Van den Broeke 1991; this vol.).

Since the start of the project in 1987 six sites with habitation remains dating from the Middle, Late and Roman Iron Age were partially or completely excavated by the Institute of Prehistory of the University of Leiden (except site 16.48[1]) (fig. 1). All sites were located on meso- to oligotrophic peat and at each, except at site 16.10, the remains of two or more farmsteads were recovered.[2] Rebuilding at the same location is thus characteristic for the Iron Age occupation in Midden-Delfland, in contrast with the peat settlements of the Assendelver Polders (Brandt *et al.* 1987) and those in the Southern parts of the Meuse estuary (Van Trierum 1992, 73, 82) from the same period.[3]

Site 16.59 contained the heavily damaged remains of at least two successive building phases from the Iron Age. At *c.* 25 m distance a 1st century AD farmstead (site 16.24) was excavated (Abbink/Frank 1991). Site 16.48 also contained a probably Roman period farmstead built over a Middle Iron Age predecessor (Ter Brugge 1992). Site 15.04 and site 11.07/17 are the largest Middle Iron Age habitation areas excavated so far. At 15.04 the remains of six buildings could be distinguished at several building locations (Abbink 1989); three, possibly four, structures were built successively in a small area at site MD 11.17, while the remains of at least two more buildings were present within a distance of *c.* 50 m, at site MD 11.07 (Koot 1993).

All of these farmsteads were badly damaged. The construction wood and floor layers were preserved only insofar they had collapsed into the peat fissures or had otherwise subsided to a level much lower than that of original habitation. Fissures were present in all of the excavated farmsteads in Midden-Delfland. Those of site MD 15.04, the first large scale excavation in Midden-Delfland, are the basis for the descriptions and ideas in this article as their shape, location and fill proved to be characteristic for most other sites (fig. 2).

Figure 1. Midden-Delfland. Polder names with sites excavated by the IPL (a) and the three redevelopment areas (b). The first two digits of site numbers refer to the individual polders. Circle: Iron Age sites. Triangle: Roman period sites

The natural stratigraphy is more or less the same in all sites, (fig. 3). Reed peat developed on a Dunkirk 0 deposit (A2, fig. 3). In most sites the formation of this peat was interrupted by a thin clay deposit (B2, fig. 3). The C14 date of the first peat on this deposit was dated to 2730 BP ± 45 (GrN-16754) and 2970 ± 35 (GrN-16914).[4] The reed peat gradually changed into mesotrophe and/or oligotrophe peat (cushions) during the Early and Middle Iron Age. At the time of the Middle Iron Age settlements the total peat cover (A1+B1, fig. 3) must have been at least 2 m thick. At present the remaining thickness of the upper layer (B1) is usually less then 20 cm in 'undisturbed' circumstances. The decay is due to drainage and subsequent oxidation of the peat since the Medieval period. This also resulted in the decay of all organic remains from the prehistoric occupation under such circumstances.

During the Later Iron Age, flooding took place in most parts of the Meuse estuary, referred to as the Dunkirk I deposits (Van den Broeke, this vol).[5] However in the area discussed here the influence was largely indirect; geological disturbance mainly occurred below the surface in the form of erosion of the weaker (reed) peat layers above the first Dunkirk 0 deposit (A2, fig. 3) (Abbink 1989). The process taking place was one of increased waterlogging of the peat and the formation of lake-like areas in which 'islands' of peat were lifted upwards, but where very little movement of water and material took place.[6] The force of water action was especially reduced below the inhabited areas.

These post-occupational processes had both negative and positive effects on the archaeological remains. They caused damage in most of the excavated sites, but in varying degrees. There is a relation between the degree of disturbance and the density of the occupation itself. In some areas within and around inhabited areas the original peat cover was completely destroyed and redeposited as laminated layers of clay mixed with organic matter, sometimes including redeposited occupation material; this occurred most often at the border of and around the occupied areas. Subsurface erosion was usually less intense below the habitated areas and even less so where habitation

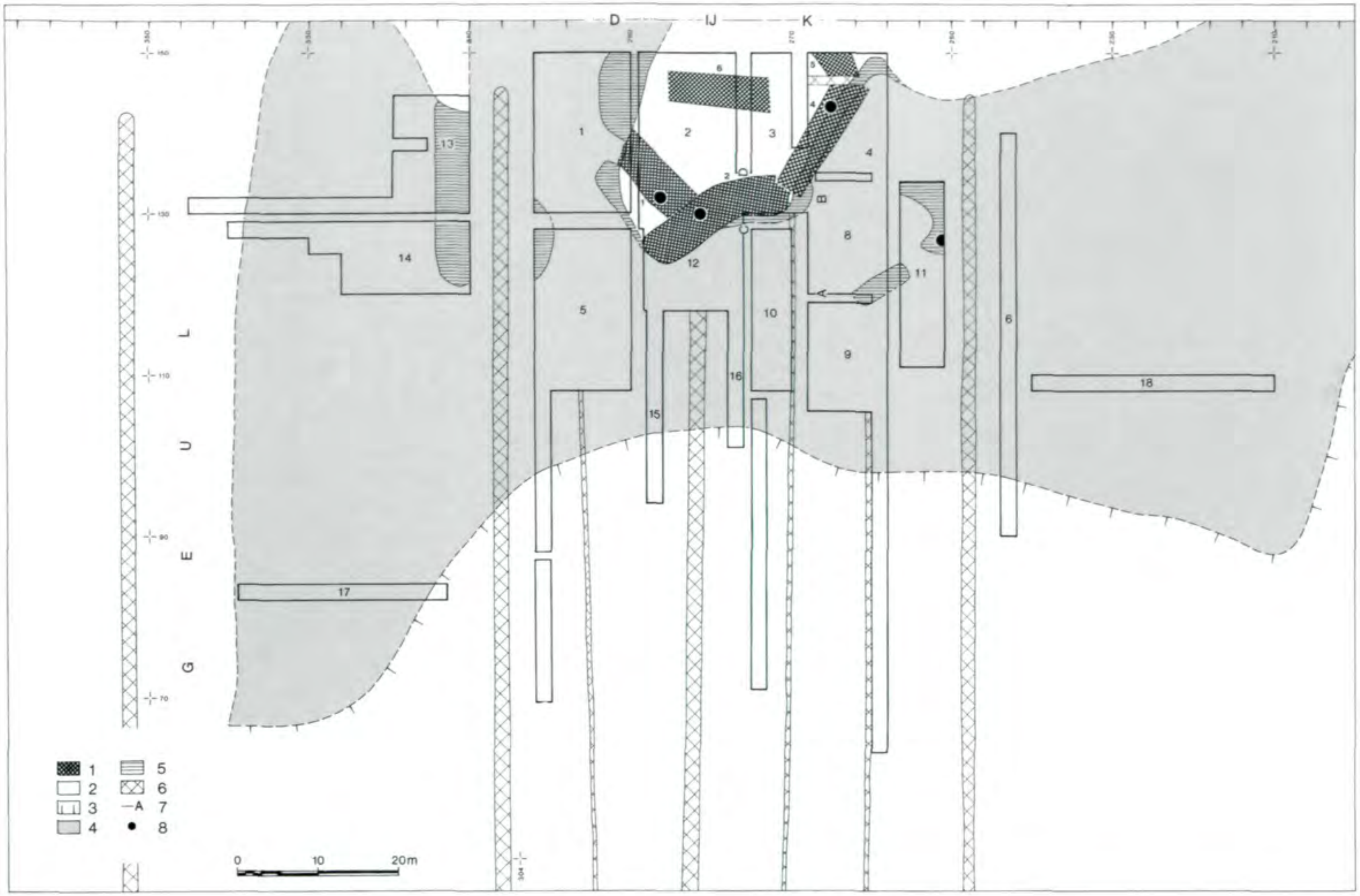

Figure 2. Foppenpolder, site 15.04. Preliminary plan of the excavations with: building remains preserved in fissures in zone 1, possible building remains or activity areas in zone 2 (badly disturbed by postdepositional processes)
1. Buildings 1,2,4,5,6 in zone 1; 2. Zone 1, oligotrophic peat with habitation remains; 3. Zone 2, oxidized peat without habitation remains; 4. Zone 3, disturbed; redeposited peat and clay; 5. Concentration of remains of habitation in zone 3, including a possible house (house 3) in trench 8/11; 6. Modern ditch; 7. Sections; 8. Hearth; Drawing by I. Stoepker, IPL.

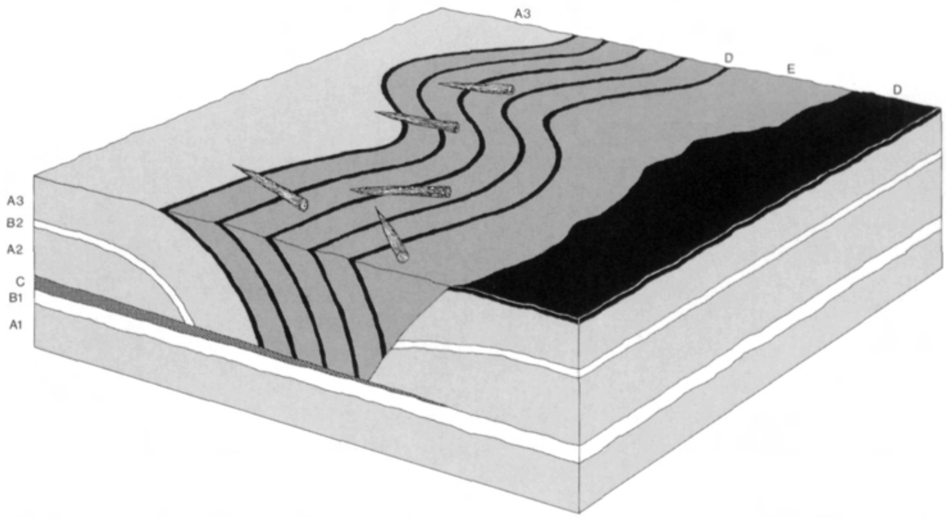

Figure 3. Schematic representation of *fissures* in buildings. On the right the 'undisturbed' stratigraphy in Midden-Delfland at present: the upper peat layer (A3) is oxidized and the organic material of the habitation is decayed. Note the break in the natural peat. On the left the still coherent peat (A2, 3) and floorlayers (D), sunken and tilted towards the deepest part of the fissure (E), filled with debris of floors, wood and other occupational remains. Drawing by H. de Lorm, IPL.
A1, A2, A3. Holland peat; B1. Dunkirk 0, early deposit; B2. Dunkirk 0, later deposit, c. 1200 BC; C. subsurface intrusion and erosion horizon with mixed peat/clay deposit; D. (tilted) floor layers; E. occupation debris in central part of the fissure.

remains were particularly dense. Subsequently less damage was done to the occupation levels.

The same processes however also resulted in the preservation of organic remains, such as wood and floor layers. Part of the prehistoric buildings and their internal features were displaced downwards after the retraction of the water to below the present day watertable, thus saving them from the post-Medieval oxidation and decay.
Site 16.10 is the only site where neither flooding nor subsurface intrusion took place. Here little or no organic occupation material survived.

However in the formation of fissures, factors other than these post-depositional disturbances must have been involved as such fissures are also found in sites where no flooding or waterlogging occurred.

2. Construction and use of prehistoric farmsteads in Midden-Delfland

Before turning to the discussion of the fissures, the construction and use of the farmsteads will be discussed briefly. Due to the disturbances mentioned above no reconstruction of a complete farmstead, *i.e.* its total length, width and specific construction could as yet be made.
The available evidence indicates however that most of the Iron Age farmsteads were similar to the better preserved examples excavated elsewhere in the region (*e.g.* Van Trierum 1988, 1992; Wind 1973).[7] The wooden structures had at least two, but possibly three longitudinal rows of internal roof supports. The upright posts in the wattled walls probably also had a roof-supporting function.
In Rockanje 8-52 (Van Trierum 1992) and Broekpolder (Wind 1973) there are indications, as at sites MD 15.04, 11.17 and 16.59, that double and/or closely spaced posts were used, both for the internal roof supports as for those within the walls. The majority of the posts were made of roundwood of ash and alder, the bark still attached. The diameters varied but seldom exceeded 12 cm. If they did the tree trunk was cleft into two, four or eight parts (Abbink 1993; Vermeeren int. report; see also Wind 1973). Whether or not extra supporting posts were present outside the walls or if posts were placed along the central axis, as is the case in many farmsteads at Voorne-Putten (Van Trierum 1992), could not yet be established for the farmsteads in Midden-Delfland.

Data from the better preserved dwellings suggest the usual division into a stalling area and dwelling part with a hearth. Frequently renewed floor layers were a recurrent feature within the farmsteads of Midden-Delfland (figs 4, 5), as in all other sites of the region (tab. 1). The standard procedure was as follows:

First, a layer of dung was laid out on the old land surface. The dung was covered by a layer of reed or sedge, usually laid out in a neat criss-cross pattern. In the Roman period farmstead of MD 16.48 a layer of branches was found incorporated within a floor (see also tab. 1). These layers formed the habitation surface, represented by a layer of ash, charcoal mixed with any kind of debris produced by animals and humans, *e.g.* dung, potsherds, butchery- and food remains. Such floors were constructed in both dwelling and stalling area, although the latter may have contained more dung. It is very likely that the floor, especially the manure, was meant to protect the soggy and vulnerable old landsurface.[8] After a while the floor was renewed in the same manner, again including manure. That the renewal of floors took place within the existing structure is shown by figure 5; the bundles of reed were carefully laid out around an upright post. In house 2, MD 15.04, at least five of such floors were still preserved with a minimum total thickness of 70 cm. (fig. 4).

At present we do not know how long a dwelling would have been in use and how often the floors were renewed. The only indirect evidence is provided by dendrochronological dates for four Roman period buildings at Nieuwenhoorn. The time between the different phases varies from 6-23 years (Brinkkemper/Vermeeren 1992; also Van den Broeke this vol).[9]

3.1 Fissures through buildings in Midden-Delfland

The main characteristic of these fissures is their asymmetrical shape and fill in cross-section (figs 3, 4). Figure 3 is a schematic representation of some essential recurrent features:

- One side, the right in figure 3, is steep, formed by a near vertical, clean break through the peat and clay layers (A1, B; A2), but usually not extending further than the Dunkirk 0 clay layer A2. In some places large chunks of peat were on the verge of breaking off the main body on this side. Outside the limits of the fissure the natural layers are still present in their original horizontal position, but the peat is much reduced in thickness because of oxidation and decay, while the floorlayers and building wood have decayed completely.
- The deepest part of the fissure is the U or V shaped area, often situated just in front of the vertical break, containing a soft, structureless mixture of bits of floors and occupational debris.
- The opposite side of the fissure is defined by gently sloping and coherent peat-, clay- and floor-layers, without a break in the (natural) layers outside the fissures. Within the fissure the original stratigraphy of both peat and floor layers are very well preserved, as are the organic materials themselves, even though or rather because they are all tilted down towards the deepest part of the fissure. In some places the floorlayers were tilted as much as 90 degrees!
- All fissures occur along the longitudinal axis. The deepest part is usually located more or less along the central axis (as reconstructed from the position of the wattle walls and the hearths). An exception may be site MD 16.59 where a fissure seems to occur along the long wall.[10] The side with the sloping layers generally extended up to the long wall of the building, which was found collapsed to a horizontal position or even tilted downward. Parts of walls, like the floors, survived more or less intact in most houses, but notably in house 1 and 2, MD 15.04 and house 1, MD 16.59. On the opposite side however the long wall had usually completely decayed as it was situated outside the fissure. There is as yet little evidence about the short ends of buildings in Midden-Delfland, but there are indications that the faults narrowed or stopped towards these sides.

The above, and its representation in figure 3, is an idealtype description of the form and fill of fissures. Much variation was observed in the depth, width and fill of the fissures both between and within farmsteads. In site 15.04 the depth to which floor layers had subsided varied from *c.* 50 cm (house 6) to more than 1 meter (house 1 and 2); the total width also varied but is usually more than 3 m, *i.e.* the fissures extended over more than half the width of the buildings. In general there appears to be a relation between the width and depth; the smaller cracks are also less deep with less disturbance of all features. The thickness of the surviving peat and floor layers varies with the depth of the fissure: in house 2, MD 15.04, the floors measured 70 cm at the point where they were maximally preserved. The maximum recovered thickness of the upper peat layer (B1) was 1.20 m. Both the peat and floors are likely to have been much thicker originally.

Moreover the degree to which the original stratigraphy was disturbed, can vary considerably from one meter to the next within most houses. The length over which the original stratigraphy was preserved was seldom more than 2-3 m. The floors can be badly broken up into small chunks, displaced both horizontally and vertically. The position of the centre of the fissures (E, fig. 3) also varied in relation to both sides.

To sum up, the fissures in the Midden-Delfland buildings are characterized by their asymmetrical shape and fill as well as their whimsical course throughout one building.

Figure 4. Section through tilted floorlayers in the fissure of house 2, site 15.04, Foppenpolder

Figure 5a. Renewed floorlayer put on around a small post, house 2, site 15.04.

Figure 5b. Detail.

3.2 PARALLELS IN THE WESTERN NETHERLANDS

The discussed features of the Midden-Delfland farmsteads are by no means exceptional. Since the 1950's quite a number of farmsteads located on peat have been excavated in the Western Netherlands, notably in the Assendelver Polders and the Meuse estuary. Table 1 lists the indications for the presence of fissures and/or "pressed down" floor layers within these farmsteads. Although most publications are of a preliminary nature it was possible to deduct many similarities between Midden-Delfland and those sites, sometimes with the help of the original field drawings and photographs. In all of these peat settlements floor layers consisting of dung, reed and/or wood (twigs and branches) were observed.[11] The presence of a fissure through the centre of the farmstead could be definitely established for the Iron Age peat sites at Kethel (IA 11), Hargpolder (IA 10), Broekpolder (IA 13-9), Holierhoekse Polder (IA 24-8), located in the immediate vicinity of the Midden-Delfland sites.

The shape and fill of the fault at site Q in the Assendelver Polders (Therkorn 1987) is very similar to those in Midden-Delfland. Van Trierum (1992) mentioned fissures in several settlements, south of the Meuse.
In Spijkenisse 17.35 the fissure is related to the post

occupational processes comparable to those in Midden-Delfland. In site 17.34 the fissure was filled in during occupation, *i.e.* before the DI flooding of the site. In site 18.50 (ibid, 72) a layer of dung was present in the centre of the byre, whereas a fissure was observed running along one of the walls.[12] In Nieuwenhoorn (site 09-89, Roman period) a fissure formed along one of the walls during occupation and 'forced the inhabitants to rebuild' (ibid, 88).

Both subsidence and fissures are often more pronounced within the stalling area, but also extend into or occur in the living area, as for example in site 10 (Hargpolder) with a tilted hearth and site 11 (Kerklaan) and Spijkenisse 17.34, see table 1. In the Midden-Delfland farmsteads fissures through both parts are usual.[13]

Altogether the data show that the construction and renewal of floors in living and dwelling areas was a standard procedure within (and sometimes also outside) buildings on peat in the Western Netherlands, whereas the association with fissures is a common phenomenon. There are however several settlements and buildings on peat without such fissures, for example most of the (Roman) Iron Age buildings on peat in the Assendelver Polders, several buildings in the Voorne-Putten sites (Van Trierum 1992) and those in some Roman period settlements in Schiedam (tab. 1).

4. Interpretation and hypotheses

There are thus two basic questions concerning the fissures: a. when and how and b. why do they take place?

4.1 How and when did fissures develop

The first question is whether faulting took place during or after occupation or both. The data provide evidence for both. Although the post habitation processes in the Meuse area, discussed above, were partly responsible for the subsidence of occupation remains, they cannot be the sole cause as fissures also occurred in locations without such influence. Moreover, subsurface erosion cannot explain the specific form and location of fissures within buildings. The following arguments can be put forward to associate fissures with the occupation itself:

- There is ample evidence, specifically in the thickness of floorlayers, that the floors compressed the underlying peat and consequently subsided during occupation. Going in or out of the house and stalling cattle would otherwise have become difficult if not impossible. The compression is no doubt due to the pressure exerted by the weight of the floors, which was increasing with every new floor.
- The shape and fill of the fissures suggest that some form of disintegration, perhaps oxidation?, of the natural peat took place below the occupied surface. It seems likely, that this is associated with the development of a (vertical) fault. These faults may have started out as small more or less V-shaped cracks which slowly but surely deepened as well as widened. The mixed and structureless fill in the centre of the fissures and the 'near' breaks in the peat suggests a continuous process of bits of peat- and perhaps floor layers breaking off. This indicates that cracking took place during occupation and that the inhabitants kept on repairing the cracks by filling them with debris and dung (as was clearly the case at site Q and Spijkenisse 17.34). So far, no direct evidence of such repairs was found in the Midden-Delfland sites.

Site Q is by far the most informative example with clear evidence for actions of the inhabitants in reaction to the widening and deepening of the fault during occupation. Therkorn (1987, *fig.* 6) *mentions the sliding down of floor* layers and snapping of the ground plate between the stalling and working area. Repairs were made during occupation, such as a wooden revetment along the fissure in part of the byre. This revetment however also slided down. The groundplate for the dividing wall was repaired as well and then covered again with new floors (ibid). The fissure at Spijkenisse site 17.34, which as an exception occurred outside the dwelling, was also filled in during occupation. According to Van Trierum it was probably caused by the presence of the creek (pers. comm.). These observations clearly confirm that fissuring took place and became worse during occupation.

Supporting evidence was found in MD 15.04 and 16.10: In MD 16.10 numerous small cracks were found in the remaining natural peat with tilted remains of floors and debris (mainly consisting of sandy clay and much decayed organic material). Tilting and subsidence was more pronounced around the hearth. However, any evidence for repairs was lost due to the bad preservation of floors and peat. The small fault of house 6, MD 15.04 (fig. 6) showed that a U-shaped hollow had formed in the peat below the surface, which was filled with a chunk of broken off and pressed down peat covered by a small section of floor levels.

To summarize, these data suggest three hypotheses about when en how fissures occurred:

Firstly, small cracks were being formed from the beginning of occupation onwards and gradually developed into a large continuous fissure.

Secondly, some form of peat decay took place within the fissures leaving empty spaces into which occupation levels subsided especially along the central axis of the building. Repairs of floorlayers in this area must have been an ongoing process.

Thirdly, the (final) tilting of the peat and floor layers as stratigraphically coherent units at one side of the fault

Table 1. Parallels for fissures in peat sites the Western Netherlands

DESCRIPTION FEATURES:

a. Site name (local designation), location and municipality, OS: Ordnance Survey map, dating, publication
b. Type of floors
c. Evidence of subsidence and/or fissures
d. Evidence for post habitation (subsurface) erosion and/or flooding during the Later Iron Age/Roman period. Dunkirk III deposits will not be mentioned here.

IRON AGE

1a. **Site Q, Assendelver Polders**, 25 W, EIA, Therkorn e.a. 1984
1b. Stalling area: dung, straw, twigs.
Dwelling area: sand, dung, wood shavings, turfs.
1c. Fissure through the stalling area, extending into the partition and dwelling area, filled in during occupation with dung and other materials.
1d. None

2a. **Site 24-8, Holierhoekse Polder**, mun. Vlaardingen, 37 O, EIA, possibly two phases. Havelaar 1970, Wind 1973, van Heeringen 1987
2b. Stalling area: dung, ash, burnt bone
Dwelling area: 'reed', possibly clay on manure
2c. Text and field drawings: Wedge-shaped fissure (50-70 cm deep) through stalling area, filled with dung, possibly also below hearth
2d. A thin layer of clay within the floors of the living area is interpreted as flooding; however this layer almost certainly part of the floor structure as it is absent in the stalling area.

3a. **Site 13-9, Broekpolder**, mun. Vlaardingen, 37 O, M/LIA, possibly two phases, Van Heeringen 1987,Wind 1973
3b. Stalling area: dung, ash, sand
Dwelling area: Reed floors (manure not mentioned)
3c. Text and field drawings: 'Subsidence of dung and debris of more than 1 m. **with disturbance of underlying peat layers'** in stalling area (emphasis added)
3d. None.

4a. **Site 10, Hargpolder**, mun. Schiedam, 37 O, IA, Van Heeringen 1987, Verwers 1965. Limited excavation area, mainly dwelling part.
4b. Dung, reed, (possibly ash and clay around the hearth)
4c. Field drawing and photographs (Archives Schiedam): fissure through dwelling area with partly tilted floors and hearth
4d. Post occupation flooding, clay covering floor layers in fissures. No subsurface erosion.

5a. **Site 11, Kerklaan**, Kethel, mun. Schiedam, IA, 37 O, Van Heeringen 1987, Verwers 1965.
5b. Dung, reed
5c. Field drawings: fissure in most of the excavated area (which includes part of the stalling and living area) filled with floors and manure, with partly collapsed wall,
5d. No data

6a. **Site 17.35, Spijkenisse**, EIA, OS 17, Van Trierum 1993.
6b. Stalling area: dung, reed.
Dwelling area: dung, no later floors surviving
6c. No clear indications. However along both long walls Dunkirk I deposits were present below the structureal remains (wood).
6d. Post occupation (sub)surface erosion and flooding.

7a. **Site 17-34, Spijkenisse**, MIA, OS 17, Van Trierum 1993
7b. Stalling area: dung on layers of reed
Dwelling area: tree trunks covered with twigs and manure. The yard was covered with a thick layer of manure, vegetable material, ash and occupation debris (p61)
7c. Text: Peat fissure from the short wall of the living area towards the creek. The fissure was filled in during occupation with branches, dung and sods (thickness 30 cm) and had formed before subsurface erosion (pers. comm. Van Trierum)
7d. Post occupation (subsurface) erosion.

8a. **Site 10-28, Spijkenisse**, MIA, OS 10, Van Trierum 1993
8b. No data
8c. Fig. 47: peat fissures along the long walls
8d. Post occupation flooding and deposition of clay

9a. **Site 18-50, Spijkenisse**, MIA, OS 18, Van Trierum 1993
9b. A layer of dung through the middle of the stalling area 9c. As the layer of dung is partly lying below the level of the wooden beams of stalls this indicates subsidence in central part of byre.
9d. No data

10a. **Site 09-89, Nieuwenhoorn**, Roman period, OS 9, Van Trierum 1993
10b. The farmsteads were built on a raised platform (partly made of dung), more than 1 m. thick, on an oligotrophic peat cushion.
10c. A fissure along the (Southern) long wall "which forced the inhabitants repeatedly to rebuilding" (p89)
10d. Surface deposition of Dunkirk I clay, no subsurface erosion.

ROMAN PERIOD SITES ON A THIN D1 CLAY DEPOSIT ON PEAT

1a. **Schiedam, Nieuwlandse Polder, site IR 1**, 37 O, Apon 1960: Site IR 1
1b. Floors consisting of twigs, clay and peat sods with a thickness of 60 cm in living area.

2a. **Schiedam, Nieuwlandse Polder, IR 2e,** 37 O, Apon 1960: Site IR 2e
2b. Floors with a thickness of 60 cm.

3a. **Schiedam, Kethel**, Roman IA, Modderman 1973
3b. Field drawings show a subsidence of floors (consisting of small tree trunks, twigs, manure and reed) of at least 40 cm. Outside the dwellings the yard was 'heigthened' towards the creek with twigs, dung, peat and occupation debris, with a total thickness of 1.20 m, also indicating considerable subsidence. There are no indications for fissures and/or tilting of floors.

Figure 6. Section through the small fissure of house 6, site 15.04, Foppenpolder, showing blocks of broken off peat and floors.

(figs 3, 4) partly points to a post occupation origin. This type of subsidence must have been a very gradual and slow process as both floor- and peatlayers were found broken off together as one unit. A post occupation date is also suggested by the presence of chunks of floorlayers and the sometimes chaotic distribution of twigs and structural wood in the fill of the fissures. This phase can be linked with the postdepositional subsurface erosion (see below).

However, it can also be argued that the final 'snapping' of the peat and consequently the sagging of the peat-floorlayers as a coherent unit took place after a period of occupation, but before the postdepositional changes. Taking site Q, Assendelver Polders and MD 16.10 again as an example, this tilting occurs in the same manner in sites without such postdepositional disturbances. The main difference seems to be one of degree rather than kind of subsidence, fissuring and tilting. It is suggested here that the final snapping and the development of one large fissure ultimately led to abandonment of the building.

4.2 Why do fissures develop?

The second major question is why cracks did develop in some cases or indeed why not in others. There are three seemingly obvious explanations for the existence of fissures during occupation which are also mentioned in the literature.

Therkorn (1987) suggested that the house was built over an already existing fault in the peat, which the inhabitants filled up with manure and used as a 'natural' dung drain. Alternatively, the inhabitants themselves dug a gully through the centre of the byre, as a manure drain as suggested by Havelaar (1960) and Wind (1973). Both explanations are unsatisfactory. Considering all examples collected here it seems very unlikely inhabitants of peat areas built their houses by happenstance over a peat fault. If done intentionally, I can think of no reasons, rational or otherwise, for such a choice.[14] The weakness of the subsoil and of the manure itself would lead to continuous damage to the surface and would be a danger to cattle as well as humans. Moreover the fissure at site Q clearly worsened, *i.e.* became wider and deeper during occupation.

Clearly the data from site Q can be interpreted in a different manner in light of the Midden-Delfland evidence. The construction of a primary floor directly on the old landsurface as the first habitation layer in all sites discussed here (tab. 1) suggests that the inhabitants tried to protect and conserve the natural subsoil as much as possible. Reinforcements of these floors at areas most trodden on, such as entrance areas, are also a common feature (see Therkorn 1987; Van Trierum 1992). In house 2, MD 15.04 a large wooden platform measuring *c.* 1 × .80 m was incorporated within the floor in what is interpreted as the entrance area (Abbink 1989). The same arguments can be used to reject the idea of a dung drain. Most importantly, this idea obviously does not explain the presence of fissures within a dwelling area or within the wall, as observed in several farmsteads.

More likely the fissures are caused by a combination of several factors and processes associated with the habitation itself.

The first of the arguments in favour of this hypothesis was discussed above, *i.e.* the floors will cause compression of the natural peatlayers and more so after every renewal. The occupation surface will become dirty and mushy after some period of use. The pressure of the floors may have been aggravated by trampling by cattle and humans. Together these factors could result in small cracks and/or destruction of the floor and the peat. Renewal of the floors solved this problem temporarily and also increased the firmness of the foundations. But at the same time this added more weight contributing to subsoil compression and cracking. The archaeological evidence suggests (sub)surface deterioration took place more quickly in the stalling area than in the dwelling quarters and more so in the central parts of the buildings. Repairs of floors could have been an ongoing process before complete renewal took place.

Secondly the wooden structure itself is likely to play an important role. It not only exerts vertical load, but sideward pressures as well. Depending on the specific roof-attachment techniques this pressure will be outwards or inwards: in three- and four-aisled structures such as published by Van Trierum (with only a few central posts) the roof will have been secured at the wall-posts (so-called 'hanging' roof). The pressure of the roof is then directed outwards (pers. comm. drs. J. Flamman, drs. H. van Londen; see also Huyts 1992).[15] Because of the very non-resilient subsoil the whole structure would therefore tend to sag down- and outwards. This might also result in damage to the peat along the central axis.[16]

To summarize, it is suggested here that the combined weight exerted by the structure, the floors and the inhabitants are the major cause for the occurrence of fissures, which must have started to form in the peat itself. The pressure of the floors is mainly downward, perhaps more so in the most trodden areas, *i.e.* the central aisle(s). The load of the structure itself is also outwards from the centre. This could explain both peat-fissuring and the orientation of faulting as being usually along the central, longitudinal axis of the house. Continued occupation probably worsened the situation and it highly probable that the continuous sagging and cracking of peat-and floorlayers finally resulted in the formation of one large fault, causing floors and peat to tilt towards its main course in the end. This hypothetical process however presupposes the decay (oxidation) of the peatlayers in and around the fissures. However, how and why this decay took place and wether or not compression and cracking were the cause of it, is not explained by these processes and remains difficult to explain (see below).

At the same time the continuous adding of floors also consolidated the farmstead interior and perhaps stabilised the subsurface. This solidity could explain why in Midden-Delfland old building sites were so often selected for the erection of new farmsteads.

Faults occurring along a wall as in Spijkenisse 10-28 and possibly MD 16.59 may indicate a different building construction, with pressures directed inwards.[17]

A third and as yet very hypothetical factor which could have played a role in this process is the possible change in water content and circulation in the peat underneath the occupation layers: the load may have pushed the water in the peat down- and outwards and/or caused dehydration of the upper peat layers weakening their structural coherence, whereas the building and floors would cut off the rainwater. Again, why and how differences in water content and pressure would result in a fissure is as yet not clear.
As Casparie pointed out for the peat tracks in Drenthe, subsidence will cause water from the environment to run off to these tracks, which resulted in a better conservation of peat on these tracks. The peat below the tracks was partly oxidized (Streefkerk/Casparie n.d.). Translated to the Midden-Delfland situation this entails that the floors would be well preserved, whereas the peat below might have been subject to oxidization.

Fourthly, post-depositional factors played a role in creating the final situation as encountered in excavations. There is probably a two-way relation between these processes and the shape and fill of the fissures as present at the time of excavation for the sites in Midden-Delfland (and those on Voorne-Putten, Van Trierum 1992):

a. There is an inverse relation between the (density of) occupation remains and the degree and location of erosion: below the remains of farmsteads erosion occurred mainly in the reed peat layers (A2, fig. 1) above the clay deposit. Hardly any erosion took place in the upper peat layers (B1) or below the Dunkirk 0 deposit (A2), which was obviously resistant to erosion. The compression of the upper peat layer and the compactness of the heavy floor layers diminished or even halted the erosive force of the water (which was very weak in the first place) in and below these layers. This explains why house 6, MD 15.04, surrounded on all sides by other farmsteads was not affected by the subsoil erosion.
   The same observations were previously noted for Medieval dwelling mounds (built on peat-mounds) in the Northern Netherlands:

> "In the peat large numbers of often vertical faults were seen, together with large chunks of peat, displaced sidewards and tilted. Many faults had their point of contact with the ditches, others occurred just along the mounds".... Where mounds and dwellings were present, no lifting took place as "the heavy mounds could not float" (Casparie 1987, 5, 7).

Clearly in most Midden-Delfland farmsteads this 'point of contact' was also just at the occupied surfaces.

b. Subsurface erosion must have aggravated the subsidence of the peat and occupation layers within farmsteads surviving above the erosive zone. After retraction of the water these layers slowly sank down and tilted as coherent levels in some places. However the tilting can only be partially the result of this process, as witnessed by MD site 16.10 and site Q for example. In other parts within a building the floors lost their coherence and were broken up into chunks and pieces. Moreover the washing down of ash and dung to the deepest levels, which was noted often, is probably also a post-depositional feature. Clearly the postdepositional processes alone cannot explain why the subsurface erosion always resulted in 'faults' along longitudinal axis, always more or less the same way and the same place. This must be due to already existing conditions, that is to previously formed differences in subsidence and density of the occupation layers within the farmstead. These conditions determined the specific influence of post depositional processes on the occupational remains.

5. Summary and conclusions

The presence of fissures within structures built on peat is the result of several, closely related 'natural' processes, which are set into motion by the habitation itself. The pressures of the structure and floors together lead to subsidence and cracking of the underlying peat in a specific manner.

The evidence suggests that more subsidence and fissuring took place in the centre of the buildings and possibly more so in the stalling area. The habitation layers are probably thicker in the stalling area because trampling by cattle necessitated more frequent repairs of the floors, while the fissures grew larger and deeper because of the weight of these floors and finally resulted in a large fault with floor- an peatlayers tilting downwards.

In other words, it is probable that repairs of the fissure, the floors and of the structure itself were impossible beyond a certain point of disturbance and that this was the main reason to abandon a building! It is also quite likely that the experience of the inhabitants with dwelling on peat led them to use thinner posts and/or lower quality wood species, because they would last for the maximum possible duration of one habitation phase in one building. Following this line of reasoning, the choice of old building sites makes sense as these provided a much more compacted building platform.

After abandonment, post-depositional erosion reinforced already existing faults and/or the subsidence of floors in most of the sites and dwellings in the Meuse estuary, but it is unlikely they were ever causing them.

The explanations offered here for the obviously very complicated processes involved in dwelling on peat are obviously to a large extent hypothetical and by no means final. There are several unexplained aspects of fissures. For example, I can think of no good reason for the asymmetry in their fill and shape. Nor is it clear why fissures occur in some areas and not in others. Finally it is still uncertain why and when the final and coherent tilting of floors, all at the same angle, occurred. Most likely a number of factors together determine whether faults will occur or not, *e.g.* the specific local composition and thickness of the peat layer, the specific water circulation, the presence and especially thickness of clay layers within the peat, the density of occupation etc.

The reasons for the differences in location of fissures, along the central axis or along one of the long walls, are also unclear. This could be connected with differences in constructional details, mainly the distribution of the weight of the roof, *e.g.* with pressure of the structure directed inwards or outwards (see Huyts 1992). A much more detailed analysis of the Midden-Delfland and other peat settlements than executed so far is needed to gain insight into these differences (see postscript 1995). Also if we are to understand the complicated archaeological remains on peat in the Western Netherlands, experiments with dwelling on peat in all its aspects need to be carried out.

Postscript 1995

Since the submission of this article, an excavation was carried out in the Holierhoekse Polder at site 10.07, directed by drs. C. Koot, of a virtually 'undisturbed' 3-aisled dwelling on peat. The data at this site confirm most of the hypotheses and conclusions presented here. A very clear and deep fissure ran through the centre of the building. A clear vertical break was present within the peat and floorlayers, which both were tilting towards this break, but at different degrees and angles on either side. The postoccupational subsurface erosion was very limited and restricted to one end of the house, while the fissure covered the entire dwelling. Altogether, the evidence suggests a final 'snapping' of the peat after a period of occupation, but before the postdepositional changes took place. This confirms the idea that fissuring ultimately led to abandonment of the building or even to partial collapse when still in use.

notes

1 The project Midden-Delfland is a cooperative undertaking of the Institute in Leiden (mainly Iron Age) and the Institute of Pre- and Protohistory of the University of Amsterdam (mainly Roman period). Site 16.48 was excavated in 1987 by the local amateur society Helinium under supervision of J.P ter Brugge, with assistence from the Institute. The excavations at sites 11.07/11.17 were directed by drs. C. Koot, IPL. All other excavations were directed by the author.

2 The excavation at site 16.10 was limited to trialtrenching. It is quite possible that the remains of more buildings were present in the near vicinity.

3 However rebuilding at the same location took place in the Roman Period at several peat sites south of the Meuse (Van Trierum 1992, 84-91).

4 These dates correspond to other Duinkerke 0 dates in the area, see Van Heeringen 1992.

5 The terms 'Duinkerke 0 and I' are used here because they are widely understood reference terms, although their meaning is increasingly doubtfull. The dating as well as the impact of these transgression phases seem to vary considerably at local and regional levels. See also Van den Broeke, this vol. for a general review of the geological conditions.

6 The subsurface intrusion of water and the related deposition of clay is known as 'klappklei'.

7 The construction of Roman period farmsteads will not be discussed here. In this period a specific, so-called 'A' construction was used in a number of farmsteads in the Meuse estuary (Hallewas 1986).

8 Manure also has a conserving influence because of its chemical composition (pers. comment dr. Brongers) as was clear from both the preservation of old landsurface and of the floor-layers themselves.
The estimated amount of manure incorporated in one floorlayer is *c.* 1.50 to 3.75 m^3, indicating that manure must have been collected and kept apart over a period of time!

9 Estimates given in the literature for the 'lifespan' of posts made of ash and elder are very low: 6-12 years. These stimates are based on modern evaluations with unprotected posts. See Brinkkemper/Vermeeren 1992; Koot/Vermeeren this vol. More experimental research is needed to make any reliable estimate for the longevity of farmsteads built on peat. Further detailed research of the built-up of the floorlayers may provide more information (see Abbink 1993).

10 The surviving stretch of wall of this farmstead showed a construction in which more sturdy upright posts were placed at *c.* 40-50 cm intervals, perhaps indicating extra roof supports comparable to for example Spijkenisse 10-28 (Van Trierum 1992)? There were also indications for a double wall as in site Q, Assendelver Polders (Therkorn *et al.* 1987).

11 To incorporate clay and wood within the floors seems to be mainly a late Iron Age/Roman period habit in the Meuse estuary, as it is in Midden-Delfland (site 16.24 and 16.48, possibly 16.10).

12 Perhaps the Duinkerke I clay deposits along the walls in site 17.35 (Van Trierum 1992, fig. 37) can also be interpreted as an indication for already present cracks.

13 However the farmstead was only partially excavated, not including the central part of the byre.

14 Peat faults are indeed not uncommon and still happen in Midden-Delfland during a very dry summer but they are small vertical cracks with a polygone structure.

15 According to Huyts (1992) the pressure in a 4-aisled construction is exerted inwards. However this depends on the specific roof-construction. With few en asymmetrically placed central posts it is not likely that these posts carried the main weight of the roof. Also the extra posts outside the walls present in most of the farmsteads on Voorne-Putten (Van Trierum 1992) suggest a construction whith an outward direction of the pressures.

16 A seemingly obvious solution to building problems on peat was to use rather thin, but many (paired) posts, together with the use of groundplates, wedges and double posts, for all of which evidence is available. The many posts can be tied together more securely into a stable (super)structure, while small posts will not sink down as easily as large and heavy ones (Abbink 1993).

17 Again the asymmetry is striking; the fissure at site 10-28 occurred along one side only.

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A crowded peat area: observations in Vlaardingen-West and the Iron Age habitation of southern Midden-Delfland

The discovery of dozens of settlement sites in a small area in Vlaardingen-West serves as the starting-point for a calculation of the Iron Age population density in the peat area adjacent to the northern bank of the Meuse estuary. It appears that, during the 3rd-2nd century BC, this region was certainly no less intensively inhabited than any other ecological zone in the Netherlands. Some microregions probably contained 4-5 farmsteads, that is 25-35 persons, per km^2. This outcome creates a picture of well-drained raised bogs which were attractive living areas for communities with a mixed farming economy.

1. Introduction

In the triangle between the towns of Delft, Rotterdam and Maassluis lies the 'green zone' of Midden-Delfland (fig. 1). Since 1987 a land redevelopment programme has been, and continues to be, carried out in this buffer area. This entails activities such as the planting of forests, the construction of lakes and other recreational schemes, as well as the construction of roads, parcellation works, *etc*. Less conspicuous, but equally threatening in the case of archaeological sites with organic materials, is the lowering of the groundwater table.

In 1981, when the redevelopment programme was still in its planning phase, E.J. Bult was charged to make an inventory and evaluate the findspots in the area to be developed. By means of a field survey, the number of findspots known was increased from 75 to 316 within one year (Bult 1983). Most of these findspots could be classified as habitation sites, dating from the Iron Age, the Roman period and the Late Middle Ages. Other findspots only produced isolated finds from these same periods. Most of the 27 possible, probable and certain sites from the Iron Age were located on peat in the southern sector of the area, called Lickebaert. After a supplementary prospection on threatened, potentially valuable sites (Van der Gaauw 1988), the decision was made to investigate only a selection of sites. The Committee for the Reconstruction of Midden-Delfland guaranteed the finances for the archaeological fieldwork.[1]

A significant detail was the agreement that fieldwork would also include watching briefs on the ground work of the development activities as they progressed. This was especially meant to ensure that observations were made and finds collected at sites which would not be excavated.

In 1988 the financed excavation programme started in the Foppenpolder, municipality of Maasland (Abbink 1989). From 1989 on, the ground works were also followed.

This article gives a preliminary overview of the unexpected results of the archaeological observations in a recreation area in Vlaardingen-West. The Iron Age findspots are then subsequently reviewed separately. These serve as a starting point for a tentative calculation of the population density in the peat area during this period.

First of all, in order to gain a better understanding of the make up of the former landscape, a brief description of the geological evolution and stratigraphy of the area in question will be given. Together with the information on the nature of the ground works, the geological data enable the reader to get an impression of the find circumstances and the possibilities for observing remains dating from the Neolithic up to recent times.

2. Geology

2.1 Calais IV - Dunkirk 0

The north-western half of Midden-Delfland is dominated by mud-flat deposits, which for a substantial part lie on top of Dunkirk 0 channel deposits. In the remaining part of the region these elements are also represented, but there peat predominates at or just below the surface. Most Iron Age settlements have been discovered in the southern part of this peat area, in the municipalities of Maasland, Vlaardingen and Schiedam. This peat extends beyond the boundaries of Midden-Delfland, into the predominantly built-up areas of the latter two municipalities. This region will subsequently be referred to as 'the southern peat area'. It broadly covers a strip of 5 km along the northern bank of the Nieuwe Waterweg, the former Meuse estuary.

The general archaeological-geological picture of Midden-Delfland has been filled in by Hallewas and Van Regteren Altena (1979), Bult (1983) and — especially for the Iron Age — Van Heeringen (1992). The large number of observations made during the recent excavation and the ground work programmes have further improved the knowledge of the southern peat area considerably,

Figure 1a. Midden-Delfland with polder-division.

Figure 1b. The sub-regions of Midden-Delfland.

especially in Vlaardingen-West. In addition, borings have also contributed to this knowledge.[2]

The landscape of which the area shown in figure 2 forms the core, is dominated by Holland peat. During the transgression period Calais IVa, a tidal creek meandered through the swampy landscape from the north to the Meuse estuary. In 1958 the eponymous site of the Vlaardingen Culture was discovered on its high levees, in the now built-up part of Vlaardingen-West (for geology see esp. Van Regteren Altena *et al.* 1962, 23 ff.). During the recent construction of the golf-course Schinkelshoek, this creek was cut at several places. Another Vlaardingen Culture settlement came to light on one of the levees, only 0.6 m below the modern surface (fig. 2, location A). Other locations along the creek produced isolated finds of the same age (Van den Broeke *et al.* 1992; Heinsbroek 1992; Moree 1991).

A clay deposit ascribed to the Calais IVb period hardly exceeds the aforementioned creek. The growth of the Holland peat in Midden-Delfland was only really interrupted again during the Dunkirk 0 transgression period. Starting from the Meuse estuary the peat was eroded by a maze of channels and creeks. They were filled up with sand, silt and clay. The area in Vlaardingen-West appeared to contain a system of massive and smaller creeks dating to the same Dunkirk 0 period. Because of the scale of an earlier geological/pedological survey, the majority of these do not appear on the map (fig. 2).

A significant feature of the Dunkirk 0 period was that the filling of the Calais creek in Vlaardingen-West, then in a state of advanced peat growth, was recut. Subsequently, both this creek and the majority of the new channels and creeks were silted up, completely or nearly completely, during this same transgression period. In addition, two clay layers were deposited over extensive areas of the southern peat region, usually separated by some dm of reed peat.[3] In the study area of Vlaardingen-West and its northerly surroundings, the youngest of these two clay layers, usually 1-2 dm thick, is present within a depth of 1 m below the surface. C14 dates of *c.* 2960 BP from the southern peat area indicate that the development of reed peat upon this

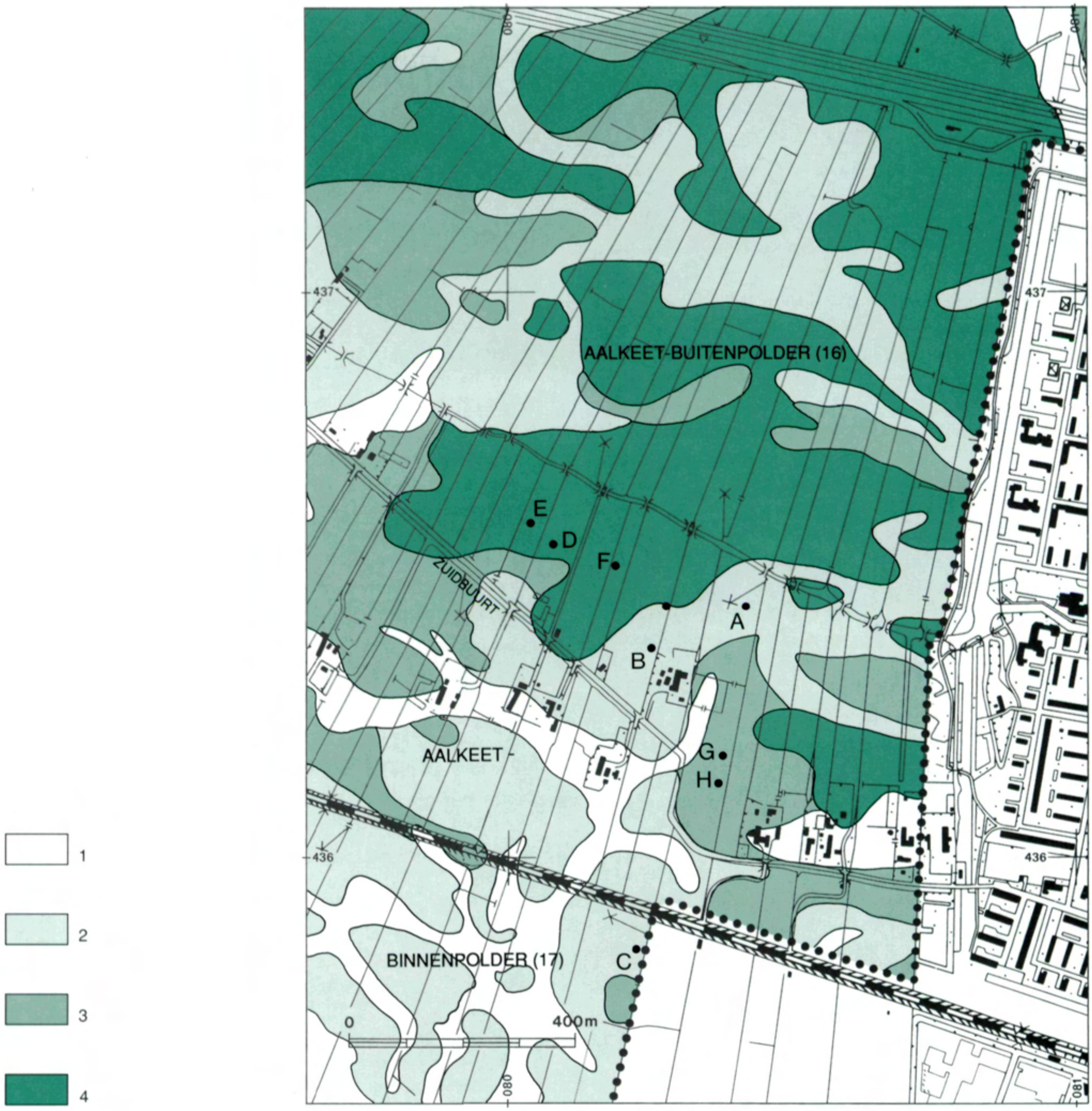

Figure 2. Geological and topographical situation in the study area of Vlaardingen-West around 1982, according to soil map scale 1:10.000 in Pleijter 1982 and archaeological map on geo-genetical basis scale 1:10.000 (documentation E.J. Bult; *cf.* Bult 1983, map-appendices). Characters indicate locations referred to in the text.

1: channel deposits (sandy clay; Dunkirk 0/I), usually with clay cover (Dunkirk I/III)

2: creek deposits and mud-flat deposits (heavy clay; Dunkirk 0/I/III, locally Calais IV), thickness more than 80 cm; locally interrupted by peat layer(s)

3: mud-flat deposits (Dunkirk I/III), thickness 30/40 – 80 cm, lying on peat

4: mud-flat deposits (Dunkirk I/III), thickness <30/40 cm, lying on peat clay started around 1200 BC (Abbink this volume; Van den Broeke 1992a, note 7; Heinsbroek 1993b). The age of the older Dunkirk 0 clay layer is not yet known.

2.2 After Dunkirk 0

The subsequent development of the Holland peat gradually resulted in the formation of oligotrophic peat in a large part of Midden-Delfland. These raised bogs, viz. their highest points, were inhabited for the first time in the Early Iron Age. This probably happened in the second half of the 7th century BC. The general opinion is that occupation had become possible due to renewed formation of creeks within the peat area, which improved its natural drainage (*cf.* Van Heeringen 1992, 306). For the concomitant Dunkirk I deposits there are, however, no dates before *c.* 200 BC for either side of the Meuse estuary.[4]

Except for the Gantel, just north of Midden-Delfland, no notably large channels were formed during the Dunkirk I transgression period, only watercourses of lesser stature. Alternatively, the water and the sediments used the residual channel and creek beds of Dunkirk 0 origin. This was also the case in the study area (*cf.* Heinsbroek 1993a, 1993b).

In the southern part of the Krabbeplas area (fig. 6b), only one creek could be determined to have been flowing during the Iron Age habitation period. A large wooden object, with a C14 date of 2275 ± 35 BP, was discovered lying against its western bank (location B in fig. 2, fig. 4).[5] This creek was probably connected with the nearby channel and creek system which dominates the Aalkeet-Binnenpolder (fig. 2). This system, too, or at least its greater part, was then open, or reopened.[6]

The mud-flat deposits of Dunkirk I in the southern part of the Aalkeet-Binnenpolder are about 5 dm thick, but wedge out completely at a short distance to the north. In the Krabbeplas area the remains of Early Iron Age date lie on top of the Holland peat bed, at the same level as remains from later Iron Age and Roman period phases (fig. 3, sites 16.75 and 16.42). This also holds for a single medieval findspot, dated to the 11th century (fig. 2, location F).[7] Only locally have one or more Dunkirk I clay layers been deposited, no more than 1 dm thick.

The clay layer covering Vlaardingen-West and its surroundings dates from the 12th century. In the area depicted in figure 2, the whole layer was probably deposited around AD 1134 (Dunkirk IIIb1; Bult 1983, 19, 1986, 119 ff.). This date was confirmed during the field observations. Apart from the aforementioned 11th century findspot on peat below the clay cover, two sites were discovered along the Zuidbuurt lying on the spur of a Dunkirk 0/I channel ridge (fig. 2, locations G and H). Pottery from the first half of the 12th century, and possibly from the last quarter of the 11th century (det. E.J. Bult), was found in humic clay (oxidised peat?) below the upper clay level. In the southern part of the Aalkeet-Binnenpolder the clay cover has a thickness of about 0.5 m. It wedges out in a northerly direction. Near motorway A 20 its thickness reduces to only 0.2-0.3 m.

When describing the geological developments, two processes have remained undiscussed. They represent the effects of water and water management on peat. The youngest process is the compaction and oxidation of the Holland peat that has occurred since the Middle Ages. The peat bed has been much thicker than we perceive nowadays. The fact that the remains from the Early Iron Age are found at the same level as those from the Roman period, does not reflect the original situation. In the Middle Iron Age as well as in the Late Iron Age and after the Early Roman period, considerable peat growth took place in Midden-Delfland (Van Heeringen 1992, fig. 60, group 1). However, local layers of peat, of at best 1 dm thick, are the only demonstrable remains of this process.

The 'decapitation' of the peat bed must be ascribed to the drainage systems which started with the medieval reclamations of the area (*cf.* Bult 1986). The digging of drainage canals and parcellation ditches led to compaction and oxidation in particular. The living proof of this is to be seen in the Vlietlanden, the only part of Midden-Delfland which has not been made into a polder (fig. 1a). It is also the only terrain with peat growth still going on. Probably since the 16th century, its surface has lain at 40 cm below NAP, the reservoir level (*boezempeil*). The surrounding polders lie about 2 m lower. The compaction and oxidation of the peat, moreover, have given way to an inversion of the relief. Because of this, the surface of Midden-Delfland is veined with many channel and creek ridges.

The fact that, despite peat oxidation, a lot of organic settlement remains from the Iron Age have still been preserved, is principally a result of the second geological process to be dealt with. This process could be described in detail after the excavations in Maasland-Foppenpolder (Abbink 1989 and this volume). Therefore, only a brief explanation suffices here.

2.3 Disruption and intrusion clay

After, or still during, the Iron Age habitation, which can be traced into the 2nd century BC, drastic geological disturbances did take place. The settlements in the greater part of the southern peat area were under water, or at least affected by a rising groundwater table. On many spots the upper part of the peat bed was torn loose, faulted and lifted, along with everything standing and lying upon it. Other plots of the peat bed were crumbled, folded or otherwise disrupted.

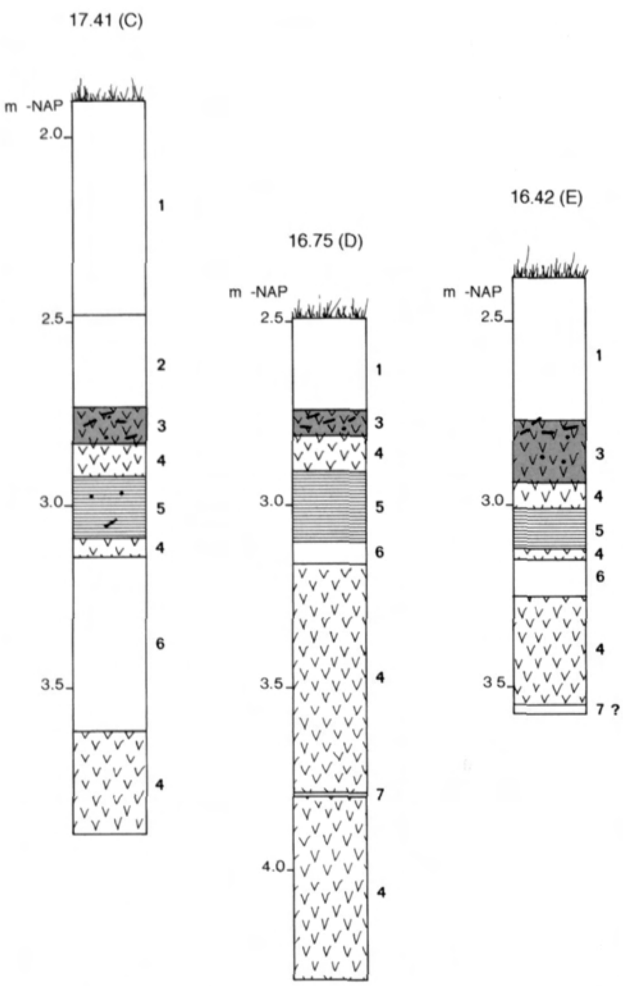

Figure 3. The stratigraphical position of the archaeological remains at some findspots in Vlaardingen-West. Dates of the findspots: 17.41: *c.* 350 BC; 16.75: *c.* 600 BC; 16.42: *c.* 100 AD.
1: mud-flat deposits, Dunkirk III
2: mud-flat deposits, Dunkirk I
3: Holland peat, decomposed; with habitation remains
4: Holland peat, raw
5: intrusion clay; with habitation remains
6: mud-flat deposits Dunkirk 0, late phase (17.41: transition from creek filling to mud-flat deposits)
7: clay (Dunkirk 0?/intrusion clay?)

After the retreat of the water, the peat 'islands' sunk again. The earlier events, however, betray themselves very clearly by the presence of layers of heavy clay and lenticular deposits between the upper and lower part of the peat bed (fig. 4). These must have been deposited under calm conditions. This intrusion clay usually has the following combination of features:

- sharp transitions to the peat at both the lower and upper edges of the clay layer; sometimes the intrusion clay has been deposited between an older clay layer and the peat above (*cf.* fig. 3, site 16.75);
- a local irregular course through the profile, occasionally even cutting diagonally through older clay layers;
- changing thickness, ramification;
- absence of plant roots;
- laminated appearance;
- very humic and polluted with twigs, lumps of peat and, at former settlement locations, archaeological materials; these objects, up to the size of beams, have come to rest at a level below the settlement surface due to faulting, turning and erosion from beneath (*cf.* fig. 3, site 17.41).

Almost everywhere in Vlaardingen-West and its wider surroundings, the peat bed contains deposits of intrusion clay. The dating of these disturbing processes is still problematical. It appears that not only Iron Age settlement sites have suffered, but also several sites from the Roman period (Abbink/Frank 1991b; Ter Brugge 1992b). The rate of disturbance seems, however, to be generally more intense on Iron Age sites. This indicates that we do not have to reckon with a unique event, but with repeated processes, occurring at intervals of possibly decades or even centuries.

Despite the absence of cover deposits from the Dunkirk I transgression period in the greater part of Vlaardingen-West, there thus positively seems to have been lateral clay deposition from the creeks at that time, but in the form of intrusion clay. On one occasion, the origin of such a deposition has been 'caught'. Starting from a creek that lay open during this period, a clay layer wedged into the peat (fig. 5; for location see fig. 2:I). At the intrusion point a groove-decorated Iron Age sherd lay in the intrusion clay (findspot 16.93).

It is still unclear when the processes took place which affected settlements of the Roman period. The latest sites that demonstrably suffered, date from the end of the 1st century AD. There are, however, hardly any younger findspots from the Roman period known on peat.[8]

3. The archaeological investigations in Vlaardingen-West

3.1 Introduction

The original intention of archaeological investigations accompanying the ground work was, that they would lead to supplementary observations and the collection of finds from findspots which had been registrated by Bult, but which were not selected for excavation. In practice, however, more new findspots were struck upon than those already registered. Despite its opportunistic nature, this

Figure 4. Overview of the Krabbeplas area in a northern direction, May 1990. The lower part shows 'patches' of intrusion clay in the Holland peat. Its local presence results from the whimsical course of these clay layers, as can be seen in the section behind (1). The habitation remains of Iron Age site 16.76 were found here. Lying on the right (2) an object made of part of a hollowed out tree trunk protrudes from the section. The object rests against the bank of a creek, which was open in the Middle Iron Age (findspot 16.80). The clay covering the Holland peat has been removed from the area behind this section.

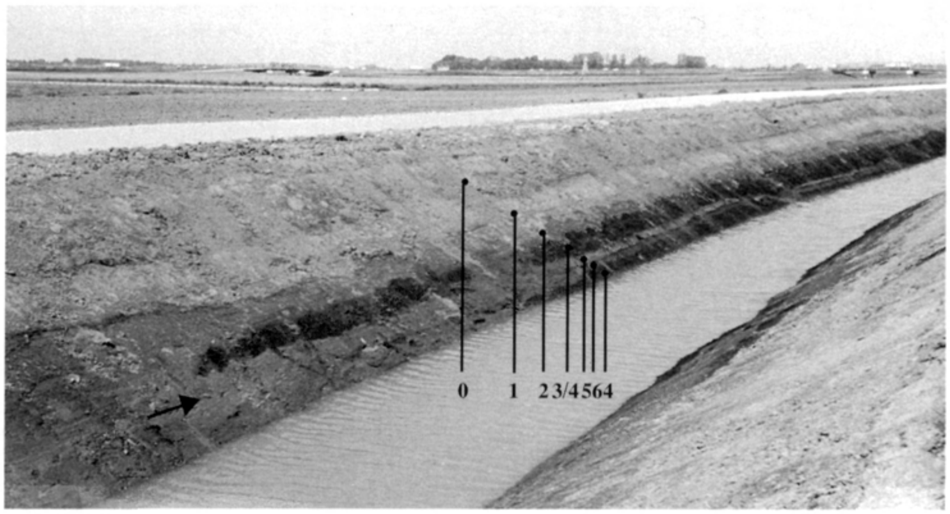

Figure 5. Western ditch-slope bordering the golf-course Schinkelshoek, showing a layer of intrusion clay, originating from a channel. This clay has entered the peat (arrow). The upper layer of soil (0) was recently deposited for the development of the golf-course. See figure 3 for the remaining legend.

aspect of the archaeological research in Midden-Delfland produces information of a qualitatively different nature than that from the regular excavation programme. It creates the possibility for:

- the (local) determination of the ratio between the number of sites registered during the earlier field survey and the real number of sites present, in other words: an evaluation of the effectiveness of the survey;
- a tentative determination of the population density in certain micro-regions.

The area of Vlaardingen-West forms the best study area in this respect. Here, in the Aalkeet-Buitenpolder, a recreation area was constructed between 1987 and 1991, the Krabbeplas forming its core (fig. 6b). In the northern part of the Krabbeplas area occasional observations were made by members of the local archaeological working group Helinium and other interested persons. In 1987, moreover, an excavation was carried out by this group in cooperation with the IPL (Abbink 1988; Ter Brugge 1992b).

From 1989 on, the development works in the southern part of the Krabbeplas area could be intensively accompanied by the present author, helped by several volunteers.[9]

Because the clay cover was mechanically removed, the top of the Holland peat was laid bare. From the foregoing geological description it can be inferred that, at this level, remains from the Early Iron Age up to *c.* AD 1134 could be documented. In a zone directly east of the southern part of the Krabbeplas this level was reached by ploughing before plantation, which resulted in a comparable findspot density.

The intensive archaeological accompaniment could be continued during the construction of the golf-course Schinkelshoek (fig. 6b). Here the digging of ditches and ornamental water features gave opportunities for archaeological observations. Other discoveries were made while a gas main was being laid, to the north and east of both recreational areas.

In the Aalkeet-Binnenpolder, too, some findspots came to light in the same period. Between the Zuidbuurt and the railway-track many hectares of land were surveyed after ploughing to a depth of *c*. 40 cm. This preceded forest plantation. This ploughing primarily affected the Dunkirk III clay cover; the underlying Dunkirk I deposits were at best only locally affected. Since the Iron Age habitation probably ended before the deposition of the Dunkirk I sediments, only findspots of the Roman period and the Middle Ages might be expected here.

The digging of ditches and borings during the construction of a mud-basin south of the railway-track also led to discoveries (Van den Broeke/Van Zijverden 1993; Heinsbroek 1993a).[10] This basin is only partly covered in figures 6 and 7.[11]

Until the commencement of the development programme, all the areas described above comprised grazing land and farmsteads.

3.2 Results

The results of the archaeological accompaniment exceeded by far the expectations (figs. 6a, 6b).[12] The discovery of a Middle Neolithic Vlaardingen Culture settlement on a creek levee came fully unexpected, as well as the discovery (by playing children) of a human skeleton from the Middle Bronze Age (Van den Broeke *et al.* 1992, Van den Broeke 1992a resp.).[13]

Concerning the Iron Age and Roman period, the quantity of findspots in particular came as a surprise. Whereas E.J. Bult discovered five Iron Age sites by surveying the ditches, another 22 could be added afterwards. Moreover, the prevailing idea that the peat area of Midden-Delfland had scarcely been inhabited after the Iron Age, appeared to be fallacious: the area outlined in figure 6 produced 16 sites from the Roman period[14], primarily dating from the 1st and the beginning of the 2nd century AD. In addition, some dozens of findspots with isolated finds from both the Iron Age and the Roman period must be mentioned here.[15]

The comparisons presented above do not yet allow an objective evaluation of the effectiveness of surveying in grassland. Such a comparison is only expedient in a continuous, unbroken terrain where the maximum possibilities would exist for making observations. A plot of 12 ha in the south-western part of the Krabbeplas area meets this requirement. Here so many groundworks were executed and observations made that, at best, only a few sites from the Iron Age and Roman period can have remained undetected.[16]

During the construction of the southern part of the Krabbeplas (an area of more than 6 ha) even almost ideal observation opportunities existed (see above). Both the top of the peat and the underlying intrusion clay gave opportunity to discover mobilia and house remains.

On these 12 ha of land Bult had discovered two sites, both dating to the Iron Age, by surveying ditch-banks (on average, one every 50 m). During the ground works 12 more sites were added, in addition to 6 from the Roman period. Of these last sites 4 were found on the same location as Iron Age remains. In one case this was at an Iron Age site already discovered by Bult (16.24). By merely counting locations, 15 new ones were discovered on the 12 ha plot. This means that during the earlier survey, at least 88% (15/17) of the locations remained undiscovered in the grassland, although it was only covered with a clay layer no more than some decimetres thick.

The modest increase of late medieval sites (6 sites added) can be ascribed to a changed settlement pattern in combination with dissimilar observation opportunities with regard to that period. The late medieval sites primarily lie on or near some east-west oriented channel ridges. The effect is a ribbon-like pattern of medieval house sites, for a great part lying on eye-catching, individual dwelling-mounds (small terps), some of which are still inhabited today. When surveying, Bult had already collected many 12th century and later finds at or just below the surface, which was essentially formed in the 12th century.

As a result of the overwhelming mass of newly-discovered findspots, only a restricted number of sites could be excavated (see Abbink 1988, 1989 [16.32]; Abbink/Frank 1991a, 1991b; Van den Broeke *et al.* 1992). On most of the other findspots the investigations had to be restricted to borings and the collection of finds on the (temporary) surface.

3.3 The iron age findspots

The study of the Iron Age habitation of Midden-Delfland forms part of the research programme of the Institute of Prehistory (see especially Abbink 1993). Within that framework we will now concentrate on the Iron Age data from the aforementioned area, to estimate the population density of the southern peat area during that period. For that reason several basic data are presented in table 1. Besides the observations and finds of the recent archaeological

Figure 6a. Distribution of the sites in Vlaardingen-West after the field survey of Bult in 1982. For legend see figure 6b.

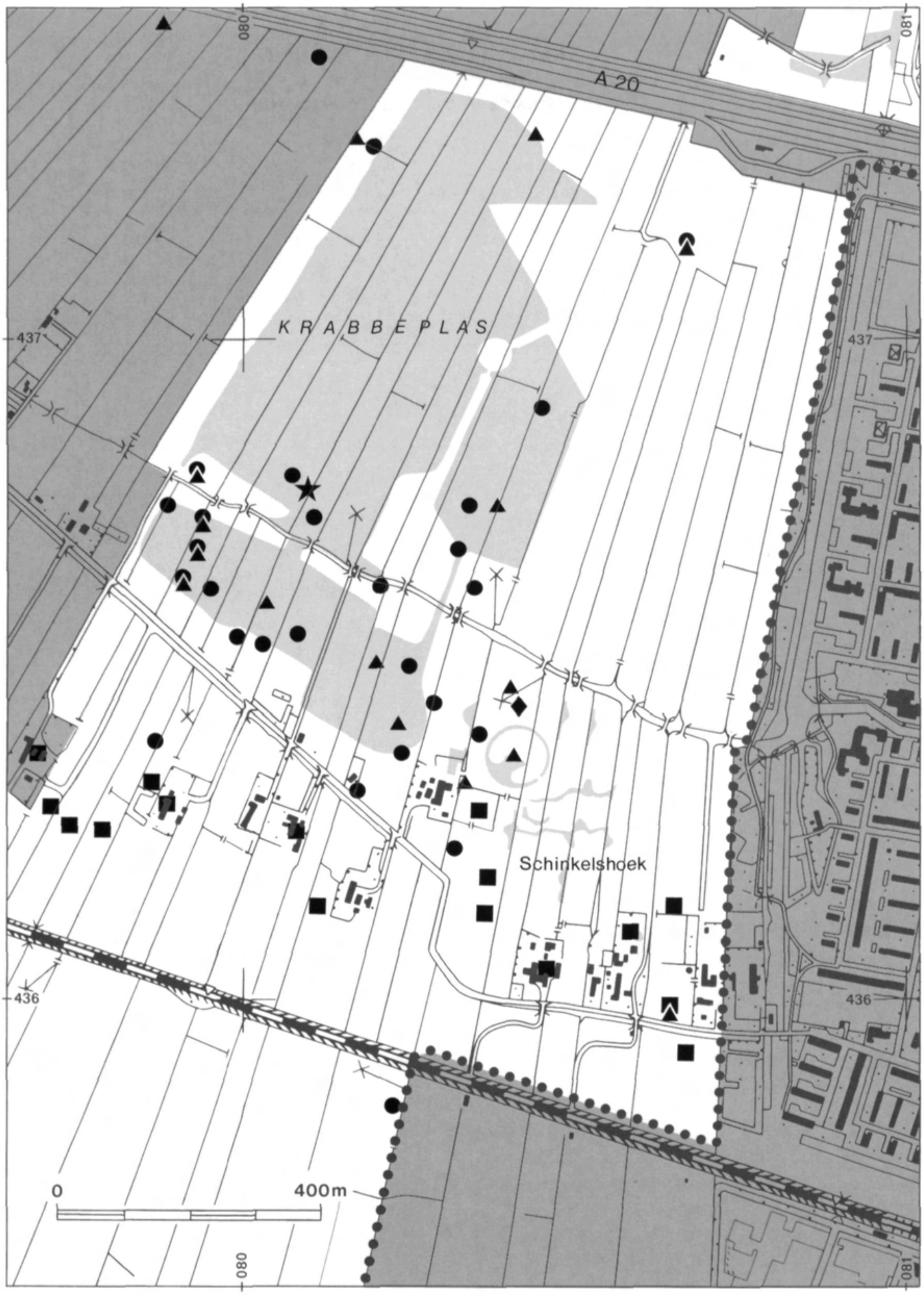

Figure 6b. Distribution of the sites after development works in 1992. Locations of isolated finds not mapped. Star: Middle Bronze Age human skeleton.

◆ Middle Neolithic
● Iron Age
▲ Roman period
■ Late Middle Ages
water (pond, lake)
not redeveloped

investigations the findspots recorded by Bult have also been included. All findspots are indicated in figure 7. Several categories in table 1 deserve an explanation:

Find circumstances

This category primarily has importance for the interpretation of the nature of the findspot. If a modest number of finds has been brought to light on a spot that has only been exposed by profiles or borings, its interpretation as a settlement site is still thought legitimate.

At locations where, after the field observations, a more thorough investigation (viz. including machinery and an excavation-team) has taken place, other observation categories have not been specified.

Position of finds

Finds have generally been collected on top of the Holland peat[17] and from within the intrusion clay below. Fissured occupation layers sloping down into the peat, which are regularly met in excavation trenches, have not been entered separately. They represent former occupation on Holland peat.

Features and finds

For this column categories have been selected which are thought to be the best indicators of settlements. The characteristic hearths (clayey to sandy patches, usually interlarded with layers of charcoal and furnished with a sherd-pavement) play an important part. For that reason they have been entered quantitatively. The same holds for the pottery sherds, entered on the basis of a preliminary inventarisation. The number of potsherds from a findspot have been considered together with the findings and the opportunities for observation, in order to determine the nature of the smaller find assemblages.

At several Iron Age findspots some Roman period pottery (both native and Roman) has been found, as well as late medieval or still later pottery. Considering the find circumstances and the stratigraphic position of these latter remains, this is not at all remarkable. For that reason they have not been entered in table 1. On the other hand, where native-Roman looking pottery seems to be present in significant quantities, intermingled with Iron Age pottery, this has been mentioned separately. It will be self-evident that we cannot be sure in every case that the other categories of finds and features stem exclusively from the Iron Age.

Type of findspot

In principle, an Iron Age settlement, apart from containing one or several farmsteads, may have included pits, field ditches and surrounding parcellation ditches. At least, such a layout of the settlement has been established for Roman period sites on clay in Midden-Delfland (Van Londen 1992a, 1992b, 1992c) and in a northerly direction, at Rijswijk for example (Bloemers 1978). On peat, on the other hand, pits, ditches *etc.* can only be recognised when deep features have been filled up with clay before oxidation of the peat occurred (*cf.* Van Trierum 1992, fig. 35-2). In other cases we may only expect to retrieve find concentrations as a relict of dug features which were afterwards filled with rubbish. In practice, concentrations of finds in the peat area of Midden-Delfland appear to be restricted to the farmsteads themselves. The majority of finds even stem from the interiors of the farmhouses. Outside these areas, the find density visibly falls off.[18] For this reason we have assumed that, in cases of restricted observation opportunities, even small find concentrations without visible building-remains derive from a dwelling place, or at least indicate one in the close vicinity.

Period

Even with small assemblages of finds it is relatively easy to discriminate between pottery from an early Iron Age occupation phase and a later one (see below). This is due to fast developments in the spheres of pottery temper and decoration (fig. 8), as well as to an occupation hiatus. The same features allow a rather sharp distinction between Iron Age pottery and pottery from the Roman period, even if the latter does not include imported Roman pottery. Only the recurring weathering of sherds provides difficulties in determination.

4. The Iron Age habitation

4.1 Towards a model for density calculation

At the end of the 1950's it became clear for the first time that, in the coastal zone, not only the higher, mineral grounds had been occupied in the Iron Age, but also the peat area behind the dune belt. Especially as a result of the intensive investigations carried out on both sides of the Meuse in recent years, it appears that living on peat certainly brought with it some drawbacks: repeated inundations, subsidence and faulting of the living space, a restricted crop assortment and more chance of livestock diseases (see esp. Abbink 1993 this volume; Brinkkemper 1993; Van Heeringen 1992, 303 ff.; Van Trierum 1992; Van Wijngaarden-Bakker 1988). This raises the question of whether the peat area offered advantages which counter-balanced these drawbacks.

Another possibility is that the peat area functioned as a buffer zone in times of insufficient means of subsistence in the surrounding ecological zones, be it due to population growth or by other causes. In the case of the dune belt one may think of factors such as dehydration, sand-drift or scarcity of wood.

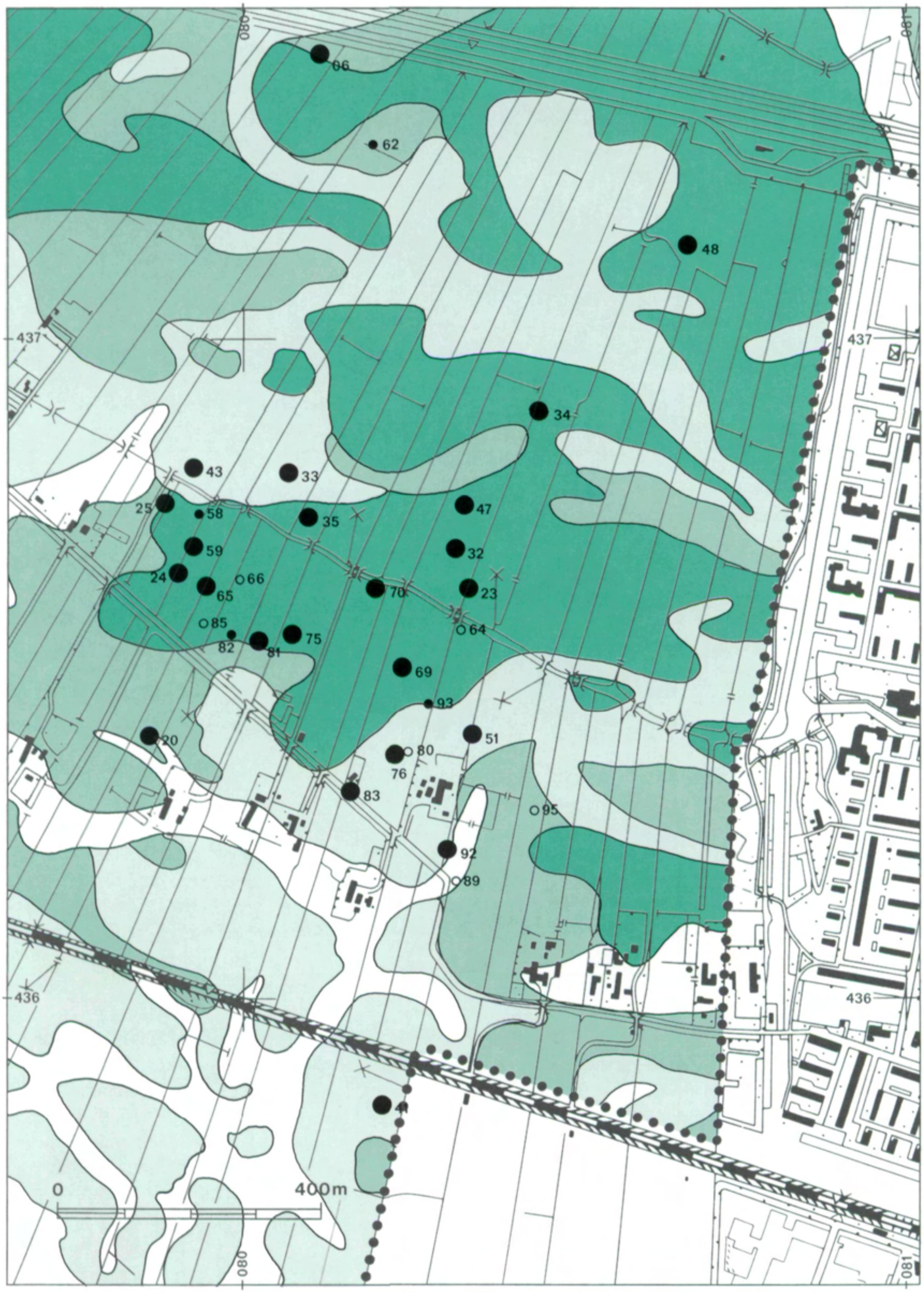

Figure 7. The Iron Age findspots in Vlaardingen-West, plotted on a geological map (for legend see fig. 2).

● certain or probable settlement site ● possible settlement site o isolated finds (?)

findspot	coordinates	find circumstances					position of finds				features and finds 1987-1992								type of findspot			period		note	references
			1987-1992																						
		survey Bult 1981-1982	dug out soil only	section/boring	in plan	excavation	top of peat	intrusion clay	creek fill	unknown	hearth (n)	wood	charcoal	pottery (n)*	loam	bone/antler	stone	other finds	certain/probable site	possible site	isolated finds (?)	Early Iron Age	Middle/Late Iron Age		
16.06	80.10/437.43	x	.	x	x	.	x	.	.	.	1	.	+	267	+	+	+	+	x	.	.	.	x		Van Heeringen 1992, 37-O-55
16.23	80.35/436.62	x	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	x	.	.	.	x		Van Heeringen 1992, 37-O-65
16.24	79.91/436.65	x	.	.	.	.	?	?	.	.	.	.	.	.	.	.	.	.	x	.	.	.	x	a	Van Heeringen 1992, 37-W-22
16.25	79.88/436.75	x	.	x	.	.	x	.	.	.	.	+	+	6	.	.	.	.	x	.	.	.	x	b	Van Heeringen 1992, 37-W-23
16.32	80.32/436.69	.	.	.	.	x	x	x	.	.	2	+	+	>3000	+	+	+	+	x	.	.	.	x		Abbink 1990
16.33	80.05/436.80	.	.	x	x	.	x	.	.	.	2?	+	+	4628	+	+	+	+	x	.	.	.	x		
16.34	80.45/436.90	.	.	.	x	.	.	.	.	x	.	.	.	75	+	+	.	.	x	.	.	.	x		
16.35	80.10/436.72	.	.	.	x	.	?	.	.	.	.	.	.	16	.	.	+	.	x	.	.	.	x		
16.43	79.92/436.80	.	.	.	x	.	?	.	.	.	.	.	.	21	.	.	.	.	x	.	.	.	x		
16.47	80.34/436.75	.	.	x	.	.	x	?	.	.	.	.	.	>6	.	.	.	.	x	.	.	.	?		
16.48	80.67/437.16	.	.	.	.	x	x	.	.	.	1?	.	.	>100	.	.	.	.	x	.	.	.	x	c	Abbink 1988; Ter Brugge 1992b
16.51	80.36/436.41	.	.	.	.	x	x	x	.	.	.	+	+	>800	.	+	+	+	x	.	.	.	x	d	Van den Broeke *et al.* 1992
16.58	79.94/436.72	.	.	x	.	.	x	x	.	.	.	.	.	18*	.	.	+	.	.	x	.	.	?	e	
16.59	79.93/436.69	.	.	.	.	x	x	x	.	.	1	+	+	>4000	+	+	+	+	x	.	.	.	x		Abbink/Frank 1991a
16.62	80.19/437.29	.	.	.	x	.	.	.	.	x	.	.	.	13*	.	.	.	.	.	x	.	.	x		
16.64	80.33/436.57	.	x	.	.	.	.	.	.	x	.	.	.	2	.	.	.	.	.	.	x	.	?		
16.65	79.95/436.63	.	.	x	x	.	x	x	.	.	1?	+	+	40*	.	+	.	.	x	.	.	.	?	f	
16.66	80.00/436.63	.	.	.	x	.	.	x	.	.	.	.	.	8	.	.	.	.	.	.	x	.	x		
16.69	80.25/436.51	.	.	.	x	.	x	?	.	.	1	+	+	384	.	+	+	+	x	.	.	.	x	g	
16.70	80.21/436.63	.	.	x	.	.	.	.	.	.	.	.	.	68	.	+	+	.	x	.	.	.	x		
16.75	80.07/436.56	.	.	x	x	.	x	x	.	.	1?	+	+	869	+	+	+	.	x	.	.	x	.	h	Van den Broeke 1991, 333
16.76	80.23/436.38	.	.	x	x	.	x	x	.	.	2?	+	+	1207	+	+	+	+	x	.	.	.	x		
16.80	80.25/436.39	.	.	x	x	.	.	.	x	.	.	+	+	32	.	+	.	+	.	.	x	.	x	i	Van den Broeke 1991, 333, esp. fig.6
16.81	80.03/436.54	.	.	x	.	.	x	.	.	.	1	.	.	16	.	.	.	.	x	.	.	.	x		
16.82	79.98/436.55	.	.	x	.	.	.	x	.	.	.	.	.	10	.	.	.	.	.	x	.	.	x		
16.83	80.18/436.32	.	x	.	.	.	.	.	.	x	.	.	.	12	.	.	.	.	x	.	.	.	?		
16.85	79.94/436.57	.	x	.	.	.	.	.	.	x	.	.	.	506*	.	.	.	.	.	.	x	.	x	j	
16.89	80.33/436.18	.	x	.	.	.	.	.	.	x	.	.	.	16	.	.	.	.	.	.	x	.	x		
16.92	80.32/436.23	.	.	x	.	.	x	.	.	.	.	.	.	24	+	+	.	.	x	.	.	.	x		
16.93	80.29/436.45	.	.	x	.	.	.	x	.	.	.	.	.	2	.	.	.	.	.	x	.	.	x		
16.95	80.45/436.29	.	x	.	.	.	.	.	.	x	.	.	.	3	.	.	.	.	.	.	x	.	?		
17.20	79.87/436.39	x	.	.	.	.	?	.	.	.	.	.	.	3	.	.	.	.	x	.	.	.	x		Van Heeringen 1992, 37-W-25
17.41	80.23/435.84	.	.	x	.	.	x	x	.	.	.	+	+	209	.	+	.	+	x	.	.	.	x		Van den Broeke/Van Zijverden 1993

Table 1. (opposite) Summary of the Iron Age findspots in Vlaardingen-West (*cf.* fig. 7). *= Roman native pottery included.

a. The finds discovered by Bult on this location, which have been published by Van Heeringen (1992), no doubt derive from a Middle or Late Iron Age site. The settlement that was excavated here in 1990, however, dates from the Roman period (Abbink/Frank 1991b). Because the original findspot (ditch) formed the eastern limit of the native-Roman settlement excavation, it may be supposed that the older settlement was situated on the other side of the ditch. **b.** In addition, floor remains and ashes were identified. **c.** This site was certainly inhabited in the 1st century AD after an earlier occupation on the same spot. A C14 sample taken from a hearth foundation consisting of twigs gave 2265 ± 25 BP (GrN-20569). **d.** Findspot 16.60 was later joined to this site. **e.** Animal dung observed within the intrusion clay. **f.** Pottery from the intrusion clay definitely dating to the Iron Age; the hearth is probably also of the same date. **g.** Two find concentrations with an interspace of some 20 m. **h.** Number of pottery sherds corrected with regard to Van den Broeke 1991, 333. **i.** Found in dug-out soil deriving from the creek fill, or from covering or adjacent deposits: upper part of human cranium (sub-adult; det. M.L.P. Hoogland, Archaeological Centre Leiden). C14 date: 2190 ± 60 BP (GrA-799). **j.** Displaced finds from the Iron Age and Roman period.]

Before being able to answer the question why the peat area was colonised, we should at least have an impression of the population density in the relative regions. The first steps in this direction have been taken by Van Heeringen (1992, 311 ff.). His estimations did, however, start with the assumption that the documented sites rendered a complete coverage of the habitation.

For a calculation of the population density in the peat area north of the Meuse estuary, the recently obtained data from Vlaardingen-West create a better starting-point. This especially holds for the aforementioned area of 12 ha, which will henceforth be referred to as 'Krabbeplas-south'.

The fact that only one of the encompassing sites has been adequately investigated (16.59; *cf.* Abbink/Frank 1991a), however, makes it difficult to state all elements in the calculations as exactly as desired. A particularly obscure element is the number of buildings or building phases (i.e. the complete rebuilding of a farmstead) present on one site. In total, four elements have to be taken into consideration:

1. the overall length of the habitation;
2. the number of farmsteads on a site;
3. the lifespan of a farmstead;
4. the number of inhabitants of a farmstead.

4.1.1 Length of the habitation

If the total of twelve certain and probable sites would have to be distributed evenly over the eight centuries of the Iron Age, the result would be an extremely thin population scatter. On the contrary, however, the evidence suggests that a varying pattern of presence can be outlined. This holds for the whole peat area directly north of the Meuse estuary. By this area we mean not only a great part of Midden-Delfland, but also the adjoining south-eastern region, which now for the most part lies in the outskirts of Vlaardingen and Schiedam.

No more than three sites date from the first colonisation phase of the peat area, between *c.* 650 and 550 BC. One of these early sites lies at Krabbeplas-south (16.75).[19] There then follows an occupation hiatus of some two centuries, just like in the other peat areas of the western Netherlands. This hiatus coincides with a phase of wetter conditions and peat growth. It is remarkable that only a few habitation traces from the dune belt are known from this same time span (Van Heeringen 1992, 303 ff.).

Apart from the three Early Iron Age sites, all datable findspots on the peat north of the Meuse estuary can be ascribed to a time span of two and a half centuries at most. The earliest one in this series is site 17.41, lying in the Aalkeet-Binnenpolder (fig. 7). Its pottery shows some characteristics which distinguish it from the other pottery assemblages of reasonable size from this second occupation phase (fig. 8): a substantial proportion of roughened

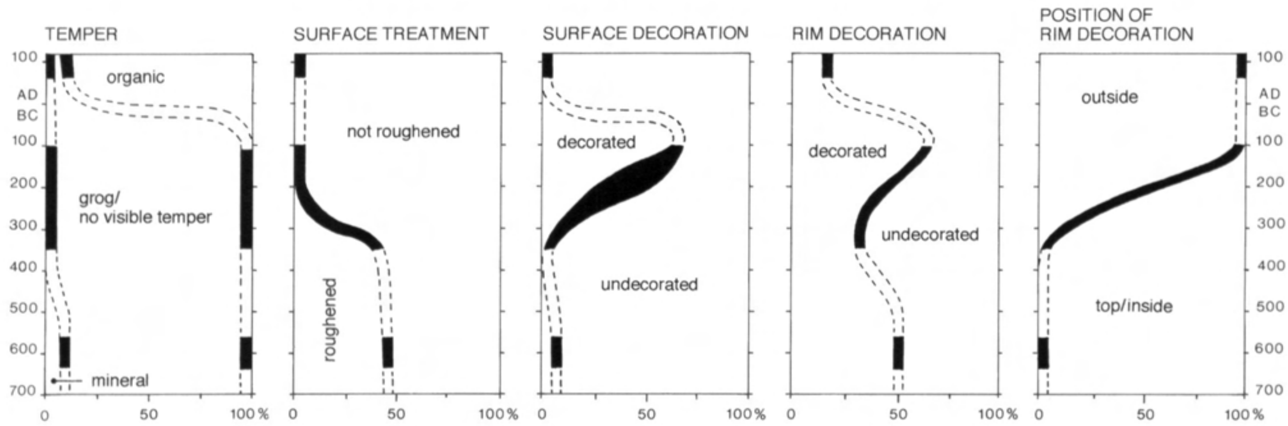

Figure 8. Schematic representation of the developments in the frequency distributions of some pottery characteristics in the peat area of southern Midden-Delfland and immediate surroundings. Based on sherd counts (Van Heeringen 1992 and author's documentation). The suggested continuity in pottery traditions around the 1st century BC is strictly hypothetical.

(*besmeten*) pottery, a low percentage of wall decoration, and the absence of decoration on the outer side of the rim.

The absolute date must provisionally be determined by means of comparable pottery from Spijkenisse (findspot 10-28), in the peat area south of the Meuse estuary (Van Trierum 1986, esp. fig. 30: 1-16). For this (single phase?) settlement three C14 dates are available (Van Trierum 1992, 61). After calibration[20], the combined dates point to the middle of the 4th century BC. The C14 date of 2220 ± 25 BP (GrN-20531) from a charred branch from site 17.41 itself gives a timespan of *c.* 370-200 cal. BC. The supposed date around 350 BC fits within this range, but can not be corroborated by this outcome.

The high degree of similarity between Middle and Late Iron Age pottery on both sides of the Meuse estuary was good reason for Van Heeringen (1992) to ascribe the pottery of both areas to the same regional (Broekpolder) style group. Therefore the date of about 350 BC for Spijkenisse 10-28 is here adopted as the start of the second occupation phase of the peat area north of the Meuse estuary.

The other findspots produced pottery with later characteristics. The C14 dates (about thirty) which have been obtained for sites around Maasland and Vlaardingen cover a short timespan. They vary between 2280 ± 35 BP and 2120 ± 20 BP.[21] This last date is based on wood from a farmstead, from which a second wood sample gave a C14 date of 2130 ± 25 BP.[22] For this last site a date somewhere in the 2nd century BC is most probable, but even the first half of the 1st century BC lies within the range of possibilities. The pottery from this site belongs with the younger assemblages of the peat area.

For the time being, some pottery assemblages from Schiedam may be considered to be the youngest ones in the peat area, namely those with the highest proportion of wall and rim decoration, and which, moreover, have rim decoration almost always placed on the outer edge of the rim (Van Heeringen 1992, esp. 37-Oost-1, -4, -5, -11). However, due to the lack of absolute dates this statement cannot yet be verified.[23] It is still conceivable that not chronological, but regional cultural differences within the peat area (and the Broekpolder style group) resulted in the observed variations between Late Iron Age pottery assemblages.

The youngest Iron Age settlements in the peat area need not be dated later than *c.* 100 BC. We may point at drastic changes in pottery characteristics before the end of the 1st century AD, which theoretically need a considerable lapse of time. The many sites from the 1st century AD which have been recovered in Vlaardingen-West show pottery with almost exclusively organic temper instead of grog; moreover, decoration is very uncommon (fig. 8).

It is still unclear where people lived during the period between. Wetter environmental conditions are seen as the impetus for a depopulation of the peat area north of the Meuse estuary around 100 BC or, at the utmost, half a century later (Van Heeringen 1992, 309). This possibly forced the communities onto the levees of the river Meuse for one or two centuries. Later erosion of the levees, however, precludes the testing of this hypothesis.[24]

Considering the state of affairs in the 1st century BC, when the southern half of the Netherlands suffered from Caesars's Gallic War and experienced ethnic shifts, one is justified to oppose the explanation of discontinuities in pottery characteristics in terms of local cultural drift. Instead of an evolution of the pottery within the original population (outside the archaeological field of view), we should consider a sudden break in the pottery tradition. It is quite reasonable to suppose that in the 1st century AD a population with a new ethnic signature was also present in the peat area north of the Meuse estuary. In any case, the native Roman pottery in the area between Meuse and Rhine shows a distinct Frisian stamp (Taayke 1990, 177), although this area is known as the living area of the Cananefates, for which tribe Roman literary sources suggest an eastern origin (summarised in Bloemers 1978, 75 ff.).

Looking at the Early Roman native pottery from Vlaardingen-West, we should, in our opinion, reckon with at least a considerable contribution by descendants of the original Iron Age population (*cf.* Fontijn 1994). Also considering the given C14 dates, we therefore propose a time lapse of more than one century between the latest Iron Age and the earliest known native Roman pottery.

The foregoing discussion makes clear that in order to calculate the Iron Age population density, we should have in mind two phases of occupation. The one site from Krabbeplas-south which belongs to the early phase (around 600 BC) can hardly be used for such calculations. Therefore, these will have to be restricted to the second occupation phase. For this phase two and a half centuries at most may be reserved, namely from 350 to 150/100 BC. The pottery from those findspots in table 1 which could not be specified within the Iron Age, seems, at least for the greater part, to belong to this occupation phase.

4.1.2 *The number of farmhouses on a site*

It is difficult to establish how many farmhouses stood on the sites of Krabbeplas-south, be it contemporaneously or at different stages. During the investigations in the Foppenpolder, in 1988/1989, the image of solitary farms which had previously been held, was completely undermined: in an area of no more than 80 × 40 m, the remains of at least six farmhouses came to light (Abbink 1989). That these six were certainly not all in use contemporaneously does not affect our point, since we are primarily trying to calculate the total number of houses during the second occupation phase. The observed clustering of houses appears not to be restricted to the Foppenpolder. On the contrary, in the south of Midden-Delfland it seems to be the rule rather than an exception.[25]

At most findspots in Krabbeplas-south it could not be determined if there had been more than one farmstead on the find location, owing to the find circumstances. However, at the location which could be investigated most thoroughly (16.59), at least two farmhouses or building phases were represented, just as at site 16.32 elsewhere in the Krabbeplas-area (Abbink this volume). The observations at site 16.69 also raise the assumption of the presence of more than one farmhouse. The presence of more than one hearth at a site (16.33 and 16.76), is, however, alone not sufficient to suppose more than one farm.

Backed by the findings from well-investigated sites in Midden-Delfland, an average number of houses or building phases of 1.5 per site for model A can be stated, and 2 for model B (tab. 2).

4.1.3 *The lifespan of a farmhouse*

Assuming that people inhabited a farmhouse until it needed replacement, it would be useful to be able to calculate its average lifespan. The wood species used for the structure are, in our case, the most relevant clues. The wood-species from several Iron Age farmhouses in the southern peat area of Midden-Delfland have been determined (Koot/Vermeeren this volume). One appears to have predominantly used the, less durable, wood of alder (*Alnus*) and ash (*Fraxinus excelsior*), whereas durable material, notably oak, has not yet been demonstrated to have functioned as building-material. For alder and ash under moist conditions, above groundwater table, an average use-life of less than five years is proposed (*cf.* Bakels 1978, tab. 6). During British field tests with stakes of 5 × 5 cm, alder and ash lasted for 4 and 4-6 years respectively when placed in loam soil (Purslow 1976). The author, however, states that the average use-life would be in direct proportion to the thickness of the stakes.

Apart from the diameter of the posts being a variable factor when determining durability, the prehistoric practice seems to legitimate a readjustment of use-life in an upward direction. For instance, for the early phase of the Bronze Age settlement of Bovenkarspel a succession of at least 25 generations during some six centuries could be established, following the intersecting house-plans. This results in an average maximum lifespan of 24 years for a farmhouse on the clay grounds. Here too, wood of the lowest durability class seems to have been predominantly used, willow and alder especially. The modal diameters of the posts are between 11 and 21 cm (IJzereef/Van Regteren Altena 1991, 74-76).

Compared with Bovenkarspel, the farmhouses in the peat area are characterised by a lower average diameter of the posts. A thickness of more than 12 cm is rare (*cf.* Koot/Vermeeren this volume).

The repeated discovery of farmhouses which have subsided in the peat, a process which must have started during habitation (Abbink this volume), will have shortened the lifespan of these houses. For a native Roman farmhouse in Nieuwenhoorn (Voorne-Putten) it has been ascertained that it was rebuilt three times after its erection, probably as a corollary of the formation of a fault on the spot. Dendrochronological research has shown that the first three habitation phases lasted 6, 21 and 23 years respectively (Van Trierum 1992, 88). Several species of wood were utilised for the wall-posts, mostly oak and elm, but also alder, willow and maple. The posts supporting the cross-beams of the first phase were made of maple and elm (average diameter 13.9 cm), for the later ones predominantly oak had been used (Brinkkemper/Vermeeren 1992, 112). Therefore, the length of the use-lives may primarily reflect the kinds of wood which had been used for the structure.

An argument of a completely different nature for a longer lifespan of the farmhouses is supported by the large amounts of pottery found on many sites in the peat area. The house-sites which have been investigated most thoroughly, produced in every case many tens of kilograms.

For the Iron Age house in the Assendelver Polders with most traces of repair, Therkorn estimated a maximum lifespan of 35 years. The largest quantity of pottery was collected from this farmhouse, the weight of which was 261 kg (Therkorn 1987, 219).

The values of 8 and 12 years for the farmhouse lifespan in model A and B respectively, do not then seem to be exorbitant in the light of the foregoing facts.[26]

4.1.4 *The number of farmstead inhabitants*

The modal household at least comprised a core family with several children. Possibly also one or two members of an older generation completed the household. For later prehistory one usually reckons with an average number of 6-8 persons.[27]

4.2 Modelling

For the models A and B in table 2 values are presented which lead respectively to a low and a high number for population density. Only the 11 probable and certain settlement sites from the Middle and Late Iron Age in the extensively surveyed area Krabbeplas-south have been taken into account to form the starting-point for the calculations. Extrapolated to 1 km^2 this would mean 92 sites. By way of precaution, only 80 sites are entered here.

For determining the number of house-generations (b/d), we assume an occupation period between 350 and 100 BC in model A; with model B the chronological limit has been set at 150 BC.

The number of farmhouses at any one moment can be calculated with the formula $y = a \times c/(b/d)$. The outcome of *c.* 4 and 10 farmsteads per km^2 imply that around one farmstead lay *c.* 25 ha and 10 ha of land respectively.

In view of these facts it may be argued that a population of 23 persons per km^2 (model A) is a lower limit indeed. This is because two more findspots have been classified as possible settlements at Krabbeplas-south, some findspots with isolated finds may also represent sites, and some plots have remained covered with clay and thus could not be surveyed. Moreover, an occupation period of 250 years is probably too high an estimate for the peat area of Vlaardingen and Maasland.

On the other hand, we must reckon that a density of 77 persons (model B) would be among the impossibilities. The economic carrying capacity of the area would have been insufficient. Prummel calculated the need for land for agriculture and livestock with regard to the contemporaneous inhabitants of the peat area of Voorne-Putten, at the other side of the Meuse estuary (Prummel 1989).[28] The minimum requirement of 16.5 ha land per (small) farmstead would allow a coverage of maximally 6 farmsteads, or 36 persons, per km^2. Brinkkemper (1993, 150 ff.) arrives at a minimum requirement of 31 ha of pastures and 5 ha of arable land for a farmstead with 10 stalls and 6 inhabitants in the same region. This would mean a maximum of no more than 3 farms per km^2, if one assumes that arable land and pastures all lay around the farmstead. None of these calculations even considers the extra spatial requirements, such as for the farmyard and coppice woodland (*cf.* Fokkens 1991, 157).

Knowing that the raised bog area contained dispersed swampy locations and that creeks crossed the landscape, the surface area suited for an agricultural economy is still more restricted.[29] Therefore, we will certainly have to reckon with an outcome closer to model A than to model B. It is, however, quite conceivable that the inhabitants used land outside the immediate surroundings of the settlement, arable land as well as pastures. In this case one should think of the levees of the river Meuse (now washed away), only 2-3 km away, and of the coastal plain (transhumance; *cf.* Brandt/Van Gijn 1986). How representative, then, is the picture sketched above on the basis of an area encompassing no more than 12 ha?

4.3 Rule or exception?

There are arguments to state that at least several parts of the peat area contained some tens of persons per km^2.

In the first place, on the 12 ha of Krabbeplas-south no settlement of a village nature was discovered. On the contrary, the landscape comprised dispersed settlements with one or two, at most three, contemporaneous farmsteads. This settlement pattern obviously continues beyond Krabbeplas-south. Although the observations were less systematic there, the many findspots that were discovered nonetheless, assure us that at least the 1 km^2 that figures in table 2 has been covered. This area was more strongly dominated by peat than the geological data suggest (fig. 7). The stretches of clay that cross the peat are, in fact, composed repeatedly of: a Dunkirk 0 creek fill, a younger peat layer resting on it (with intrusion clay and archaeological remains), and a cover of Dunkirk III clay (*cf.* fig. 7 with tab. 1, column stratigraphic position).

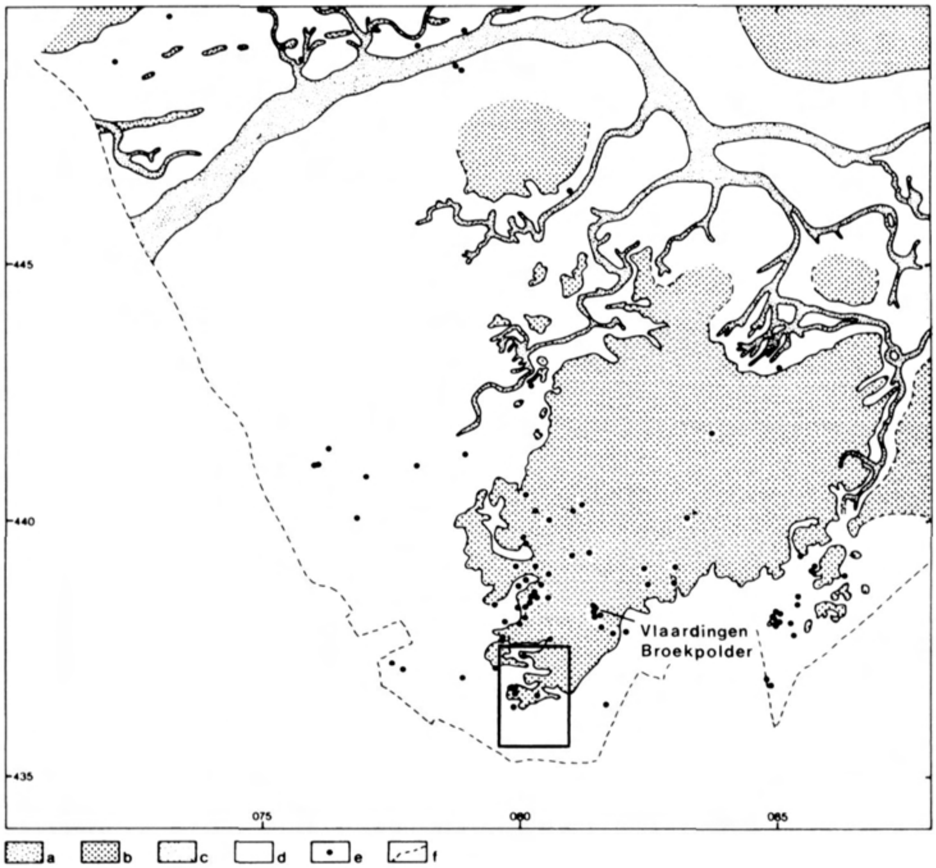

Figure 9. Palaeogeographical map of the area north of the Meuse estuary; rectangle: figs. 2/6/7. After Van Heeringen 1988.
a: beach barriers
b: Holland peat
c: Dunkirk I channel deposits
d: Dunkirk I mud-flat deposits
e: findspot Middle and/or Late Iron Age
f: area not mapped

Table 2. Two models for calculating population density in Vlaardingen-West during the Middle and Late Iron Age.

	A	B
a. number of sites per km^2	80	80
b. length of habitation (in years)	250	200
c. number of farmhouses on a site	1.5	2.0
d. lifespan of a farmhouse (in years)	8	12
e. number of farmhouse inhabitants	6	8
y. number of farms at any one moment per km^2	3.8	9.6
z. number of persons per km^2	23	77

In the second place, at a distance of 1 km in both a northerly and north-easterly direction from the Krabbeplas, clusters of Iron Age findspots were also discovered, even under conditions of observation much less favourable than those in Vlaardingen-West. These clusters are in the north of the Aalkeet-Buitenpolder and in the Broekpolder (fig. 9). As a consequence of the aforementioned and of still more recent discoveries during land development works, a practically uninterrupted series of settlement sites on peat can be traced along a stretch of 4 km, from Vlaardingen-West into the Duifpolder.

From all these facts we can conclude that the peat area north of the Meuse estuary was densely occupied during at least two centuries of the Iron Age. Because remains from before 300 BC appear to be relatively scarce, between 300 and 150/100 BC certain micro-regions must have been optimally occupied.[30] We may reckon with 4-5 farmsteads per km^2, that is 25-35 persons. Although we do not know the relative proportions of the spatially not very demanding arable farming and the much more extensive livestock keeping, we must assume that part of the agricultural grounds lay outside the densely inhabited areas.

A population density of 25-35 persons during the 3rd and 2nd century BC by far exceeds the calculations made for other parts of the Netherlands, especially for the sandy areas. For those regions the calculated densities vary between 1.5 and 5 persons per km^2 (e.g. Harsema 1980, 32; Kooi 1979, 174; Slofstra 1991, 149; Verlinde 1987, 326). These figures are almost invariably based upon settlement and urnfield data from the Late Bronze Age and the Early Iron Age. Data for the later periods are scarce. However, in the micro-region that is covered by the excavations at Oss-Ussen, along the Meuse in the province of North-Brabant, there are strong indications that the population density was considerably higher in the Late Iron Age compared with the Early and Middle Iron Age, amounting to a minimum of 18 persons per km^2 (Schinkel 1994, 264).

4.4 The peat area as a whole

Van Heeringen assumes an inhabited peat area of 12 × 4 km on the northern side of the Meuse estuary in the Middle Iron Age. All known findspots are ascribed to one single century, that being the 3rd century BC. Stating a use-life of 25-50 years for a farmstead, he arrives at 60 to 190 contemporaneous inhabitants for the whole region during the Middle Iron Age (Van Heeringen 1992, 315).

If we, on the other hand, reckon with the use-life of 8-12 (model A/B) and if we date the sites concerned between 350 and 150 BC, this would result in only 10-23 contemporaneous inhabitants in the whole peat area during the two mentioned centuries.

In order to arrive at a more realistic estimate, now that the observations in Vlaardingen-West have been made, we can make a feed-back to the systematic survey of Bult. Within the 1 km^2 area of the Aalkeet-Buitenpolder, Bult discovered four Iron Age sites (fig. 6a). Even these few sites form a relative cluster among the total of 22 possible to certain Iron Age sites which he discovered in the surveyed parts of the peat and peat/clay area (Bult 1983, tab. 13). After a reappraisal of findspots with isolated finds[31], these make up 14% of the sites discovered. They lie in an area which comprises hardly more than 3% of the indicated part of Midden-Delfland: 100 ha of the 3258 ha of peat and clay/peat in the triangle Aalkeet-Buitenpolder/Woudse Polder/Akkerdijkse Polder (fig. 1a).

If these four sites likewise contained 14% of the population, and if we — according to our calculations — assume these 14% to be 25-35 individuals, then the population as a whole theoretically counted 179-250 individuals. After correction for the parts of the peat and clay/peat area which have not been surveyed by Bult[32], and after adding substantial margins, as a 'remedy' against the extrapolations from a small area, we arrive at 160-300 individuals for the peat and clay/peat area of Midden-Delfland.

The distribution of the sites over this area is, however, very imbalanced (fig. 9). In fact they are almost completely concentrated in a belt of 14 km^2 in the southern half of the area (south of coordinate 441). For a peat area of 5 km^2 bordering Midden-Delfland on the eastern side, in the municipality of Vlaardingen, this same average density may be assumed (*cf.* Bult 1983, Map-appendix 1). This means that between *c.* 350 and 100 BC, a zone of 19 km^2 was inhabited by a population which on average comprised roughly 200-400 people, figures which indicate the presence of a self-sustaining group in both a social and reproductive respect. Other average values for this area then are (on the basis of model A) per km^2: *c.* 10-20 individuals, 2-3 farmsteads and *c.* 30-50 ha land around each farmstead.

In an area of about 5 km^2 even further eastwards, now in the built-up part of Schiedam, we can ascribe even higher densities, but only in the 2nd century BC; in earlier times the area was uninhabited (see note 30).

The northern part of the peat area of Midden-Delfland, lying more than 6 km away from the Meuse, seems only to have been very sparsely occupied. The hydrological situation may account for this fact, at least for an important part. In this northern area the peat bog will have been drained to a lesser extent than near the creek mouths along the Meuse.

5. Some conclusions

Because other parts of the coastal peat area must also have been occupied during the Iron Age (Assendelver Polders, Voorne-Putten, Walcheren), we cannot help but conclude that the peat formed an economically coveted landscape instead of a buffer zone during periods of overpopulation in bordering zones, for instance in the dune belt (*cf.* Abbink 1993). The impressive work of Van Heeringen on the Iron Age of the Western Netherlands gives no indications of overpopulation either (Van Heeringen 1992, esp. fig. 74).

Although the area south of the Meuse estuary (Voorne-Putten) has also produced some clusters of farmsteads from the Middle and Late Iron Age (Van Trierum 1992, figs 6, 68), we must estimate the overall population density to be lower than in the peat zone bordering the northern banks of the river (see also Brinkkemper 1993, 145). As an important explanatory factor we may consider the nature of the habitat. Voorne-Putten seems to have comprised fewer oligotrophic peatbogs and more fen-peat than Midden-Delfland (*cf.* Brinkkemper 1993, 32). The peat area around the Oer-IJ estuary, which for a great part lies within the Assendelver Polders, does not give the impression of a dense occupation (Van Heeringen 1992, 314-317).

All data indicate that people moved into the peat area of Midden-Delfland as soon as this had become inhabitable (again) by natural drainage. The area was probably left only when a minimal subsistence was no longer feasible (after submerging?). Around 600 BC the peat area of Midden-Delfland was, for a short period, inhabited by only a few dispersed, pioneering farmers. In a second phase there must have been moments, between 350 and 100 BC, when some microregions on raised bogs knew densities of some 25-35 persons per km^2. It remains, however, an open question as to whether the presence of mineral grounds (creek and channel fillings, levees) was an essential factor in attracting communities with a mixed farming economy.

Apparently the inhabitants took into account that by dwelling on peat they regularly had to take measures against subsiding and faulting floors, and that one also had to accept the other miseries which living in a swampy landscape brought with it for human beings and animals. The current ecological investigations will particularly have to address the question as to what benefits the peat area had to offer on the positive side of the balance.[33]

notes

1 The Institute of Prehistory of the University of Leiden (IPL) and the Institute of Pre- and Protohistoric Archaeology of the University of Amsterdam (IPP) are both involved in excavating settlements which will be partly or completely destroyed by the subsequent development programme. The activities of the IPL concentrate on the Iron Age habitation, whereas the IPP mainly focuses on the Roman period. The State Service for Archaeological Investigations in the Netherlands (ROB) has undertaken some rescue excavations at several late medieval sites.
The bulk of the archaeological work is financed by the parties concerned in the development works, these being the Government Service for Land and Water Use (*Landinrichtingsdienst*), the Department of Outdoor Recreation of the Ministry of Agriculture, Nature Management and Fisheries, the Midden-Delfland Recreation Authority (*Recreatieschap Midden-Delfland*) and the Union of Delfland Drainage Districts (*Hoogheemraadschap Delfland*). The Province of Zuid-Holland has also made a substantial financial contribution.

2 Particularly borings done by P.G. Heinsbroek (see Heinsbroek 1991, 1993a, 1993b).

3 *Cf.* Abbink 1989, fig. 7, layers 2 and 4; Heinsbroek 1993b, fig. 3.

4 The repeatedly quoted C14 date of 2645 ± 65 BP from Lodderland has been described by its author as a *terminus post quem* for the deposits (Van Staalduinen 1979, 60). See also Van Trierum 1992, 19.

5 GrN-18641. For further information about the object see Van den Broeke 1991, 333.

6 Close to the intrusion point of the channel under discussion from the Meuse estuary, in the Aalkeet-Binnenpolder, Mr P.G. Heinsbroek established by means of borings that in a channel deposit of probably Dunkirk 0 age, a new watercourse had been formed during the Dunkirk I transgression period, or a still existing residual bed had been recut. This watercourse was filled up almost completely during this same transgression period. During boring, a groove-decorated Iron Age sherd was brought to light from the bottom of the fill (3.20 m below surface); pottery sherds were also found at a higher level (0.4-1.0 m below the surface), lying in and along a narrow residual bed in the almost completed creekdeposits (Van den Broeke/Van Zijverden 1993, findspot 17.40; Heinsbroek 1993a). This last-mentioned pottery is almost certainly native-Roman (all sherds contain organic temper). These creek deposits and the adjoining mud-flat deposits are then obviously of Dunkirk I date. The clay layer covering the finds consists of Dunkirk IIIb deposits.

7 Findspot 16.67. This concerns sherds of one or more handmade globular pots of hard fabric and fine temper, as well as sherds of early wheel-turned ceramics of globular pot fabric (det. E.J. Bult). The fact that medieval findspots on peat are scarce in Vlaardingen-West must be related to a different choice of settlement location during the Middle Ages (see below).

8 A site with pottery from the 2nd and/or 3rd century AD (det. M. Brouwer) also contained a sherd of native fabric in the intrusion clay below the settlement level. This sherd does, however, seem to be of older date, possibly stemming from the Iron Age site which was discovered some tens of metres away in an easterly direction (fig. 7, no. 16.62).

9 Here should be mentioned — with thanks — the names of Ms J. Mostert, J.P. ter Brugge, O. Dorenbos, P.G. Heinsbroek, L.A. Kaal and A. Uleman. Their observations, which were put in writing in many cases, have found their way into this article.
I was happy to receive much administrative assistance from Ms J. Schreurs-Verwer.

10 The surveying of dozens of deepened field drains in this terrain in 1993 did not produce new sites.

11 The indicated Iron Age site 17.41 is, however, the most southern findspot known from this period on the northern bank of the Meuse.

12 Most of the preliminary notes on the discoveries in this area can be found in 'Archeologische Kroniek van Zuid-Holland' published in volumes 1988-1992 of the magazine *Holland*.

13 After the appearance of the last-mentioned publication, the Centre of Isotope Research (CIO) in Groningen did a second C14 measurement on the skeleton. The outcome of 3080 ± 40 BP (GrN-19619) supports the first result, which gave 3060 ± 40 BP (GrN-18960). I would hereby like to thank Dr. J. van der Plicht for his attention.

14 Sites containing remains of both periods have been entered twice.

15 A complete list, based upon the documentation compiled by the present author, can be found in Ter Brugge/Moree 1993.

16 These 12 ha cover the area between the southern bank of the Krabbeplas and the watercourse (Poeldijksche Wetering) that seperates the small southern part of the Krabbeplas from the large northern part, as well as the adjacent strip which contains sites 16.33, 16.35 and 16.43 (figs 6, 7).

17 Especially in borings also sometimes pottery (grit) appeared to be present above the Holland peat, up to a decimetre in the covering clay. Particles of charcoal were present at a still higher level. This latter material will have been displaced during inundations. In the case of the vertical displacement of pottery, bioturbation should be thought of as the primary cause.

18 During the excavations in the Foppenpolder (Abbink 1989) and in the Duifpolder (Koot 1993) trial trenches were dug outside the

dwelling places. Leaving floor remains in the Foppenpolder which have been displaced by post-depositional processes out of consideration, only the Duifpolder produced a find-concentration outside the dwelling-places. This one lay in a nearby creek filling, a situation comparable with findspots 16.76 and 16.80 in Vlaardingen-West. For equally restricted find distributions on dwelling places on peat see also Van Trierum 1992, figures 29-32, 42, 60, 62, 74.

19 For a first communication, see Van den Broeke 1991, 333. The other sites are Vlaardingen-Holierhoekse Polder (Van Heeringen 1992, 37-Oost-34) and Maasland-Foppenpolder. On the latter site most settlement remains date from a younger Iron Age habitation phase (Abbink 1989).

20 Stuiver/Pearson 1993, incorporated in the computer calibration program CAL15 from the Centre for Isotope Research (CIO), Groningen.

21 Except for a date of 2320 BP with the considerable standard deviation of 70 years for 37-Oost-22, Vlaardingen-Broekpolder (Van Heeringen 1992, tab. 47). The pottery of this site can be placed in a late phase of the second occupation period.

22 Nos. GrN-19603 and -19602 respectively. See for this site Abbink 1990, 337; Fontijn 1995. The site (16.10) lies some 500 m north of the Krabbeplas.

23 Van Heeringen considers the whole group of sites in Schiedam to be younger than those in a more westerly direction (Vlaardingen, Maasland), in a region which is thought to have been abandoned after around 200 BC. All the same, there is no good reason for this hypothesis. In the first place, C14 results of all three dated settlements from the Schiedam group are inconsistent (Van Heeringen 1992, 254-257, esp. note 35). In the second place there are strong similarities between some pottery assemblages in both regions. These assemblages are, however, artificially severed in figure 43. Moreover, the aforementioned C14 dates for site MD 16.10 imply that the peat area of Vlaardingen and Maasland was still occupied in the 2nd century BC (see also Fontijn 1995).

24 Here should certainly be mentioned a settlement site, possibly dating from the 1st century BC, which has recently been excavated in the centre of Vlaardingen. It lies on a creek fill which was deposited during Dunkirk 0 or I (Ter Brugge 1992a; Fontijn 1994).

25 See also below (16.32 and 16.59); Van Heeringen 1992, 316 (Vlaardingen-Broekpolder) and Koot 1993 (Maasland-Duifpolder).

26 These guesses will possibly be superfluous within some years, considering the development of dendrochronological curves on the basis of ash.

27 E.g. Fokkens 1991, 155; Harsema 1980, 26; Prummel 1989, 255. Brinkkemper (1993, 146) uses the low numbers of 4 and 6 persons for the Iron Age habitation of Voorne-Putten.

28 The data concerning stable length, which is an important factor in the calculations, are still unknown for the peat area of Midden-Delfland during this period. The well-preserved long farmstead of Vlaardingen-Broekpolder probably comprises more than one building phase (Van Heeringen 1992, 316). Considering the total farmstead length, there is, however, no need to suppose essential differences in comparison with Voorne-Putten.

29 Although wetlands are renowned for their wealth of game and fish, it is certain that hunting, fowling and fishing did not play an important part in the economy of the peat areas of the Western Netherlands (Brinkkemper/Van Wijngaarden-Bakker in prep.; IJzereef *et al.* 1992). The watery elements in the landscape can, therefore, be left out of consideration when calculating subsistence requirements. For a reconstruction of the landscape of southern Midden-Delfland see Koot/Vermeeren this volume.

30 This may have resulted in an extension of the habitation in an easterly direction, to the peat area of Schiedam, for which area only area only 2nd century BC dates have been given (Van Heeringen 1992, fig. 44). Considering the aforementioned C14 dates for site 16.10 in the Aalkeet-Buitenpolder, there is, however, no need to assume a complete shift of habitation (in one move) from the peat area around Maasland and Vlaardingen to that of Schiedam around 200 BC, as has been suggested by Van Heeringen (Van Heeringen 1992, 309, 317, fig. 44; see also Fontijn 1995).

31 In the peat and clay/peat area 13 locations with isolated finds have also been discovered. Looking back, we may suppose that at least half of these (= 7 locations) represent settlements. None of these lay within the aforementioned part of the Aalkeet-Buitenpolder. The Iron Age findspots that were known at the start of the field survey in the peat and clay/peat area, are so low in numbers (2 sites and 1 location with isolated finds) that they hardly affect the sampling nature of the field survey.

32 Apart from the 3258 ha surveyed in the peat and clay/peat area, 918 ha (22%) remained uncovered for several reasons (Bult 1983, appendix 7). The area in question in the Aalkeet-Buitenpolder has been completely covered by the surveys (documentation E.J. Bult). The number of inhabitants outside this area can, therefore, be multiplied by 1,28 (100/78).

33 When preparing the text, I benefitted greatly from the information and/or remarks of Ms A.A. Abbink (IPL), J.P. ter Brugge (Mun. of Vlaardingen), P.G. Heinsbroek (Vlaardingen), C. Koot (IPL), Ms H. van Londen (IPP), and M. Verbruggen (IPL) and (other) members of the section 'Metal Ages' of the IPL. For the determination of Roman finds from Vlaardingen-West I would like to thank Ms M. Brouwer and Ms M. Kleiterp (RMO), for those of medieval finds, E.J. Bult (Mun. of Delft). My 'wrestling' with table 1 was kindly taken over by Ms M. Wanders (IPL). All illustrations are by H.A. de Lorm (IPL). The recent (digitalized) topographical map of Vlaardingen-West, which underlays several figures, was kindly produced by A. Krijgsman (Mun. of Vlaardingen). The English text was corrected by Ms K. Waugh.

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Indirect Correspondence Analysis and Botanical Macroremains: a case study

Correspondence Analysis is one of the multivariate statistical analyses used to explore large data sets. Application to a data set of 106 samples and 246 taxa of waterlogged botanical macroremains from Iron Age and Roman Period settlements on Voorne-Putten (the Netherlands) yielded interesting results. The main distinction between the sites corresponded to their location either in the eastern or in the western part of the area studied. This confirms the results obtained by Cluster Analysis, an alternative multivariate technique. The relation between the samples and the taxa is far more clearly expressed in Correspondence Analysis. Both salinity and moisture appear to be important factors. There is a clear correlation between the occurrence of wild plants indicating salinity and the crop plant barley. This agrees well with experiments revealing the salt tolerance of this crop. Differences in crop plants are also closely related to the dating of the sites. There is a remarkable reduction in the number of crops cultivated during the Roman Period, which can be seen as an indication of arable specialisation.

1. Introduction

One of the previous issues of *Analecta Praehistorica Leidensia*, my thesis (Brinkkemper 1992), dealt with botanical remains from Iron Age and Roman Period settlement sites. The study area comprised the present-day islands Voorne and Putten, situated to the south of the Meuse estuary in the Netherlands (see fig. 1).

An important part of the research concerned botanical macroremains. A total of 107 different samples from eleven sites were analyzed, partly by the present author, partly by W.J. Kuijper. 106 of these samples yielded 246 different taxa preserved in waterlogged, uncarbonized conditions. One sample only revealed carbonized remains. Preservation by waterlogging is usually limited to situations below the water table. In the wet Dutch coastal sites, this means that below ground remains of posts and settlement waste are often preserved in waterlogged conditions.

The possibilities of analyzing the large data set which resulted from the analyses of botanical macroremains "by hand" are severely limited. Our attention is focused on remarkable taxa in the data set, such as crop plants and rare wild plants. The conclusions that can be reached have a fairly limited stretch and are of a haphazard nature. The computer can offer us the possibility of reducing the complexity of the data by means of multivariate analyses. As Lange (1988, 37) stated,

"the tracing of recurrent combinations (synonyms are: associated groups, correlations, covariations, regularities, [...]) in complex data sets is the realm of the Multivariate Analyses of classification and ordination."

One branch of multivariate analyses was used in my thesis, viz. Cluster Analysis. This technique can be characterized as a hierarchical classification technique, where the dendrograms resulting from Cluster Analysis show the relation of the different samples or taxa to each other. Samples or taxa within a given cluster are more similar to each other than to samples or taxa in other clusters.

The data set of waterlogged remains used in my thesis did produce good clusters of the separate sites. The first separation was between the sites in the eastern and in the western part of the study area. Analyses of the taxa yielded clusters which could hardly ever be interpreted satisfactorily from an actuo-ecological point of view. Whether this means that the past vegetation types on Voorne-Putten are not comparable to present ones or whether the data set is of limited value cannot be assessed.

In the introduction to the various multivariate analyses in my thesis, I concluded that the use of Correspondence Analysis would provide a means to explore the robustness of the results obtained by Cluster Analysis. Correspondence Analysis belongs to the second branch of multivariate analyses, being an ordination technique. Ordination techniques search for the largest variation within the data set. The results are generally presented in so-called "biplots", which represent a two-dimensional reduction of the multi-dimensional data set. The first axis accounts for the largest variation within the data, the second axis for the largest remaining variation, and so for the third and higher axes. The distance between the points on the graph is a measure of the degree of similarity or difference. Points close together indicate samples similar

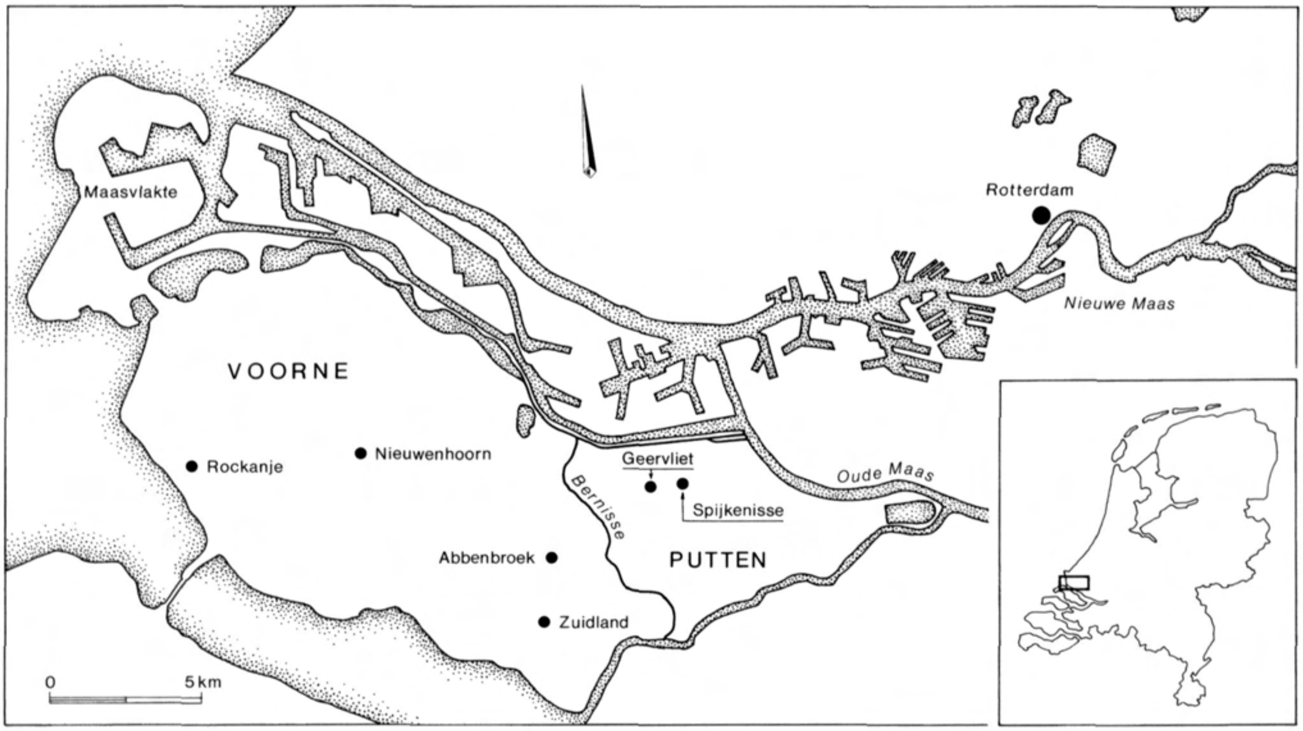

Figure 1. Location of Voorne-Putten in the Netherlands.

in species composition or species occurring in similar samples.

The most commonly applied ordination technique is Principal Components Analysis. A large drawback for its use with palaeo-ethnobotanical data sets is the requirement of a normal distribution of the data. The large number of zero scores in our data sets conflicts with this requirement (compare Jones 1991, 69). Correspondence Analysis does not require such a normal distribution. Furthermore, as Kent and Coker (1992, 203) state, Principal Components Analysis is now widely acknowledged as having serious limitations as a method for the ordination of floristic data. An arch- or horseshoe-shaped distortion in the biplot as a result of this method is one of these limitations.

Correspondence Analysis plots the samples and the taxa against the same axes. This implies that a grouping of samples in a biplot can be interpreted directly in terms of species composition. As Lange (1988, 37) observed, an advantage of Correspondence Analysis and Principal Components Analysis over Cluster Analysis is that both continuous (serial) as well as discontinuous (clustered) patterning may be observed. According to him, Cluster Analysis will produce discrete groups, even when these groups are not present in the data, while ordination would reveal the continuity of the data (see also Sneath/Sokal 1973, 252; Van Tongeren 1987, 174). However, with many clusters, an ordination may give no simple low-dimensional result (Sneath/Sokal 1973, 252).

A considerable advantage of Correspondence Analysis is the possibility to add so-called "environmental variables" to the data analyzed, giving a Canonical Correspondence Analysis. These are extrinsic variables which, in an archaeological context, are either temporal or spatial (*cf.* Jones 1991, 70). Environmental variables used here are dates and contexts of the samples and locations of the sites. Thus, the roles of these factors in any separation of sites and/or samples in Correspondence Analysis can easily be identified. In the default option in Canonical Correspondence Analysis, the axes are based on environmental variables exclusively (see for instance Gaillard *et al.* 1992). This "direct analysis" (*cf.* Kent/Coker 1992, 162) is of great use when determining the effect of these variables on the different species in recent vegetations. In the present study, however, the environmental variables were made passive, *i.e.* they did not contribute to the axes. We can, therefore, speak of an "indirect" analysis, in which the environmental variables are correlated after the variation in the data has been described. According to Kent and Coker, indirect methods can be used in situations where the underlying environmental gradients are unknown or unclear.

Table 1. Archaeological dating and Dutch national coordinates of the sites on Voorne-Putten (after Döbken *et al.* 1992; Van Trierum *et al.* 1988).

Site	Dating	X-coordinate	Y-coordinate
Spijkenisse 17-30	Early Iron Age	80.03	429.86
Spijkenisse 17-34	Middle Iron Age	80.22	429.68
Spijkenisse 17-35	Early/Middle Iron Age	80.275	430.240
Geervliet 17-55	Middle Iron Age	79.300	429.714
Abbenbroek 17-22	Late Iron Age	75.52	427.65
Zuidland 16-15	Late Iron Age	74.33	425.850
Zuidland 17-27	Late Iron Age	75.810	425.250
Rockanje 08-52	Late Iron Age	63.818	432.045
Nieuwenhoorn 09-89	Roman Period	69.660	431.930
Rockanje II	Roman Period	64.44	431.84

2. Methods

The software used for Correspondence Analysis was the CANOCO 3.12 package of the Faculty of Spatial Sciences, University of Amsterdam. In the following analyses, the data were scaled symmetrically, samples and taxa were weighed equally. A ln- or ^{e}log-transformation of the data was used to reduce the influence of taxa occurring in large quantities, such as *Juncus* seeds. Downweighting of rare species appeared to have no influence on the resulting biplot. As some rare species were important in the interpretation of the biplots, they were not downweighted. Two data sets will be discussed below. One set includes all waterlogged macroremains (246 taxa), found in 106 samples. In this data set are 3843 occurrences, which amounts to 15.2%. The remaining 85% of the data set are zero-scores. The second set concerns all remains of crop plants, both waterlogged and carbonized, which occurred with 25 taxa in 69 samples.

The environmental variables considered in this publication are dates, contexts and locations of the sites. The location is expressed in X-coordinates (easting) and Y-coordinates (northing) in accordance with the Dutch national (R.D.) coordinates. These parameters are given in table 1. The contexts and raw data on the macroremains themselves are to be found in tables 10-20 of my thesis (Brinkkemper 1992).

In the following biplots, the diagrams of the samples plus the environmental variables and the diagrams of the taxa are presented separately for reasons of clarity. The axis are identical and the plots can be overlayed.

3. Results and discussion

3.1 WATERLOGGED BOTANICAL MACROREMAINS

The first biplots presented here concern the data set of waterlogged macroremains. The initial Correspondence Analysis included all samples. The resulting biplot showed a dense clustering of all but seven samples. The two samples from Rotterdam-Hartelkanaal, which both yielded very few taxa, were outliers along the second axis. The four samples from the natural subsoils, consisting of raised bogs, in Rockanje 08-52 and Nieuwenhoorn, had high values along the first axis. Similarly high values along the first axis had the sample of goat dung from Nieuwenhoorn, which contained virtually nothing but remains of *Myrica gale*. The low number of taxa for which Correspondence Analysis is sensitive (Ter Braak 1987, 110) causes the extreme position of the samples from Rotterdam-Hartelkanaal and the goat dung, while the low number of taxa and the non-anthropogenic context will be important in the natural subsoil samples. As this is of limited relevance in the interpretation of the data, it was decided to omit these samples in a second analysis. The resulting biplot for the remaining 99 samples is presented in figure 2a.

The eigenvalues of the axes are a measure for the part of the total variation explained (*cf.* Kent/Coker 1992, 187). The eigenvalues of the first and second axes are 0.36 and 0.26 respectively. Ter Braak (1987, 102) stated that values over 0.5 often denote a good separation of the species along the axis. Considering the very large data set, the values obtained here are satisfactory. The sum of all unconstrained eigenvalues is 3.713, so the first two axes account for 9.6% and 7.1% of the total variation respectively.

The separate sites have been indicated by different symbols in figure 2a. The negative scores on the first axis (the left-hand part) exclusively concern sites located in the eastern part of the study area, whereas the sites on western Voorne have positive scores. There is not a single sample that occurs in the "wrong" group. For clarity of the picture, a few samples have been omitted, but these were located in the vicinity of samples from the same site and in the "correct" part of the biplot. A measure of the variation explained by the first and second axes is the squared residual distance of the samples from the plane represented by the axes. Gaillard *et al.* (1992, 13) found a good fit for their modern samples, with low distances (0-10) and a bad

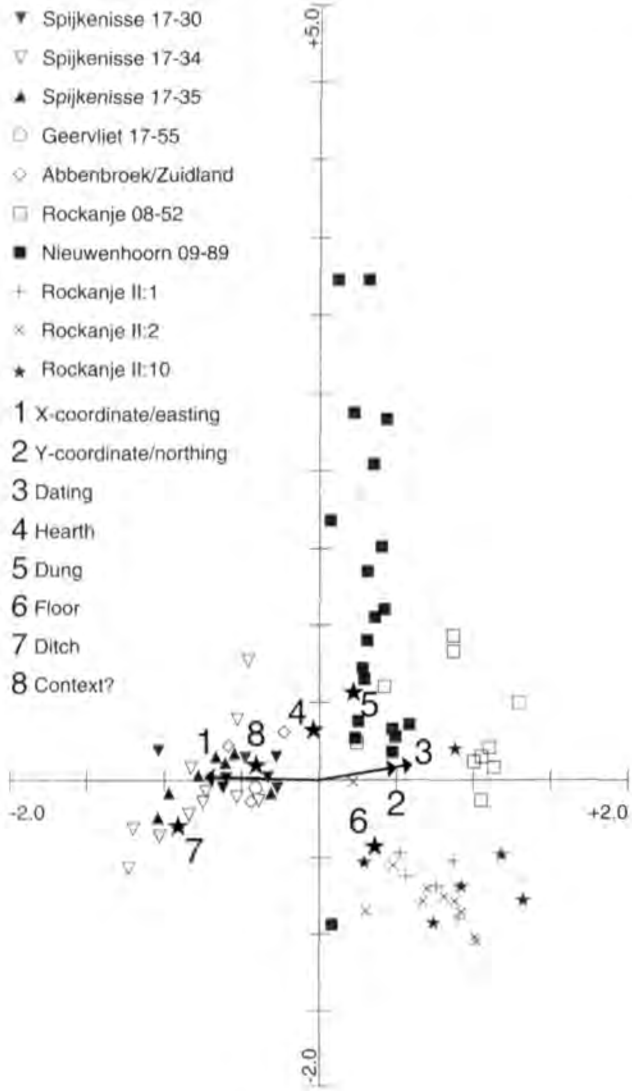

Figure 2a. Correspondence Analysis biplot of samples and passive environmental variables on the basis of waterlogged macroremains.

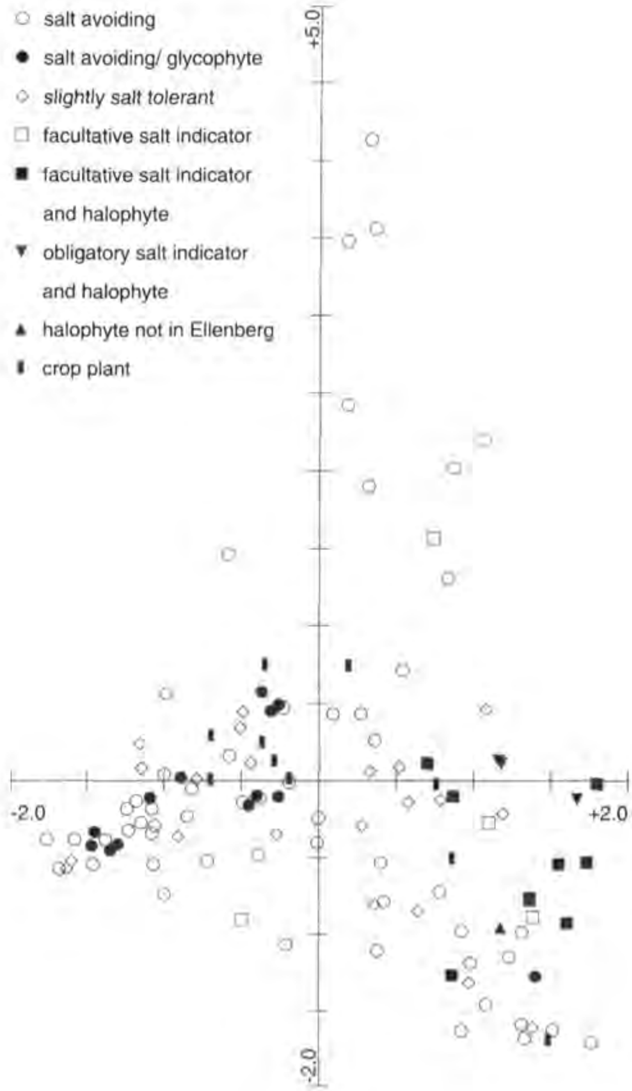

Figure 2b. Correspondence Analysis biplot of species replaced by their salinity indicator value according to Ellenberg 1979.

fit for several fossil spectra (distances >737). The values for the samples from Voorne-Putten range between 0 and 38.3, only sample 10-1-5 from Rockanje II has a value of 645.6. This indicates that only the variation in this last sample is not well explained in the biplots.

The environmental factor X-coordinate (easting) is strongly associated with the first axis, which supports the observed importance of the location of the sites. The factors Y-coordinate (northing) and dating are also mainly directed along the first axis, and have considerable vector-lenghts. This indicates that these are of noticeable influence as well. The fact that the westerly sites are also on average younger than those in the eastern part of the area explains the significance of the dating of the sites. The importance of the Y-coordinate is probably mainly due to the northeast-southwest orientation of the series of sites in the eastern part of the study area, which results in a partial dependence of both variables.

The nominal variables for contexts, indicated by stars instead of vectors, are notable as well. The samples from ditches are grouped in the lower left part of the biplot, those from floor layers on the lower right. The dung and hearth contexts score positive values along the second axis. The separation of the different context types can be seen as an

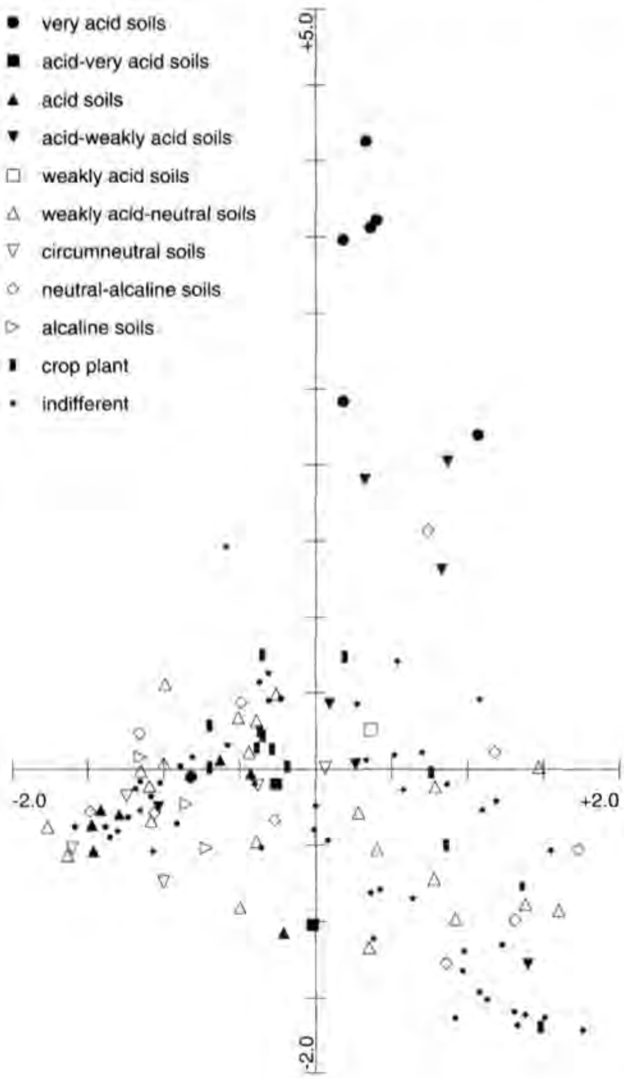

Figure 2c. Correspondence Analysis biplot of species replaced by their acidity indicator value according to Ellenberg 1979.

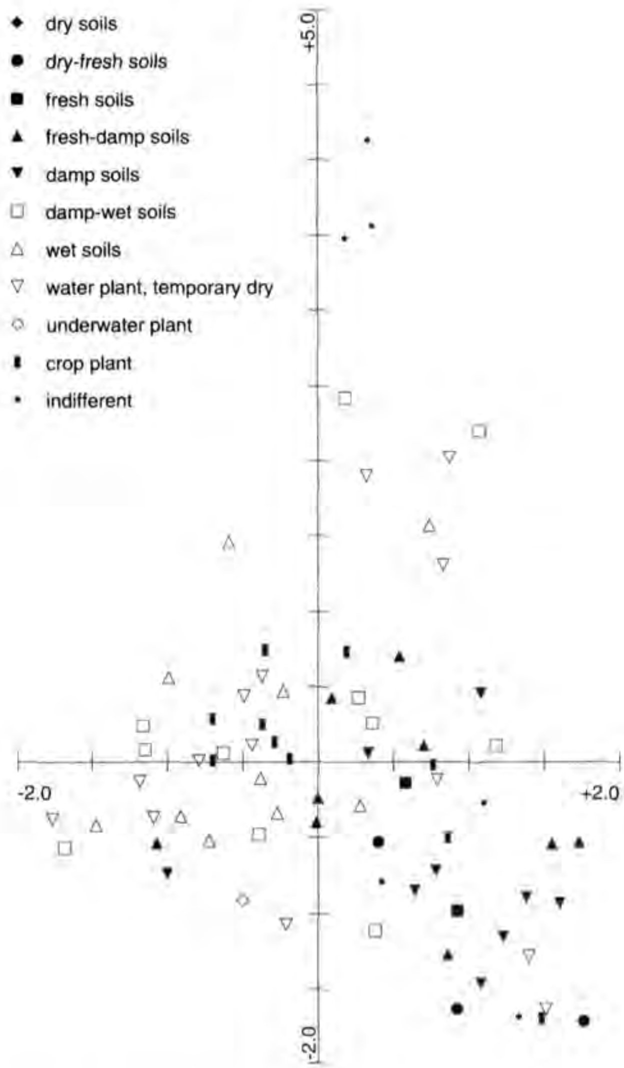

Figure 2d. Correspondence Analysis biplot of species replaced by their moisture indicator value according to Ellenberg 1979.

indication of the necessity to sample as many different contexts on a site as possible to cover the variation in sample contents.

The multiple regression correlation of species and environmental data is 0.97 for the first axis and 0.53 for the second. This indicates that especially the variables along the first axis account for the greatest variation in the species composition (compare Ter Braak 1987, 140).

Corresponding plots for the species are presented in figure 2b-d. A plot containing all taxa names is either unreadable due to overlap or uninformative due to omission of many names. Therefore, the taxa have been grouped according to several criteria. These criteria have been drawn from the study of Ellenberg (1979), who drew up tables classifying species according to their occurrence in relation to abiotic factors. These factors are moisture, nitrogen content and acidity of the soil, salinity, openness of the vegetation and temperature and continentality of the species' distribution. Temperature and continentality are not of relevance here in view of the very small geographical variation between the sites.

In interpreting the results of the Cluster Analyses, salinity was found to be the key factor for the separation of the different sites. Other abiotic factors seemed more or less equally distributed over the sites.

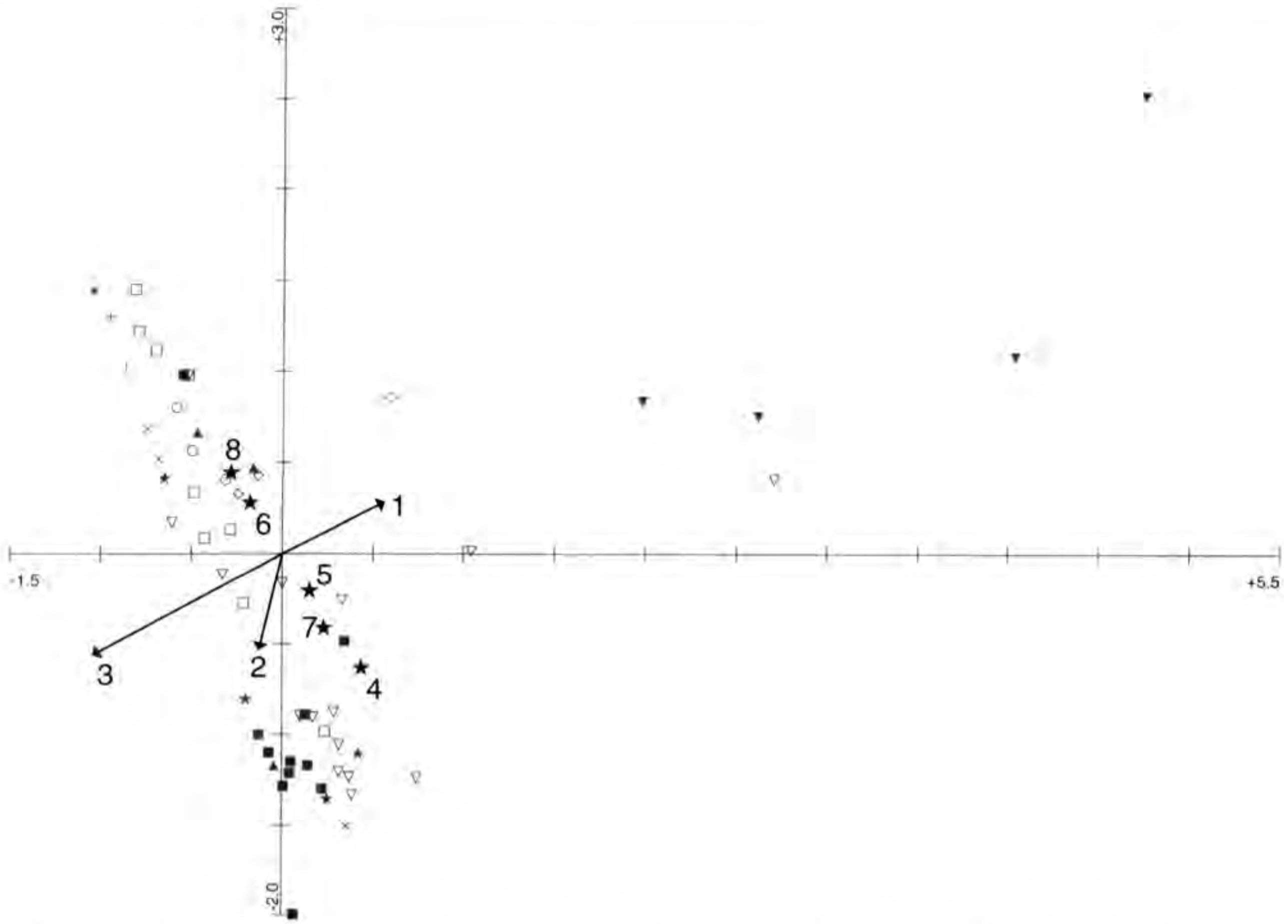

Figure 3a. Correspondence Analysis biplot of samples and passive environmental variables on the basis of all crop plant remains. For legend see fig. 2a.

In figure 2b, the species have been grouped according to their tolerance for salt according to Ellenberg. Besides, taxa which Behre (1985) selected as characteristic for salt (halophytes) or fresh conditions (glycophytes), have been given corresponding black symbols. It should be noted that only identifications to species level can be used here, as genera were not included in Ellenberg's study. Owing to the differences in the ecology of species within most genera, the use of genera is often impossible. Only the higher taxa which Behre included in his study, viz. *Spergularia maritima/salina* or *Rhinanthus* cf *minor*, have been included in figure 2b.

The species biplot shows that nearly all facultative and obligatory halophytes have positive scores on the first axis, whereas the glycophytes occur on both sides of the biplot. The separation of Behre's halophytes and glycophytes is even more pronounced as all halophytes have positive scores and only one glycophyte does. This glycophyte is *Ranunculus flammula*, which is, remarkably enough, limited to samples from Rockanje II.

Interestingly, most crop plants, indicated by black boxes, have negative scores on the first axis as well. The three crop plant remains with distinct positive scores all concern barley remains. Barley is a crop with a relatively high salt tolerance, as has become clear from cultivation of prehistoric crops in saltmarsh conditions (see Körber-Grohne 1967, 230; Van Zeist *et al.* 1977). The association with indicators for saline environments shows the importance of the environment for the agricultural possibilities in the past. In the coast-near sites around Rockanje, the potential of crop plants that could be cultivated successfully was limited in comparison with the sites in the freshwater environment around the Bernisse. Especially the common occurrence of emmer in these latter sites is noteworthy.

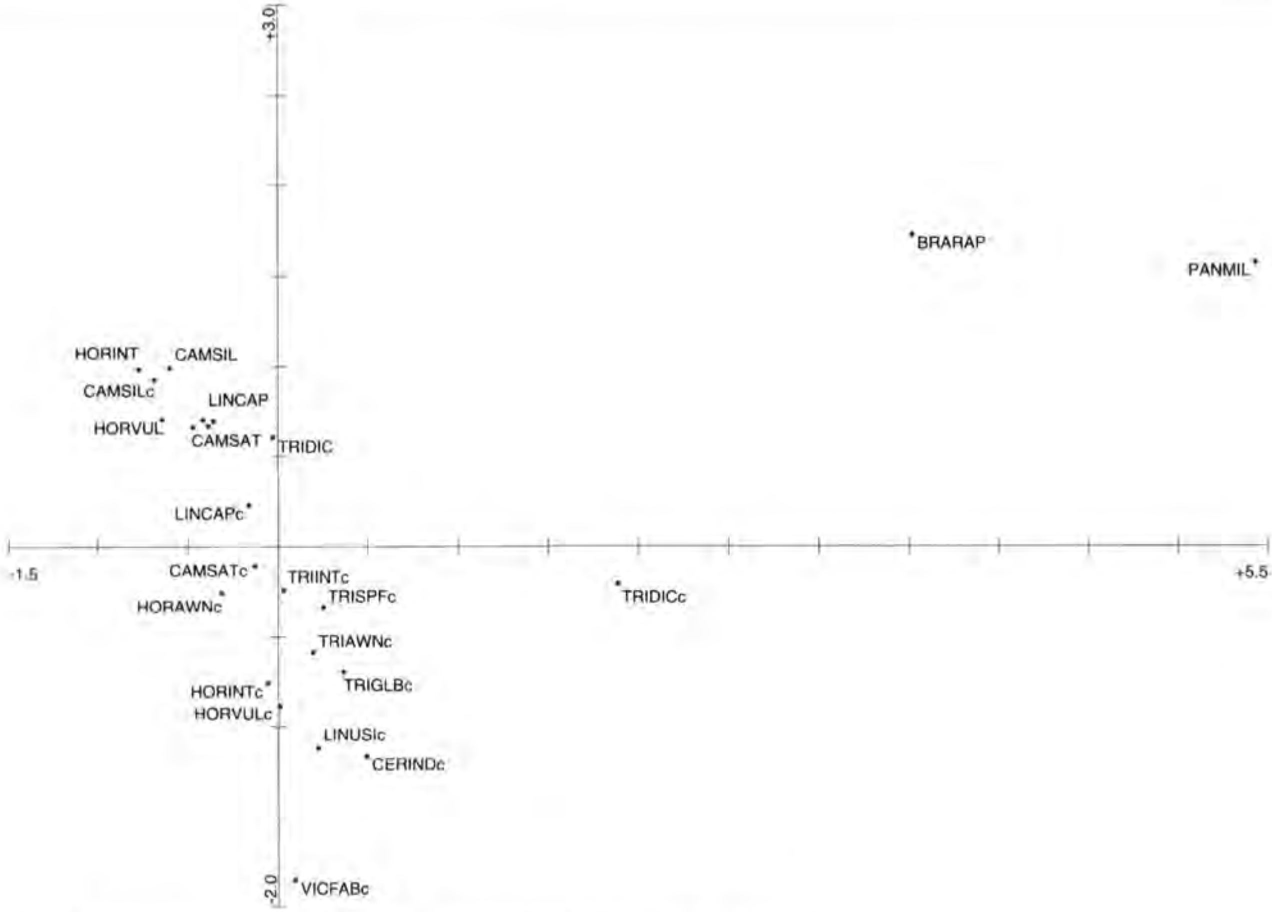

Figure 3b. Correspondence Analysis biplot of taxa on the basis of all crop plant remains.

BRARAP = *Brassica rapa*
CAMSAT = *Camelina sativa*
CAMSIL = *Camelina sativa* silicles
CERIND = Cerealia indet.
HORINT = *Hordeum vulgare* internodes
HORVUL = *Hordeum vulgare*
LINCAP = *Linum usitatissimum* capsules
LINUSI = *Linum usitatissimum*
PANMIL = *Panicum miliaceum*
TRIAWN = *Triticum* spec. awn fragments
TRIDIC = *Triticum dicoccum*
TRIGLB = *Triticum dicoccum* glume bases
TRIINT = *Triticum* spec. internodes
TRISPF = *Triticum dicoccum* spikelet forks
VICFAB = *Vicia faba* var. *minor*
c = carbonized

In figure 2c, Ellenberg's acidity values have been used. Clearly, the taxa with high positive scores along the second axis are plants from very acid soils. It concerns *Erica* and *Calluna* remains, which dominate in several samples from Nieuwenhoorn. These samples are located on corresponding parts of the biplot in figure 2a. Other clear trends in the distribution of the different acidity-values are not discernible.

The nitrogen values show a comparable distribution. The above-mentioned taxa are characteristic of very low nitrogen levels as well. Species of very rich and extremely rich soil conditions occur both on the negative and on the positive side of the first axis.

The moisture values (see fig. 2d) show a clear separation along the first axis. Species with lower moisture preferences are concentrated on the right-hand side of the biplot, where the samples from Rockanje II can be found. This site is located near the dry dune area in the western part of Voorne-Putten. Plants from wet environments mainly show negative scores on the first axis. The distribution of crop plants indicate that salinity might have been a more important factor regulating these crops viability than higher moisture values.

The light values show a very restricted range. Shadow and half shadow plants are virtually lacking in all samples.

Thus, the differences in this factor in the biplot are minimal.

3.2 CROP PLANT REMAINS

The data matrix for crop plant remains included 69 samples with 25 taxa. Carbonized and uncarbonized remains were treated as separate taxa. The biplot of the samples (see fig. 3a) shows extreme locations for samples from Spijkenisse 17-30 along the first axis. The corresponding plot for the taxa (see fig. 3b) reveals that *Panicum miliaceum* (broomcorn millet) and *Brassica rapa* (rapeseed) are responsible for the deviating character of the samples concerned. The remaining samples form a denser cluster, in which most samples from Nieuwenhoorn have relatively low scores along the second axis. The presence of *Vicia faba* (Celtic bean) and the fact that *Triticum dicoccum* (emmer) and *Camelina sativa* (gold of pleasure) are almost absent, causes the separation in the samples from Nieuwenhoorn. The (passive) effects of the different environmental variables, as indicated in figure 3a, is in accordance with these observations. The samples from Spijkenisse are from the early Iron Age, resulting in a considerable score of the vector for dating along the first axis. The samples from Nieuwenhoorn are from the Roman Period, giving an appreciable vector-length along the second axis. The influence of the location of the sites is not as strong as with the waterlogged remains. Besides, they have a bigger influence along the second axis. The vector for dating is longer, indicating that this variable plays a more important role than the location does. This means that there is a time trend discernible in the occurrence of crop plants. It mainly manifests itself in the decrease in the number of cultivated taxa through time, culminating in the virtual absence of crops other than *Hordeum* (barley) in Roman Rockanje. This is a clear indication of increasing specialisation in the cultivation of crops from the Iron Age to the Roman Period.

The nominal variables for contexts mainly reveal a correlation between carbonized crop plant remains and hearths, which is a rather predictable conclusion.

The conclusions for crop plant remains again support and elaborate the results of Cluster Analysis on crop plant remains.

4 Conclusions

The results produced by Correspondence Analysis in the first instance provide a confirmation of the results from Cluster Analysis. The relation between samples, species and the abiotic information drawn from the species, however, is much more straightforward in Correspondence Analysis. The conclusion that salinity is the key factor, explaining the differences in waterlogged macroremains of the different sites, is confirmed. However, the relation of barley with saline conditions is not expressed in Cluster Analysis. Moisture is another abiotic factor which shows a clear trend in Correspondence Analysis, which remained hidden in Cluster Analysis. Passive inclusion of extrinsic environmental variables substantiated the conclusion that the location of the sites, mainly expressed in proximity to the sea, is of great importance in the differences in waterlogged macroremains. It further demonstrates the need to sample as many different contexts as possible on a site.

The Correspondence Analysis of crop plant remains revealed that the samples from Early Iron Age Spijkenisse 17-30 are different owing to the presence of broomcorn millet and rapeseed. Many samples from Nieuwenhoorn are diverging through the presence of Celtic bean and the near absence of emmer and gold of pleasure. This again supports the conclusions drawn on the basis of Cluster Analysis. The interpretation is further aided by passive inclusion of the environmental variables, where the role of dating apparently exceeds the importance of the locations of the sites.

Acknowledgement

The main stimulus for applying Correspondence Analysis to the data from Voorne-Putten was given by G. Jones (Sheffield), both during the Symposium of the International Work Group for Palaeoethnobotany in Kiel as well as during the Workshop "Statistics in Archaeobotany" in Sheffield. W. Schnitger (Amsterdam) gave valuable support with the conversion of the large data set and the printing of figures 2 and 3. C. Brinkkemper (Amsterdam) produced the hardcopies of these figures on film. C.C. Bakels (Leiden) and R. Cappers (Arnhem) gave valuable comments on previous drafts, K. Fennema made the inevitable corrections of the English text.

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Bottle gourd seeds at Gallo-Roman "Le Bois Harlé" (Oise, France)

This paper presents the preliminary results of the botanical research of 15 samples from 7 ditches and 8 wells at the Gallo-Roman site "Le Bois Harlé" (Oise, France), occupied from the first century until the middle of the third century AD. An important feature at this site was a large ditched enclosure divided into small plots, where horticulture is believed to have been practised. Botanical remains of several interesting species have been found, among which the seeds of Lagenaria vulgaris, the bottle gourd.

1. Introduction

The site of "Le Bois Harlé" is situated in the village of Bois d'Ageux near Longueil-Sainte-Marie (Oise, France), on a marshy lowland (average altitude: 31 metres NGF) on the right bank of the Oise, 300 metres to the west of the present-day river (fig. 1). In 1988 and 1989 a total area of 12 ha. of this site was excavated. Since then a number of preliminary reports and papers have been published by the *Centre de Recherche Archéologique de la Vallée de l'Oise* (Vangèle/Dujardin 1988; Bonin/Vangèle 1989; Vangèle/Bonin/Valentin 1990). All the archaeological data presented in this paper were taken from these publications.

The "Le Bois Harlé" site is important because of the Gallo-Roman features which came to light here. The site was occupied from the first century until the middle of the third century AD. A striking feature found at the Gallo-Roman site was a large space surrounded by a deep ditch and internally subdivided by a series of shallow ditches. The orientation of the ditches within the large enclosed space was roughly NW-SE and SW-NE. They divided the terrain into small plots of land, the smallest of which measured 280 m^2 and the largest 1850 m^2. The shape of the parcels varied from rectangular or trapezoidal to oblong and very narrow. The ditches, which had depths of 1-1.5 m in one of the later phases, definitely reached the level of the groundwater: their lower parts were probably constantly filled with water (Vangèle/Bonin/Valentin 1990, 127).

This extensive system of ditches within the enclosure cannot be seen as the result of an agglomeration of successive parcelling; it is the result of a methodical and rationalised organisation of a plot whose limits had been fixed beforehand. The same phenomenon of planned parcelling is known from the Roman site of Rijswijk, De Bult (the Netherlands), where from the 2nd century onwards an entire domestic terrain was surrounded by ditches and the arable area was laid out in a regular pattern (Bloemers 1978, 46-54).

Other archaeological features observed at the site of "Le Bois Harlé" are the Gallo-Roman wells, fourteen of which were found on the terrain outside the enclosure and three inside it. The structures of these wells were in many respects the same. The fills of the wells consisted of two layers: the upper layer was sandy, the lower clayey. This lower layer had favoured the preservation of all kinds of organic material, such as fossil seeds. It was quite difficult to determine when the wells had been dug as the oldest layers of the well fills usually yielded few remains. Most of the wells had fallen into disuse between AD 175 and 230.

The method of construction and the dimensions of the structures on the site indicate that they cannot be interpreted as units of domestic habitations. The buildings must be seen as sheds, barns or stores, probably associated with the agricultural activities that were carried out at this site. The abundant amounts of household litter, ceramics and also worked wood (Bernard/Dietrich 1990) in the ditches and the pits, however, did indicate the proximity of an inhabited area.

The best information for determining the site's function dates from the second century and the first half of the third century AD, when the site's organisation was the most apparent.

Part of the complex was undoubtedly used for agricultural purposes (Vangèle/Bonin/Valentin 1990, 140-144). The ditches within the large enclosure extending to the level of the groundwater had been dug for irrigation (Bonin/Vangèle 1989, 102) or reclamation purposes (drainage of the arable land) (Vangèle/Bonin/Valentin 1990, 144). Small-scale intensive agriculture was presumably practised on the plots of land between the ditches. Whatever its main function may have been, we must regard the ditch system as a form of water management: the removal of surplus water from the land involves more or less the same techniques as the supply of water to areas where there is a

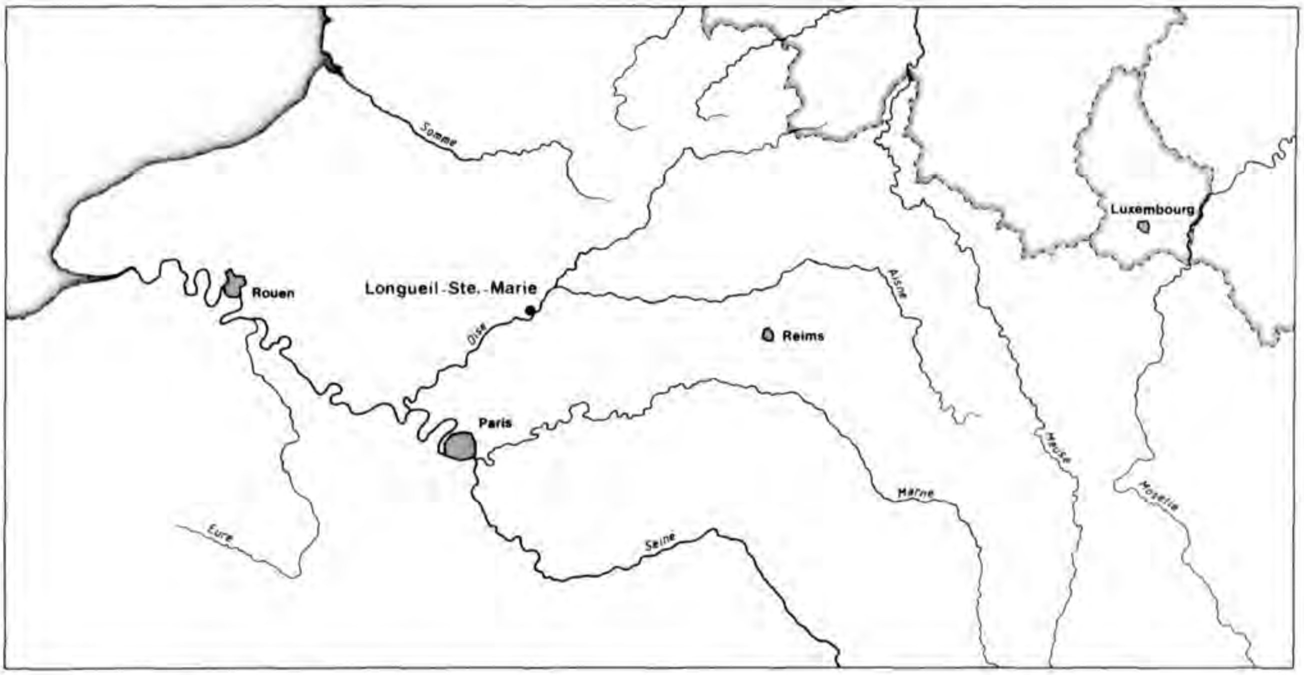

Figure 1. Location of the site "Le Bois Harlé", Longueil-Sainte-Marie (Oise), France.

natural deficiency. There is some evidence for similar enterprises in other parts of the Roman Empire, some of which involved both the protection of productive land from inundation and the profitable use of surplus water (White 1970, 146, 160). The ditches must have had an additional function as boundaries between the parcels. The fact that the enclosed areas were relatively small is in complete agreement with the assumption that a type of intensive *horticulture* was practised here.

2. Botanical research

Samples for palynological and botanical research were taken from features recommended by the French archaeologists, among which were some of the ditches and the wells. The high level of the groundwater in this valley, which has not changed since the Gallo-Roman period, had protected all organic materials, such as leather, wood and seeds, against oxygen and, as a result, the organic remains had been very well preserved.

A more detailed list of all the species will be published later, in a forthcoming paper dealing with the entire botanical research of Gallo-Roman Longeuil-Sainte-Marie (de Hingh in prep.). Meanwhile some interesting results can already be presented here (tab. 1).

I already mentioned that the site of "Le Bois Harlé" had a principally agricultural function; this hypothesis had been based mainly on the archaeological features, such as the field system of ditches and parcels mentioned above. The hypothesis that a so-called *polyculture* (proposed by Bonin/ Vangèle 1989, 102) was practised on these parcels in the 2nd and 3rd centuries is supported by the range of cultivated species that was found in the botanical samples. It could be assumed that each single crop was grown on its own plot.

3. The bottle gourd

Lagenaria vulgaris (= Lagenaria siceraria)

An extraordinary find consists of two fragments of seeds of the so-called bottle gourd (*Lagenaria vulgaris*) or calabash, found in samples from two different Gallo-Roman wells. The first specimen was partly damaged, but the specific features were still clearly visible (fig. 2). The flattened, originally rectangular seed was grooved across its length on both sides. Two more or less parallel dark brown grooves ran over the shoulders like braces. The two 'ears' which are to be seen on present-day *Lagenaria* seeds had probably been worn down in the case of this specimen. The top of the seed was somewhat tapered. The seed wall (0.3 mm thick) was bicoloured; a very thin light-coloured inner layer and a thick, darker outer layer were distinguishable. Its measurements were: 8.5 mm × 6.3 mm × 2.9 mm.

The second specimen was only a small fragment, but still unmistakably of the lower side of a gourd seed, i.e. the

Table 1. Frequency diagram of the cultivated species of 15 samples taken from 8 wells and 7 ditches at "Le Bois Harlé".

species			number of samples
Cereals:			
Hordeum vulgare	Barley	orge	8
Panicum miliaceum	Millet	millet commun	2
Triticum aestivum	Bread Wheat	froment	4
Triticum cf. *dicoccum*	Emmer	amidonnier	1
Pulses:			
Lens culinaris	Lentil	lentille	3
Pisum sativum	Pea	pois cultivé	2
Vicia faba	Celtic Bean	vesce fève	1
Gourd family:			
Cucumis sativus	Cucumber	concombre	7
Lagenaria vulgaris	Bottle Gourd	calebasse	2
Spices:			
Coriandrum sativum	Coriander	coriandre	2
Papaver somniferum	Poppy	pavot somnifère	2
Others:			
Beta vulgaris	Beet	betterave	1
Vitis vinifera	Vine	vigne	3

point where the two dark grooves meet. Both seeds were from ripe *Lagenaria* fruits. The gourd is mentioned quite frequently in contemporary Roman literature. Roman authors like Pliny, Columella and Palladius give us detailed information about how and when the seeds are to be sown, about the process of growing and the different ways in which the fruits can be used. The unripe (green) fruits are edible — Apicius' cookery book contains many recipes for gourd — and in the autumn, when the fruits ripen and the pericarp becomes hard and thick (about 3 mm), the pulp dries out and the calabash can be used as a container for wine (Plinius 19.24.71) or other supplies, such as honey or pitch (Columella 10.385-7).

The presence of seeds of *Lagenaria*, a plant of tropical origin that is known to have been grown in the Mediterranean in these times, in this region in this early period is extraordinary. There is no consensus about the question whether the gourd was cultivated in northwest Europe at this time. Some believe that it is not possible that *Lagenaria* was ever cultivated or ever grew in northwest Europe; the chance of bottle gourd plants bearing fruit in our climate would have been very small as the plants can definitely not endure night frost (Kooistra/Hessing 1989, 172). Others are of the opinion that the fruits may well have ripened under our climatic conditions, but that the pericarp will never have hardened (Brouwer/Stählin 1975, 170). An experiment in northern Germany showed that in a hot summer *Lagenaria siceraria* plants can be grown outdoors even in a town as far north as Hamburg (Stephan 1985, 154). We may therefore assume that under favourable circumstances (protected against the wind and cold) the gourd could have been cultivated even in the temperate climatic zone of northern France.

The gourd is known to require large amounts of water, of which it absorbs enormous quantities (White 1970, 153). This fact may be associable with the irrigation system and the large number of wells that had been dug at the site.

Only one other specimen of *Lagenaria* has so far been found in a Gallo-Roman context, namely at Mazières-en-Mauge (Maine-et-Loire, France). Here Marie-Pierre Ruas found a seed of *Lagenaria* cf. *siceraria* in a comparable archaeological context, in a well at an artisanal site. This bottle gourd seed has been dated to the second half of the second century AD (Ruas 1990, 35-8). In the Netherlands one example of a bottle gourd find is known. During the excavation of a well in early medieval Houten (province of Utrecht) fragments of the pericarp of *Lagenaria* spec. were found, which were dated to around AD 650-740 (Kooistra/Hessing 1989). No other finds of remains of the bottle gourd in northwest Europe are known to the author.

4. Conclusion

We may assume that the Gallo-Roman site of "Le Bois Harlé" had an agricultural or, more specifically, a horticultural function. This assumption is based on the structure of the site as well as on the presence of seeds of

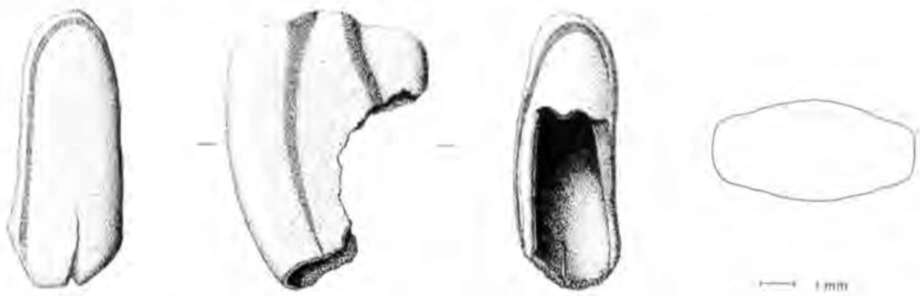

Figure 2. Seed of *Lagenaria vulgaris* (= *L. siceraria*, Bottle gourd) from a gallo-roman well. Scale unit = 1 mm.

e.g. *Coriandrum sativum, Papaver somniferum, Cucumis sativus* and *Lagenaria vulgaris* in the botanical samples from the site. It is even possible to assume that a polyculture was practised on the small plots within the ditched enclosure, which would mean that a different product was grown on each single plot. The differences in size between the fields could indicate this conclusion.

The presence of seeds of *Lagenaria vulgaris* (bottle gourd) in this region in this early period is noteworthy. There are several possible answers to the question how these two seeds ended up in the two Gallo-Roman wells. The seeds may have come from unripe or ripe fruits from the southern part of the Roman Empire, intended to be used as a vegetable or as a utensil, respectively. They may also have come from unripe or ripe fruits that were grown *in situ*. When we look at the main external features of the seeds we must conclude that the two seeds were ripe. This would mean that they came from fruits meant to be used as containers or bottles and made their way into the wells together with other domestic refuse, or from fruits that were used for obtaining sowing seed.

May we assume that *Lagenaria* was cultivated on one of the small plots at this site, in spite of the unfavourable climatic conditions? The organisation of the complex indicates an extremely rationalised use of the land for horticultural purposes. Features like the large number of wells, the parcelling of the terrain and the reclamation or irrigation system show to what extent man exploited the terrain for agricultural purposes. Perhaps we may consider the cultivation of Lagenaria a phenomenon of this same organisation: we can imagine that much attention was paid to the cultivation of the gourd, that it was protected from the wind and the cold and was provided with abundant water.

5. Résumé

Les fouilles qui ont été conduites sur le site gallo-romain du "Bois Harlé" à Longueil-Sainte-Marie (Oise) pendant 1988 et 1989 par l'équipe du Centre de Recherche Archéologique de la Vallée de l'Oise ont mis en évidence des phénomènes très intéressants. Dans le tiers méridional du site on a rencontré des fossés assez profonds dessinants un enclos trapézoïdal, qui est à son tour subdivisé par une série de fossés qui délimitent des parcelles. La vocation de cette partie du complexe est sans doute liée à des activités agricoles. Les fossés ont servi au drainage ou à la irrigation des parcelles, en tout cas au control de l'eau.

15 prélevements carpologiques pris dans les puits et les fossés ont été examinés par l'auteur à l'Institut de Préhistoire de Leiden. Des espèces intéressantes ont été trouvées, entre autres *Coriandrum sativum, Papaver somniferum, Cucumis sativus* et deux graines de *Lagenaria vulgaris* (Calebasse). On peut s'imaginer une soit-disant polyculture sur les differentes parcelles. La calebasse est une espèce d'origine tropicale, qui était, d'après entre autres Pline, l'auteur romain classique, usée soit pour manger la pulpe, soit pour le stockage du vin etc. quand le pericarp était durcie. Le fait qu'on a trouvé les graines ici semble à y indiquer que le légume a été cultivé sur place.

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Natural wood resources and human demand: use of wood in Iron Age houses in the wetlands of Midden-Delfland

The Middle Iron Age occupants of the peaty deposits of the Midden-Delfland polders used mainly wood of alder (Alnus spec.) and ash (Fraxinus excelsior) for the construction of their houses. Fraxinus excelsior was not commonly found in the surroundings of the four settlements discussed and we may therefore infer a preference for this species. The range of species used in Midden-Delfland was smaller than that in two other areas containing Iron Age occupation remains which have been intensively studied.

The woodworking methods used were rather uniform. Little use was made of timber; the worked wood consisted mainly of round wood. The wood was usually split; it was worked with axes only. Research has been done into the individual tools used to determine the minimum width of the axes and the minimum number of tools used. In the case of site MD 11.17 this research was unsuccessful: the number of toolmarks was so large that we could not see the wood for the trees.

1. Introduction

Although wood is a commonly used material, it is rarely found in archaeological excavations. In an uncarbonised form this organic material is only preserved under specific conditions involving, for example, peaty soils and a high groundwater level. The polder area of Midden-Delfland (see Abbink this volume fig. 1 for the situation of Midden-Delfland) is one of the places where such conditions can be found. Since 1988 the Institute of Prehistory Leiden has been doing research into the Iron Age occupation of this area. Archaeological and complex post-depositional processes (Abbink this volume) have inverted the archaeological remains and have caused them to sink into so-called peat-fissures. As a consequence of these disturbances it is difficult to reconstruct the plans of the houses. The processes have, however, led to better preservation conditions for the floor layers and parts of the wooden structures which, having sunk into the peat, have been cut off from oxygen by the high groundwater level. Thanks to these processes parts of wood which had been dug and driven into the ground, but even parts of the upper structure of the houses have been preserved.

This article is the first publication on the Middle Iron Age (*c.* 400-200 B.C.) use of wood in Midden-Delfland. It discusses wood from the Duifpolder sites Nos 7 and 17 (MD 11.07 and MD 11.17) and additional information from the Foppenpolder site No. 4 (MD 15.04) and the Aalkeet-Buitenpolder site No. 59 (MD 16.59). After a short introduction to the sites a review will be given of the species that grew in the area and the species which were used in the construction of the houses. Possible preferences for specific wood species will be discussed. Subsequently attention will focus on the observed evidence for different woodworking methods. Finally the toolmarks that have been traced on the wood will be discussed and the way in which those toolmarks were recorded and compared will be explained.

Little research has been done on archaeological wood and only few articles have so far been published on the subject (Coles 1982; Heal 1982). With this article the authors hope to illustrate the extra information that such research can provide on prehistoric man's knowledge of the properties of different wood species, on his skills in working (with) wood and on the tools that he used, which are rarely preserved in the archaeological record.

2. The excavations

Site MD 11.17 in the Duifpolder yielded the remains of a settlement consisting of two NNE-SSW oriented houses (fig. 1: an impression of the excavation of house 1 of MD 11.17) Both houses had been disturbed by fissures. In spite of the disturbances we were able to form an impression of the dimensions of the houses and the positions of posts, stakes and walls by analyzing the excavation plans thoroughly. The fissure of house 1 measured 25 × 5 m at most and that of house 2, 30 × 5 m at most. These reflect the minimal length and width of the houses. The floor layers of both houses were still 80 cm thick in the deepest part of the fissure. Because of their exceptional lengths we assume that both houses had been rebuilt. The presumed (partial) continuity of the different phases is currently being investigated (Koot in prep.). To the east of the houses, at right angles to their longitudinal axes, there was a third shallow fissure of at most 8 × 3 m. It contained some massive posts and fragments of wattle. No clear floor layers

Figure 1. An impression of the excavation of house 1 of MD 11.17, the posts are part of the internal construction of the house.

could be observed in this fissure. Most of the floors consisted of layers of dung alternating with layers of reed and mixed with occupation debris. This small fissure contained only reed and some sherds. Further analysis of the excavation results will hopefully provide an explanation for this.

About 70 m to the northwest of MD 11.17 the site MD 11.07 was found, also a settlement consisting of two houses, of which the E-W oriented western house had been completely undermined. The other house was oriented NNE-SSW; the maximum dimensions of the fissure were 20 × 5 m. The floor layers were about 1 m thick.

In the Foppenpolder the settlement MD 15.04 has been investigated (Abbink 1989). The excavation of this site revealed the remains of six houses, two of which had been relatively well preserved (houses 1 and 2). The orientations of the houses varied; three were oriented NE-SW, two NW-SE and one roughly E-W. The lengths of the fissures associated with the houses ranged from 12 to 20 m. In this case, too, it is almost impossible to discuss the structures of the individual houses because of the disturbances. However, it proved possible to determine the original function of much of the wood recovered from houses 1 and 2: it had served mainly as roof supports and as parts of the walls. A less common discovery was an approximately 2.5 m wide planking in house 2, which may have formed part of an entrance or a partition between the living area and the byre. In addition to the wood of houses 1 and 2, which has been studied and will be discussed in this article, about 350 other pieces of wood were identified. Most of these were found in an area that may have been a kind of industrial platform, as suggested by the iron slags and part of an oven grate found there (Abbink *pers.comm.*).

Finally we will discuss the wood from site MD 16.59 in the Aalkeet-Buitenpolder (Abbink/Frank 1991). The occupation remains at this site had been very badly disturbed by several fissures. The largest fissure measured approximately 30 × 3 m and contained the wood of a NE-SW oriented house. At right angles to the north side of this fissure were several smaller fissures containing occupation debris. The chaotic mass of wood in the fissures probably represented the remains of several building phases. The wood comprised a 12 m long part of the southern wattle wall, which had fallen inwards. Roof supporting posts spaced 2 m apart were observed outside this wall. The wood from the southern part of the site, including that of this wall, has been studied.

3. The wood spectrum resulting from the excavations

Of the three structures of MD 11.17 486 pieces have been described and identified. The following species were encountered: ash (*Fraxinus excelsior*), alder (*Alnus* spec.), hazel (*Corylus avellana*), birch (*Betula* spec.), oak (*Quercus* spec.), willow (*Salix* spec.), blackthorn (*Prunus spinosa*) and maple (*Acer* spec.). In the following discussion the wood of "structure 3" will be left out of consideration, because a) it is unknown what it represents and b) it consists mainly of a small part of wattle.

Houses 1 and 2 yielded 200 and 266 pieces of wood, respectively. It is certain that most of these pieces had been used in the construction of the houses. The pieces probably represent the remains of several building phases, but we have not yet been able to analyze the effects of the post-depositional processes sufficiently to be able to say how many phases there were. We hope to solve this problem through further analysis of the excavation plans in combination with dendrochronological research. Until the results of that research are known we will not estimate the minimum number of trees used for posts and stakes in the construction of the houses. It is, however, possible to make a conversion to pieces of round wood used by adding up the split wood. 'Posts' are here understood to be the upright parts of the structure which served primarily as roof supports. 'Stakes' are the upright parts in walls whose primary function was to add stability to the wall, but they also had a supporting function. Table 1 shows the distribution of the wood species.

The dominance of *Fraxinus excelsior* is obvious. This species was used especially for the load-bearing parts of the structures: the posts and stakes. Thin branches and twigs of *Alnus* and *Corylus avellana* were used for wattle. *Fraxinus excelsior* was also used for wattle, in which case its branches were usually split. Split wood was commonly used for the load-bearing parts of structures. In figure 2a

Table 1. The woodspectrum of the excavation MD 11.17 (the construction of the houses 1 and 2 is also showed separately).

	total	house 1	house 2
Fraxinus excelsior	382 (78.6%)	175 (87.5%)	201 (75.6%)
Alnus spec.	63 (12.3%)	20 (10.0%)	41 (15.4%)
Corylus avellana	20 (4.1%)	3 (1.5%)	17 (6.4%)
Betula spec.	8 (1.6%)	1 (0.5%)	2 (0.8%)
Quercus spec.	4 (0.8%)	-	4 (1.5%)
Prunus spinosa	1 (0.2%)	1 (0.5%)	-
Acer spec.	1 (0.2%)	-	1 (0.4%)
Salix spec.	1 (0.2%)	-	-

and b the results are given of the research discussed above.

Site MD 11.07 was found 70 m to the north of MD 11.17. The two sites were very similar. In total 119 pieces of wood were identified, 19 of which were *Alnus* (16%), the other 100 being *Fraxinus excelsior* (84%). (fig. 3). It is likely that all of the identified pieces were used to construct the two houses although we have not yet been able to ascribe all of the pieces to one of the two houses. In the following discussion the evidence from this site will be considered as one sample.

About 650 pieces of wood from site MD 15.04 have been identified; 93 of these pieces have been ascribed to house 1 and 201 pieces to house 2. Table 2 shows the use of *Alnus*, *Fraxinus excelsior*, *Corylus avellana*, *Salix*, *Acer*, *Prunus avium/cerasus* and *Quercus* as building materials. The other identified pieces which have not yet been ascribed to one of the two houses include pieces of the above range of wood species plus a number of new species: purging buckthorn (*Rhamnus catharticus*), guelder rose (*Viburnum opulus*), bog myrtle (*Myrica gale*) and probably spindle-tree (*cf. Euonymus europaeus*).

Table 2. The woodspectrum of the houses of the excavations MD 15.04 and MD 16.59

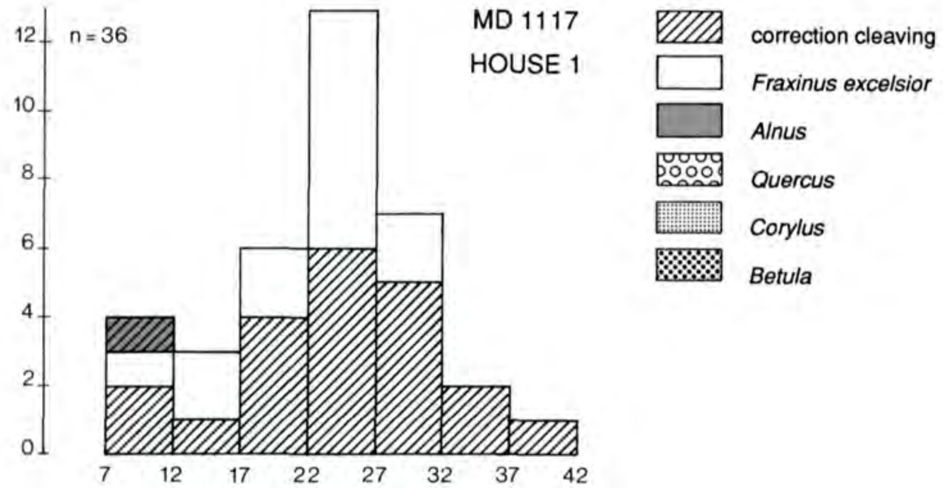
	MD 15.04 house 1	MD 15.04 house 2	MD 16.59
Fraxinus excelsior	47 (51%)	95 (47.3%)	70 (28.7%)
Alnus spec.	35 (38%)	89 (44.3%)	155 (63.5%)
Corylus avellana	-	1 (0.5%)	5 (2.0%)
Quercus spec.	-	1 (0.5%)	-
Acer spec.	3 (3%)	1 (0.5%)	4 (1.6%)
Salix spec.	2 (2%)	8 (4.0%)	8 (3.3%)
Prunus avium/cerasus	-	1 (0.5%)	-
Rhamnus catharticus	-	-	1 (0.4%)
Ulmus spec.	-	-	1 (0.4%)

224 pieces of wood from the southern part of site MD 16.59 have been identified, 33 of which belonged to the aforementioned wattle wall: *Alnus*; 16 (49%), *Fraxinus excelsior*; 14 (42%) and *Corylus avellana*; 2 (6%). All of these pieces had been used in the construction of the same house; see table 2 for the distribution of species. The high percentage of *Alnus* is striking compared with the evidence obtained for the other sites. This species was frequently used in wattle, at least in Midden-Delfland. *Alnus* may be overrepresented because many pieces of wood had diameters of less than 5 cm, which implies that they probably formed part of wattle. If these pieces are left out of consideration the distribution becomes: *Alnus*; 72 (63.3%), *Fraxinus excelsior*; 38 (33.6%), *Corylus avellana*; 1 (0.9%), *Salix*; 1 (0.9%) and *Rhamnus catharticus*; 1 (0.9%). The proportions hardly change and the conclusion must therefore be that *Alnus* was the main species used in the construction of MD 16.59. Table 2 shows the distribution of wood species ascribed to the houses of MD 15.04 and 16.59.

In summary it can be concluded that *Fraxinus excelsior* and *Alnus* were the most commonly used species; next came *Corylus avellana*, which was used much less frequently. Species like *Quercus*, *Betula*, *Acer* and *Salix* were used incidently. Other species encountered are *Prunus spinosa*, *Prunus avium/cerasus*, *Rhamnus carthartica*, *Ulmus*, *Viburnum opulus*, *Myrica gale* and *Euonymus europaeus*. The greater part of the identified wood had been used in the construction of the houses.

4. The local wood vegetation and preferences for specific types of wood

By reconstructing the environments in which the settlements were situated we can determine how prehistoric man used the local wood vegetation. The four settlements studied were built on local oligotrophic peat cushions, which were restricted in size. Remnants of these oligotrophic peat cushions were observed beneath the floors of the Iron Age houses in Midden-Delfland. The houses had been built on a decomposed surface peat. In some cases peatmoss (*Sphagnum* spec.) and cottongrass (*Eriophorum* spec.) was observed. Palynological research of samples taken from different places at site MD 15.04 (Brinkkemper 1991, 14) showed the local development. The area was originally a raised bog where *Betula* and Ericaceae predominated. In the bog margins grew *Alnus*. Some *Corylus avellana* and *Quercus* grew on mineral soils further away. Dehydration led to the formation of a bog myrtle brushwood with Graminaeae and Ericaceae. The last stage was a drained raised bog with an oxidised surface. The peat cushions were surrounded by an open, wet reed vegetation



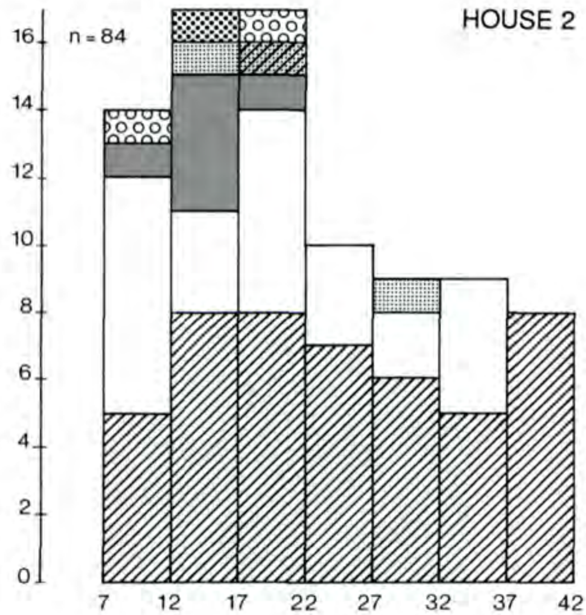


Figure 2. The bardiagrams give the number of pointed stakes and posts (y-axis) per circumference class. The distribution of wood species used is also shown for each circumference class (x-axis, cm). Per species and per class the correction for cleaving is given (hatched). This is the conversion of *cleaved wood into round wood.* Thus the three stakes of *Fraxinus excelsior* in the circumference class 7-12 cm of figure 2a represent two pieces of round wood and the stake of *Alnus* is a cleaved piece of wood and represents therefore one piece of round wood.
Figure 2a refers to the stakes and posts of MD 11.17 house 1 and figure 2b to MD 11.17 house 2.

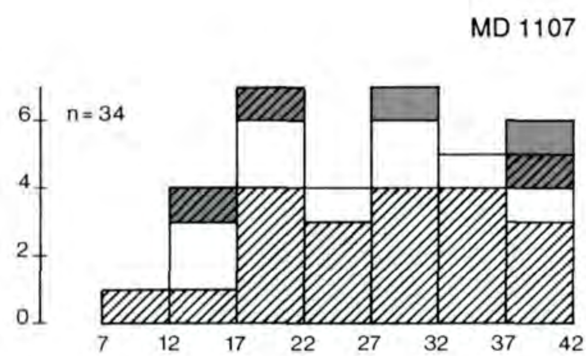


Figure 3. The distribution of stakes *and posts among species and* circumference classes for site MD 11.17, see figure 2 for the description of the diagram.

(Brinkkemper 1991, 20). This development corresponds well to developments due to marine influences observed in other Dutch coastal pollen diagrams (Brinkkemper 1992).

A similar environment has been reconstructed for "house Q", an Early Iron Age settlement which has been excavated in the Assendelver Polders (Therkorn *et al.* 1984). The pollen diagram of this site shows, in order of their dominance, *Salix*, *Alnus*, *Quercus*, *Fagus sylvatica*, *Betula* and *Ulmus* (Groenman-van Waateringe 1988, 142). The first two species grew in the environment described above, the others in the dunes. The species used most in the construction of house Q are *Alnus* and *Salix*, followed by *Fraxinus excelsior*, *Quercus*, *Betula*, *Corylus avellana* and *Acer*. Five other Iron Age pollen diagrams obtained for the Assendelver Polders present a similar picture. The most common species is *Alnus*. The following three places are taken by *Quercus*, *Fagus sylvatica* and *Salix*, in different orders; sometimes *Corylus avellana* ranks high while species like *Betula* and *Ulmus* rank lowest (Groenman-van Waateringe 1988, 143).

A third region with the same kind of landscape in the Early and Middle Iron Age was on the island of Voorne-Putten, which was covered with a fen peat with some alder carrs, where a few *Salix* trees grew besides *Alnus*. The fen peat included a few small areas of sparsely wooded raised bog. The proper woods were to be found on the higher levees and in the dunes (Brinkkemper/Vermeeren 1993, 113).

From the above it may be concluded that *Alnus* and probably also *Salix* grew in the surroundings of settlements MD 11.07, 11.17, 15.04 and 16.59, although the presence of the last species still has to be confirmed by more pollen diagrams from Midden-Delfland. The other species grew on soils with a higher mineral content, such as levees, stream ridges and the dunes (see also Orme/Coles 1985, 7-14; Van der Meijden 1990 for descriptions of a. the species mentioned and b. peaty wetlands). Those soils were not always to be found close to the settlements.

Comparison of this conclusion with the results of the research into the wood from the four settlements leads to the following observations. *Alnus* was used most in the construction of MD 16.59[1], but *Fraxinus excelsior* is also well represented. Both species had been used in almost equal proportions in the houses of MD 15.04 whereas mainly *Fraxinus excelsior* had been used in the construction of the houses of MD 11.07 and 11.17. This species had been used more than would be expected on the basis of its natural occurrence in the immediate surroundings of the settlements, which suggests a preference for this type of wood.[2] This preference is not strange in view of the elasticity and toughness of this type of wood, which properties make it very suitable for use as tool shafts and posts (Brinkkemper/Vermeeren 1993, 114-15; Orme/Coles 1985, 10). The wood can be easily worked. However, the durability of this type of wood is poor by modern standards: at most 5 years in humid soils to at most 12 years in dry soils. This shortcoming may have been outweighed by the wood's other qualities. A preference for *Fraxinus excelsior* during the Iron Age and the Roman period in the western Netherlands has been ascertained before (Brinkkemper/Vermeeren 1993; Groenman-van Waateringe 1988, 141, 148). *Fraxinus excelsior* grew especially at the edges of the larger levees with a mineral subsoil (Brinkemper/Vermeeren 1993, 113; Groenman-van Waateringe 1988, 141; Orme/Coles 1985, 10).[3]

Remarkable is the little use made of *Salix* and *Betula* in the construction of the houses in Midden-Delfland. *Salix* was appreciated especially for its suitability for wattle (Orme/Coles 1985, 12). In house Q *Salix* had been used in the wattle walls of the living area, but it had not been used at all in the byre. This has been attributed to a belief known from medieval sources which has been extrapolated to prehistory: it was believed that the twigs of this species had a negative influence on the milk production and fertility of cows that gnawed on them (Therkorn *et al.* 1984, 362). However, in recent investigations of some Iron Age settlements on Voorne Putten *Salix* has been found in wattle walls of byres (Brinkkemper/Vermeeren 1993, 116). We can think of two explanations for the little use made of *Salix* in Midden-Delfland. The first is that *Salix* was probably less common here than in the other areas. However, this will have to be confirmed by more pollen diagrams than the three so far obtained from MD 15.04. If prehistoric man had a preference for *Fraxinus excelsior* and was willing to make an effort to obtain it, why did he not make the same effort for *Salix*? Perhaps because *Corylus avellana*, which was also suitable for wattle, was available in the surroundings (Orme/Coles 1985, 9). A second possibility is that sufficient branches and twigs for wattle were produced in the preparation of trees for posts and stakes and that the branches of the species in question, *Fraxinus excelsior* and *Alnus*, were considered good enough for this purpose.

A comparison of the evidence of the Midden-Delfland settlements with that of the Iron Age settlements of the Assendelver Polders and Voorne Putten reveals a greater variation in the types of wood used in the last two regions. Posts and stakes had been made from *Alnus* and *Fraxinus excelsior*, but also from *Quercus*, *Ulmus* and *Acer*, which species are also very suitable for that purpose. The use of *Salix* for wattle has already been mentioned. We assume that the types of wood used reveal certain preferences,

Figure 4. Four examples of pointed post and stakes made from Fraxinus; a. a split stake showing remaining chips and an axe impression, b. a partly pointed split post, c. a typical example of a post with a blunt point and d. an exceptional example of a partly pointed post showing very fine facetting.

influenced by the availability of the species in question in the surrounding vegetation.

5. Woodworking

Thanks to the good preservation conditions for wood in Midden-Delfland we have been able to study prehistoric woodworking and construction methods. Due to the post-depositional processes in this particular area wood and parts of wood which, not dug or driven into the ground, are rarely encountered in the archaeological record have been preserved here. This was for example apparent from the lengths of some of the pointed posts, which exceeded 1.5 m.

Split round wood had been commonly used for the houses of MD 11.07 and 11.17. Timber, defined as split round wood with little or no remains of the outer surface (Orme/Coles 1983, 19), was rarely found. The few examples of timber had not been worked into posts or stakes. Two pieces of timber found in house 1 of MD 11.17 may have constituted a threshold. Some pieces from house 2 may have formed part of the superstructure (or may have been re-used in the wall). Other examples of timber from this house are the planks of *Alnus* and *Fraxinus excelsior*. Some of these had been made by splitting a trunk tangentially instead of radially. These planks were found beneath two hearths and hence probably served as the bases of the hearths. A similar use of timber has been observed before in Midden-Delfland. The *Alnus* planks were from much thicker trees (up to 40 cm in diameter) than the pointed *Alnus* posts in this house.[4] The wood of posts and stakes made from split wood had mostly been split radially. More stakes than posts had been made from split wood. Moreover, the points of the posts were less sharp than those of the stakes. The points of the posts were probably given larger areas to prevent them from subsiding in the peaty soil. Figure 4 shows some examples of posts and stakes.

The houses of Midden-Delfland yielded no examples of posts or stakes with traces of woodworking at the level of the floor, which suggests that the risk of the posts and stakes subsiding in the peat was prevented by means of joints. The posts and stakes were held in place by pens that were driven into the ground. The same was observed on Voorne Putten but we also know of examples of cross bonds at floor level (Brinkkemper/Vermeeren 1993, fig. 4).

MD 11.17 produced only one piece of wood with a notch. Some other pieces of carefully shaped wood were probably pegs (one of which had been made from *Prunus spinosa*).

The other two sites, MD 15.04 and 16.59, provided little new information. In MD 15.04 timber had been used for a planking. The planks had been split radially, tangentially and in a direction between the two. Some notched pieces and wooden pegs indicated the use of joints, but two joined pieces of wood were not found.

Another method of woodworking is wattling, which has already been mentioned regularly. It was used for walls, but also for baskets. MD 15.04 yielded two pieces of wattle of *Salix* twigs which may have formed part of baskets. Some pointed pens (of up to 15 cm long with diameters of about 1 cm wide) were found which appeared to have been cut using a knife. Their function is not clear. A few of these pens had carbonized points. They may have been burned because they were no longer considered fit for use but another possibility is that the points were deliberately burned during the preparation of the wood: burning hardens the surface and is also a good protective measure against woodrot. Of the other wooden artefacts found we will only mention a paddle and a piece of wood which probably served as a chopping-block. Both of these were of *Fraxinus excelsior* and both came from MD 16.59.

The many wood chips found at the Midden-Delfland sites indicate that part of the woodworking was done at the sites themselves. The chips were left lying on the ground and became incorporated in the layers of the floors. Samples of chips have been identified; they were all of *Fraxinus excelsior* and *Alnus*. Although large amounts of wood have been preserved, only few examples of wooden artefacts which were not used in house construction have been found. A lot of refuse was used for the floors; discarded wooden artefacts probably ended up in the hearth.

6. Wood and Toolmarks

Research into the methods of woodworking can provide information on the tools which were used to shape the wood. This can be done directly, by recording the toolmarks observable on the wood, or in a more indirect manner, via experimental archaeology. At the same time additional information can be obtained on the material culture, because traces of objects which are seldom preserved may be observed.

This kind of research is still very rarely carried out. The best known example of an investigation of this kind is that of the Iron Age house Q in the Assendelver Polders, conducted by M. Taylor (Therkorn *et al*. 1984, 363-367). She examined the structural wood of the house and some wooden artefacts and concluded that two or three different gouges had been used and between seven and eleven axes or adzes. In another investigation carried out on Voorne-Putten the researchers were only able to determine what type of tools had been used because the full potential of this kind of research was not recognised until later (Brinkkemper/Vermeeren 1993, 115). The Iron Age wood has yielded evidence for the use of axes having cutting edges with widths of at most 9 cm. Gouges were also used in this period and there are indications of the use of saws.

Toolmarks were also studied in the research of the wood from the four Midden-Delfland sites. M. Taylor has distinguished five classes of surviving toolmarks (Therkorn *et al*. 1984, 363-365):

1. No actual toolmarks survive, although the wood was obviously shaped.
2. Slight indications of toolmarks, such as facetting.
3. Toolmarks surviving well enough to provide limited information.
4. Marks showing the full outline of the tool or of part of it.
5. Toolmarks with their own "fingerprints".

In our analysis we have reduced these five classes to three, because we believe that the marks of classes 2, 3 and 4 are more or less the same:

1. No toolmarks on the worked wood.
2. Toolmarks that allow determination of the kind of tool used.
3. Toolmarks with their own "fingerprints", the distinguishing marks of individual tools. An example of marks of this class is shown in figure 5.

In our research we focused on marks of class three in particular because we were interested in the number of tools which prehistoric man had at his disposal. Individual tools can be recognised by the number of wire edges and their positions along the edge and by the specific shape of the cutting edge. Cutting edges cannot be recorded simply by copying the end of a facet. Facets can only be of use if several wire edges are also observable because then the number of wire edges and the distance between them can help to identify individual tools. Instead, one must look for the place where the axehead cut into the wood before being pulled clear without the chip being detached completely. The remaining chip covers the mark of the cutting edge (fig. 6). With help of a razor-blade this last part of the chip can be removed and the transition to fresh, rough wood then marks the line of the cutting edge. We recorded our cutting edges by covering them with plastic and copying the edges with a marker pen. These copies were then traced onto tracing paper and photocopied. The individual cutting edges were compared by placing the originals over the photocopies. This of course meant that we were comparing reflected images of the original axe blade.

Some authors argue that this method can only be followed in the case of metal blades (Coles/Orme 1985, 27; Orme/Coles 1983, 22; these authors also give other indications for distinguishing between stone and metal blades). In view of our own experiences we do not agree with them. We have seen posts from a late Neolithic site

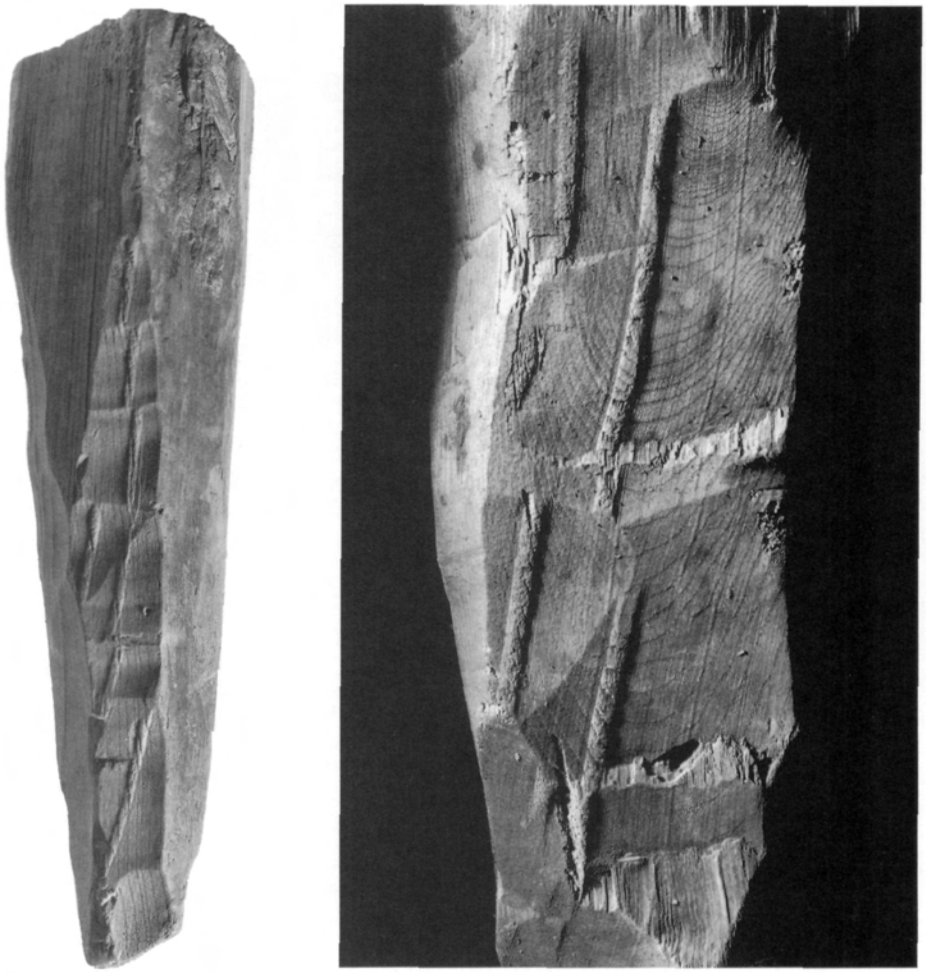


Figure 5. A clear example of two pieces of Fraxinus wood worked by the same axe, which is recognisable by the wire edges.

which had definitely been worked with stone axes and which showed the same kind of remaining chips on the wood (Jaarverslag ROB 1992).

Settlement MD 11.17, which was excavated almost entirely, yielded a large number of cutting edges for analysis and comparison. In our opinion all of the toolmarks were attributable to axes. Axe marks and adze marks differ in

a) the shape of the facets, those of adzes being curved, and
b) the angle between the wire edges and the cutting edges, which is square in the case of adzes (D. Goodburn *pers. comm.*).

It is often thought that the main difference between axes and adzes concerns the direction of hewing: in the case of adzes the direction of hewing must be parallel to the length of the wood, although a skilled adze user will be able to hew from any position.

Cutting edges were copied from 33 posts and stakes.[5] The first conclusion was that the individual pieces of wood had been worked with the same axe.[6] We found only one piece with toolmarks of two different axes. Secondly, we constructed "compositions" of several overlapping impressions of cutting edges. See for example post MD 11.17; 457 and the copied cutting edges A, B and C (fig. 7). With impression C on the left the minimum width that can be inferred for the cutting edge amounts to 7.5 cm. The alternative, with C on the right, leads to a minimum width of 9.5 cm.

The next step, attempting to recognise individual tools, proved to be more difficult than we had expected. The comparison of all the toolmarks led to much confusion and we eventually decided that between 1 and 34 different tools must have been used. What complicated our task was the possibility of wire edges having been obliterated during the later use of the tool (Coles/Orme 1985, 30). We moreover

Figure 6. The removal of the remaining chip.

believe that some wire edges may have become wider. Another factor that must be born in mind is the possibility of interim grinding. To facilitate our analysis we decided to study the toolmarks of the two houses separately. House 1 yielded 14 pieces of wood with toolmarks. The number of tools used ranged between four and eight. The number of axes used to sharpen the posts and stakes of house 2 ranged from four to ten. Because we do not know how many occupation phases there were, it is possible that these axes were used over long periods of time. We do not have any evidence that a particular axe was used during the construction of house 1 as well as that of house 2. The cutting edges were not as distinctive as we had hoped and the results of our analysis could play only a minor part in the discussion about the contemporaneity of the two houses of site MD 11.17.

Site MD 11.07 yielded the smallest number of posts and stakes because only a small part of the settlement was excavated and, furthermore, because one of the houses had been completely disturbed. Only marks of axes were found. We recorded ten cutting edges on three posts of one of the houses. One axe had produced nine of those marks on all three of the posts; the minimum width of the cutting edge was 5.2 cm. A second axe had been used at the bottom of one of the posts; its cutting edge was at least 6.5 cm wide. This post was probably a pointed post of round wood originally, which was later split into three parts for re-use.

The same kind of research (although not so thoroughly) was carried out for MD 15.04 and MD 16.59. Again all the observed toolmarks were ascribed to axes. MD 15.04 yielded only two impressions of the cutting edges of two different axes. One had a minimum width of 6.5 cm, the other of 8 cm.

The 38 cutting edges observed on 18 pieces of wood indicated that at least three different axes had been used in the construction of the house(s) of MD 16.59.

It is still too early to draw any conclusions about the usefulness of toolmark analysis. We have to admit that the results of the analysis of the evidence from site MD 11.17 are rather disappointing. The cutting edges of the axes or the width of the facets on the wood may have been too narrow to enable us to recognise individual tools. We do venture that wide axe cutting edges are easier to ascribe to

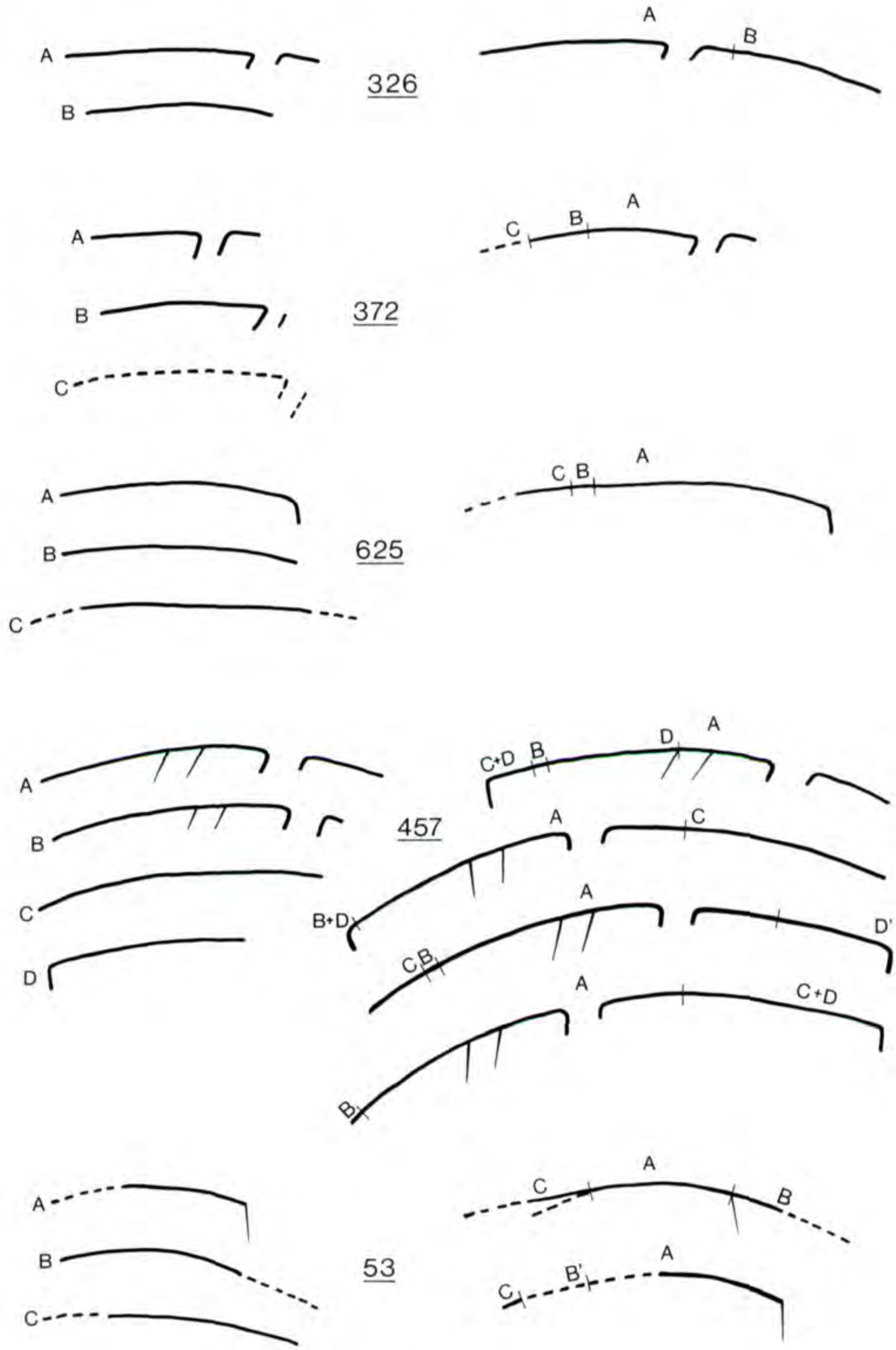


Figure 7. Reconstruction of seven cutting edges from MD 11.17.

individual implements than narrow ones. We hope that further studies will provide us with enough data to be able to say something about the kinds of tools used, about variations in the shape of a particular type of tool and about preferences for certain types of tools for certain activities. Finally, we hope that we will then be able to use these results in research on the contemporaneity of houses and building phases.

notes

1 The wood of *Alnus* is highly valued for its durability in humid soils and under waterlogged conditions (Orme/Coles 1985, 7)

2 Even if we assume that the correction factor for the pollen production of *Fraxinus excelsior* is too low, this species was still rare in the surrounding vegetation.

3 If there was indeed a preference for *Fraxinus excelsior*, what does this imply for the other species that were valued as structural wood, such as *Quercus* and *Fagus*? We are inclined to argue that the environments that were suitable for these two species lay some distance away from the settlements. The fen peats will have included areas with mineral soils, for example levees, where *Fraxinus excelsior* may have grown, but they were at that time probably still too wet for the other species. *Fraxinus excelsior* may have been preferred for the quality of its wood but also because it was more readily obtainable.

4 'Posts' are understood to be pieces of wood with an axed point and a circumference of 35 cm or more (which corresponds roughly to a diameter of 11 cm).

5 This large number of undetached chips is remarkable. It could indicate that the house(s) was (were) constructed in a hurry.

6 If the aim of a toolmark analysis is to estimate the minimum number of tools used, allowance must be made for the material of which the tools were made. Bronze tools were cast and tools cast in the same mould were similar; this must be kept in mind in estimating the minimum number of tools used.
Iron Age axes are rare and this strengthens our assumption that the axes used were made of iron: iron is much less resistant to soil processes than bronze. Iron is moreover harder than bronze and will therefore have been preferred for the manufacture of tools. The decisive factor, however, was probably the availability of iron ore in the form of 'bog iron' in the immediate surroundings.

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Oss-IJsselstraat: Iron Age graves and a native Roman settlement

In 1974 and 1975, prior to the well-known excavations in Ussen, a small site was excavated to the north-east of Oss, along the IJsselstraat. In addition to a number of graves from the Iron Age, part of a native Roman settlement was found. This settlement seems to fit in with the recently proposed regional hierarchies of rural settlements from the Roman period. However, a number of slight differences are present, which may indicate that future research will lead to different insights into the settlement system.

1. Introduction

In the 1950s the focus of attention of archaeology in the Netherlands shifted from burial practices to settlements. At the same time a tendency towards large-scale excavations became apparent. Having started off in this tradition with the investigations at Haps (Verwers 1972), the Leiden Institute of Prehistory (IPL) continued to carry out research on settlements from the Iron Age and Roman period in the southern part of the Netherlands.

One of the first sites to be excavated was situated to the north-east of the town of Oss. During a rescue campaign in 1974 and 1975, the IPL excavated a site along the IJsselstraat. As this site was situated in an industrial estate, it was not possible to extend the investigations into a large-scale project. In 1976 the IPL started excavating at Ussen, to the north-west of Oss. That excavation did provide the opportunity for large-scale research. The large number of sites discovered in that research will form the basis of an analysis of the settlement system in the Late Iron Age and the Roman period.[1] The IJsselstraat excavations, of which only a few specialist studies[2] have been presented, yielded much useful information, including a number of native Roman house plans forming a small settlement. As part of the settlement system of the Maaskant region[3] they provide a frame of reference for the Ussen data.

This article aims to present the data of the IJsselstraat excavations so that they can be included in the analysis of the settlement system of the Maaskant region.

2. History of the investigations

During the construction of a garage in the IJsselstraat in April 1973, members of the local Maasland Historical Society (*Heemkundekring Maasland*[4]) discovered postholes, pits and pottery dating from the Iron Age and the Roman period. With the permission of Mr G. Beex, who was the provincial archaeologist at the time, a trial trench was dug following the discovery of more features in September. After the local archaeologists had recorded a house plan from the Roman period the trench was filled up again; the results were promising enough to warrant the excavation of the entire plot.

From April 22nd until May 22nd 1974 the IPL[5] carried out a rescue excavation in the IJsselstraat. The archaeological team of the Historical Society continued working until the end of July and it is thanks to their efforts that all the house plans could be recorded in their entirety.

In 1975, from April 7th until May 30th, a second and final IPL excavation was carried out at the IJsselstraat site. During the following years members of the Historical Society and later the Archaeological Study Group investigated various road and building trenches in the area around the IJsselstraat, the 'Noord' industrial estate.

3. The site and its environment

The IJsselstraat site is situated to the north-east of the town of Oss (province of North Brabant[6]) (fig. 1). To the north, the excavated area was bordered by the IJsselstraat, to the south by the Scheldestraat. To the east and west of the site were plots with industrial buildings (fig. 2).

The site lies on the northern perimeter of the Pleistocene coversand of North Brabant. To the north, the Holocene backswamp deposits of the river Meuse are separated from the coversand area by a transitional zone. The Ossermeer, a remnant of an old river bed in this clay area, has yielded various Roman artefacts (Verwers/Beex 1978b, 32). These finds indicate that open water was still present in this branch, which lay about 2.5 km north of the excavated area, in the Roman period. On the whole, the area can be said to have been suitable for agriculture.

The IJsselstraat site was covered by a Medieval *es* (a layer of *plaggen* soil, a man-made soil) with an average thickness of 60 cm. During or prior to the formation of this *plaggen* soil the prehistoric surface was disturbed by digging activities. The original depths of the features will have been about 40 cm more than the recorded depths.[7] Other (sub)recent disturbances are a ditch in the (north)-

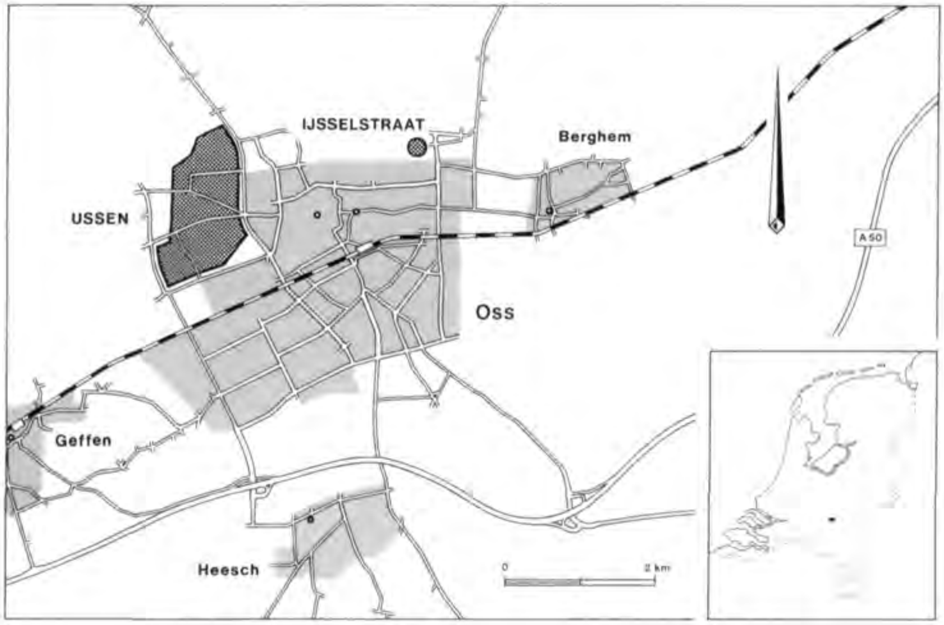


Figure 1. Oss and surrounding villages: location of Ussen and IJsselstraat.

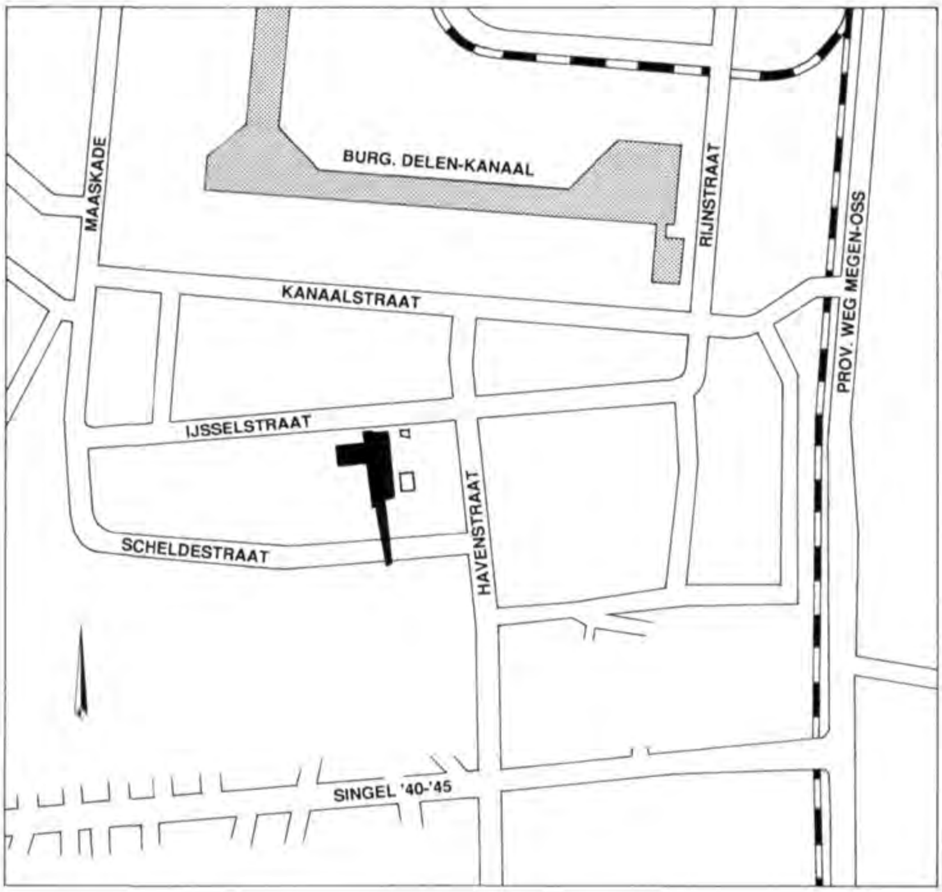


Figure 2. Part of the 'Noord' industrial estate; the investigated area is indicated in black, with the building trenches to the east.

western part of the site and some smaller pits and gullies, including a trench dug for a cable.

4. Strategy of the investigation

A total area of approximately 0.5 hectare was excavated (fig. 3). More features were observed in two building trenches immediately east of the excavated area, but they could not be joined up with the other features; possibly too little topsoil had been removed. These building trenches were therefore omitted from the site plan.

The dark *plaggen* soil was removed with the aid of a mechanical shovel down to about 10 cm above the level at which the features were visible. The last 10 cm were removed by hand, after the area had been divided into squares measuring 4 by 4 m; all the finds encountered in these 10 cm were collected. The depth below excavation level of all the features was recorded, while sections were drawn of the larger pits and of the wells. All the wells, a couple of postholes of central roof supports and one wall trench were sampled for the purpose of botanical analysis. Remains of wooden roof supports and timber well linings were identified and used for C14 analysis.

5. Prehistoric occupation remains

5.1 Late Neolithic/Early Bronze Age

Approximately 25 pottery fragments, found in several pits and postholes, and a large number of sherds collected during the shovelling of the topsoil could be dated to the Late Neolithic. The finds from the topsoil consisted mainly of pottery from the Late Neolithic, including some decorated potbeaker sherds (fig. 4).

In a number of cases the pottery found in pits and postholes had to be regarded as intrusive, since the majority of the finds from the same pits dated from the Iron Age or the Roman period. Some of these postholes were even thought to have contained the roof supports of a house from the Roman period (House 6). Only two pits could be dated to the Late Neolithic or Early Bronze Age (fig. 5). Their contents included rusticated ware (*potbeaker*) and barbed wire beaker sherds (fig. 4). A flint arrowhead with surface retouch, which was picked up as a surface find, was also dated to the Late Neolithic. Its tip and one of the two barbs were broken.

The finds of this small assemblage were interpreted as settlement refuse indicating occupation around the transition from the Neolithic to the Bronze Age.

5.2 Middle Bronze Age

Much the same holds for the Middle Bronze Age evidence as for that from the Neolithic period: most of the Middle Bronze Age pottery was found in the topsoil and only a few features could be dated to this period with certainty, notably two pits and a well[8] (fig. 5). The well contained *Drakenstein* pottery (fig. 6), which was dated *c.* 1750-1100 BC on typological grounds. This was confirmed by a C14 date (GrN-8305: 3200 ± 30 BP).[9] The well was lined with a hollowed-out tree trunk. Botanical analysis of samples from the fill of the trunk showed that the plant remains were of heterogeneous origin; they included various wild species and a single grain of barley. Some of the wild species were almost certainly eaten by man, such as blackberry, blackthorn, bullace, bitter dock and corn spurrey. Also included in the spectrum were ruderals, crop weeds and plants from wet areas, which were probably brought into the settlement from the river marshes in the Meuse valley (Bakels 1980, 122).

5.3 Iron Age

If we leave the finds from the graves out of consideration (see below), pottery that could be dated to the Iron Age was found in three places only. All three finds consisted of bowl fragments, including sherds that could be the remains of a so-called *Lappenschale* (Late Bronze Age/Early Iron Age). All the Iron Age pottery was collected during the removal of the topsoil.

Two fragments of glass *La Tène* bracelets were found at the IJsselstraat site. Such bracelets are generally thought to date from the Late Iron Age. However, as both fragments were found in wells dating from the Roman period, it is more likely that they date from the Roman period (see also Van den Broeke 1987a, 40).

The small number of occupation remains found suggests that there was no Iron Age settlement in the excavated area or its immediate surroundings.

6. An Iron Age cemetery

The most important Iron Age feature was a small urnfield (fig. 7). It was excavated in part only: only the southern limit seems to have been found. A total of 25 graves was discovered. Sixteen pits were interpreted as interments on the basis of their contents. In four of these graves the cremated bone had been placed in an urn. Nine other features were interpreted as burial monuments, even though only five of these contained (central) interments. The monuments included one so-called long bed, (parts of) six rectangular enclosures and two circular enclosures (tab. 1).

Table 1. Burial monuments and graves

	number	cremation	urn
circular enclosures	2	1	-
rectangular enclosures	6	4	-
long beds	1	-	-
cremations without enclosures	16	16	4

Figure 3. Oss-IJsselstraat: plan of the excavation; recent disturbances are indicated in grey.

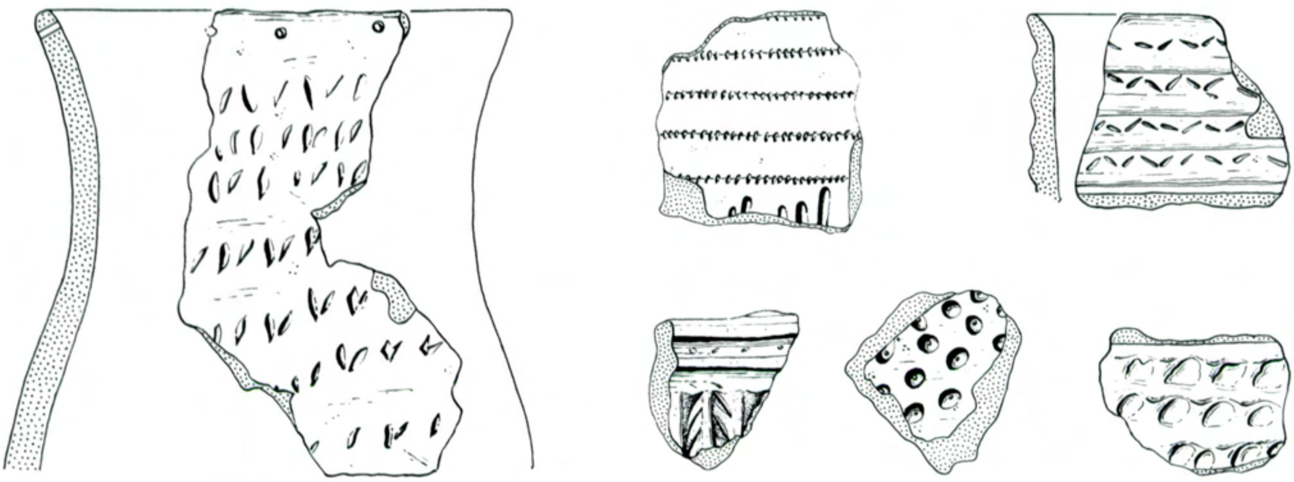


Figure 4. Potbeaker and barbed wire beaker sherds; scale 1: 2.

The long bed was oriented north/south and measured 48 × 6 metres.[10] Parts of the enclosing ditch had disappeared, which means that we do not know whether there were originally openings at the ends of the monument. A central interment was not recorded. In view of its dimensions (length: width index of 8), this monument may be classified as one of Verwers' 'Long Ditches of the Goirle Type': non-circular, long and narrow monuments (Verwers 1966b, 49). Most burial monuments of this type date from the Late Bronze Age, but a few Early Iron Age examples are known.

The only cremation remains recovered from the area enclosed by the ditch of this long bed were found almost halfway down the enclosure, but at some distance from the long axis, which makes it unlikely that they are associated with the long bed. A find that may possibly be associated with the long bed is an almost complete urn of the *'Harpstedter Stil'*, which had been placed upside down. The pot was found in a pit which contained no cremated bone and was identified as a recent feature. If this find is indeed associable with the long bed, the latter would date from the Early Iron Age.

Various elements of dating evidence have to be combined in order to be able to date the urnfield as a whole. The urns and other types of pottery (fig. 8) date the graves to the Early and Middle Iron Age (*c.* 800-250 BC) (identification by P.W. van den Broeke). The diagnostic finds include a bi-conical pot with a long neck (probably phases F-G = 450-350 BC), roughened ware of the *'Harpstedter Stil'* (Late Bronze Age or Early Iron Age), a ribbon handle (Late Bronze Age or Early Iron Age) and a bowl of phase F (450-400 BC). An iron torque (fig. 9), found in grave No. 3, probably dates from the Middle Iron Age (*cf.* Thénot 1982, 52). No good parallel is known, mainly because iron torques are less common than bronze ones.

More dating evidence is provided by the typology of the burial monuments. The two concentric enclosures were both incomplete so we do not know whether there were any openings originally. One of the six rectangular enclosures was interrupted in the (north-) east, which is uncommon for Iron Age graves. In three other cases there might have been an opening in the south-east. The rectangular enclosures that have been found in the southern part of the Netherlands date from the Middle Iron Age onwards. The rectangular ends of the long bed, however, date it to the Early Iron Age (Roymans 1988a, 97). This evidence explains — or is confirmed by — the fact that the feature of the long bed was intersected by that of one of the rectangular monuments. According to Verwers, that is certain evidence that the two features are not contemporary (Verwers 1966a, 41).

The form of burial also provides indications that can help date the cemetery. In only four graves had the cremated bone been deposited in an urn. Three monuments contained no interments at all. It is possible that the cremated remains had been buried in shallow pits and disappeared during digging activities in the Middle Ages. If that is the case it is not very likely that the remains had been deposited in urns because none of the other interments in urns were surrounded by an enclosure. That means that 84% of the graves contained no urn. The practice of burying cremation remains without an urn was most common in the Bronze Age and the Middle Iron Age. Therefore part of the urnfield at least can be dated to the latter period.

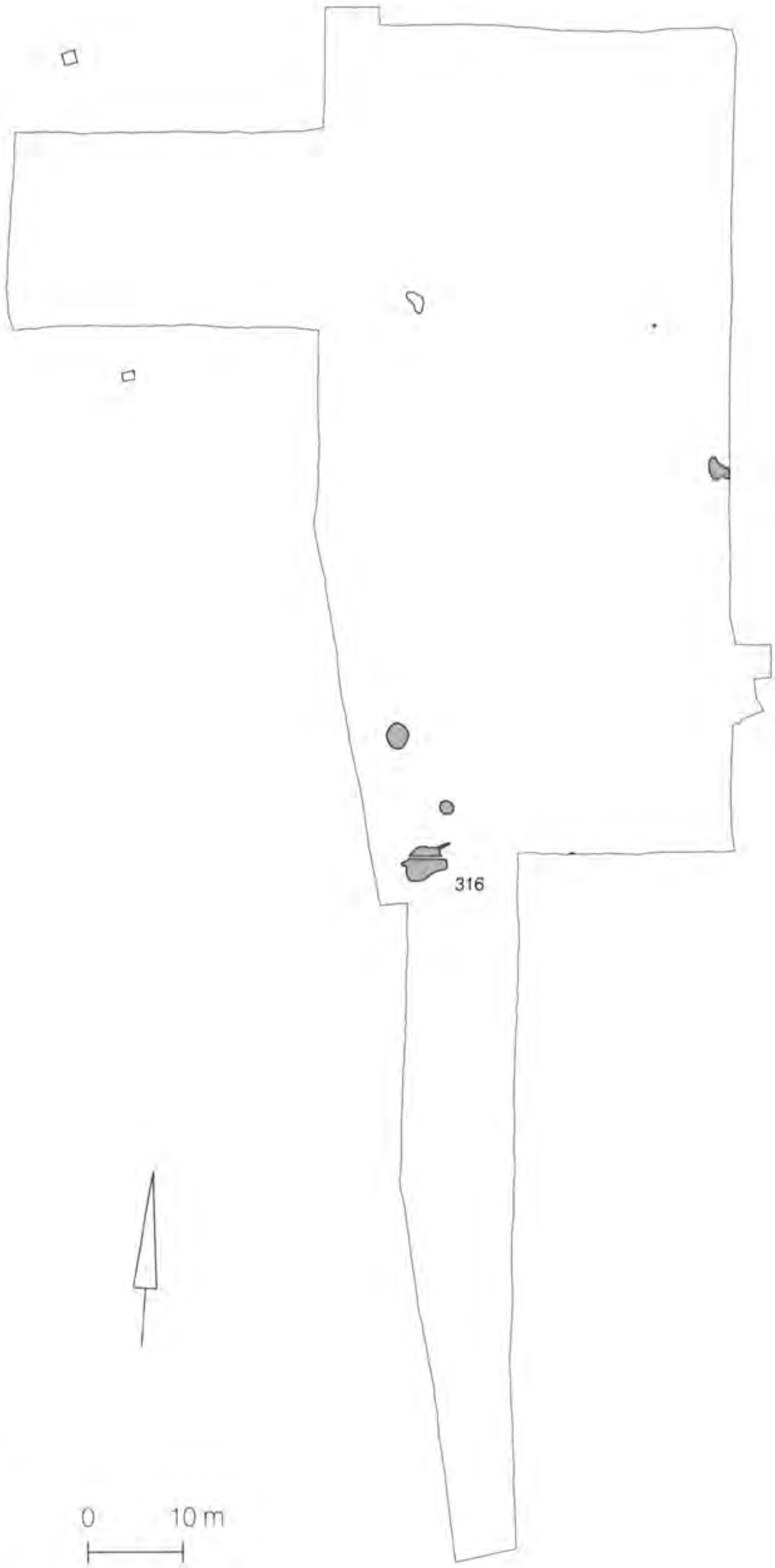


Figure 5. Oss-IJsselstraat: plan of the features from the Late Neolithic or Early Bronze Age (indicated in white) and the Middle Bronze Age (indicated in grey, the well is numbered).

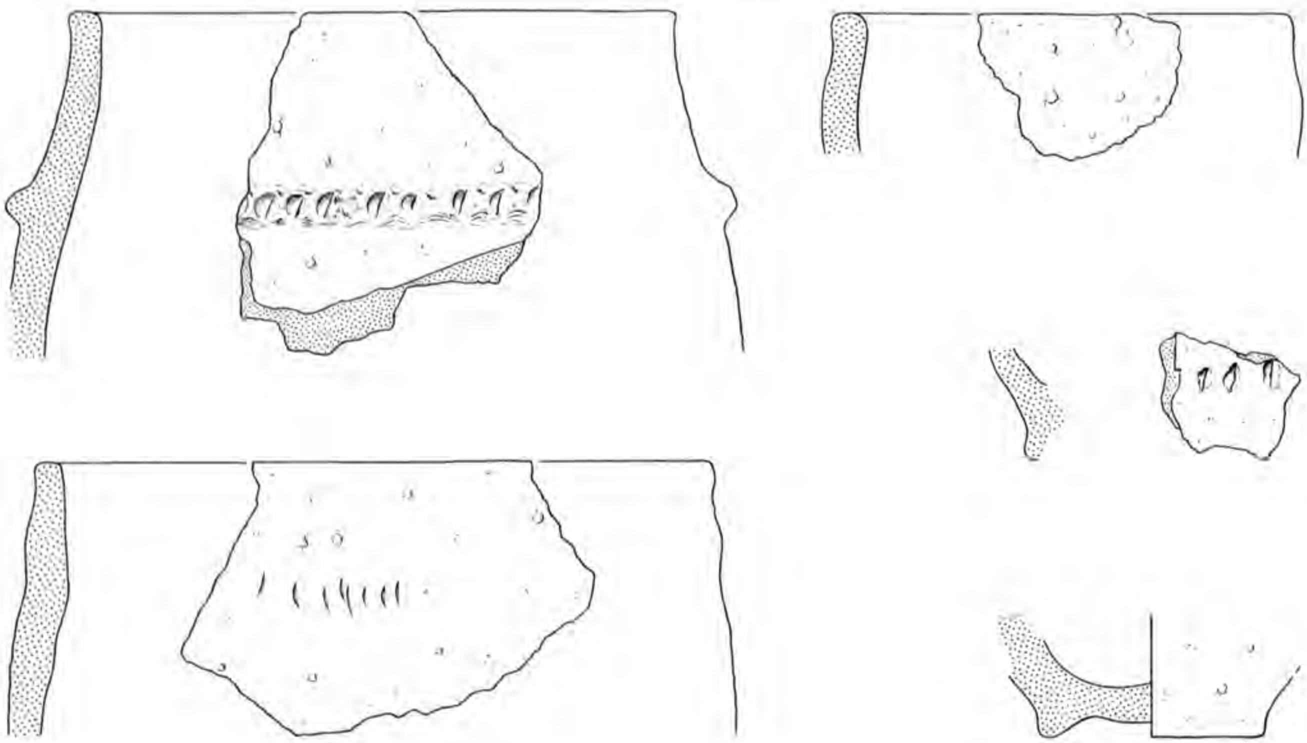


Figure 6. Some Middle Bronze Age *Drakenstein* sherds; scale 1:2.

The combination of the various forms of evidence dates the graves to the Early and Middle Iron Age.[11] That would mean that the urnfield was used for a long period. That could not be confirmed on the basis of the size of the cemetery, as it was not completely excavated.

Unfortunately we know nothing about the age and sex of the deceased as no physical-anthropological research was carried out.[12] Grave goods were scarce. The iron torque recovered from grave No. 3 was found among the cremation remains. Grave No. 7 yielded some fragments of iron that could not be identified; grave No. 4 contained the remains of an iron knife or dagger and fragments of an unidentified bronze object.

As the urnfield was not investigated in its entirety, the size of the settlement of the people who buried their dead at the IJsselstraat site can be only roughly estimated. On the assumption that the cemetery dates from the Iron Age, the settlement probably comprised a single farmstead. The fact that the cemetery was used for a long period makes it unlikely that the settlement was any larger.

The difference between the IJsselstraat evidence and that of Ussen is striking: whereas the burial rite practised at the IJsselstraat site fits in with the common urnfield tradition of burial in clustered graves, only scattered graves were found at Ussen, one of which contained an urn (Van der Sanden 1994). Another remarkable fact is that houses had been built on top of the IJsselstraat urnfield in the Roman period. Apparently the occupants lacked the respect for the former inhabitants of the area observed at other sites (Roymans/Kortlang 1993, 39; Roymans/Tol 1993, 55).

7. A settlement from the Roman period

The earliest house plans found within the excavated area date from the Roman period. In addition to five or six house plans various other features were found, including wells, granaries, an outbuilding, several rows of postholes and ditches. Together these features represent the plans of the individual farmyards of which the settlement was composed. The various categories of features will be described separately in the following sections.

7.1 House plans

A total of five or possibly six house plans from the Roman period were unearthed. They were all oriented north-east/south-west. None of the plans could be precisely

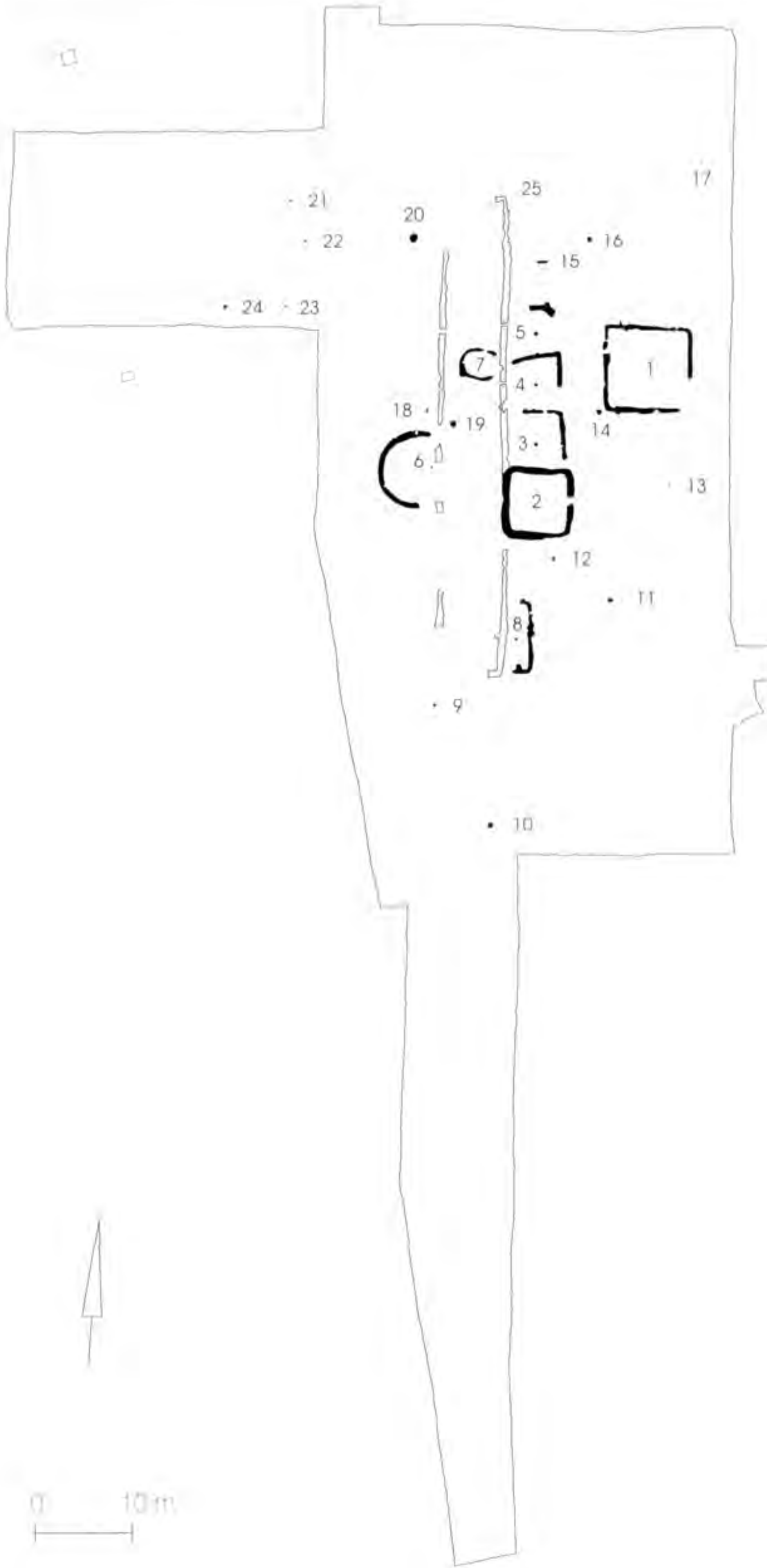


Figure 7. Oss-IJsselstraat: plan of the Iron Age urnfield; the long bed (No. 25) is indicated in grey.

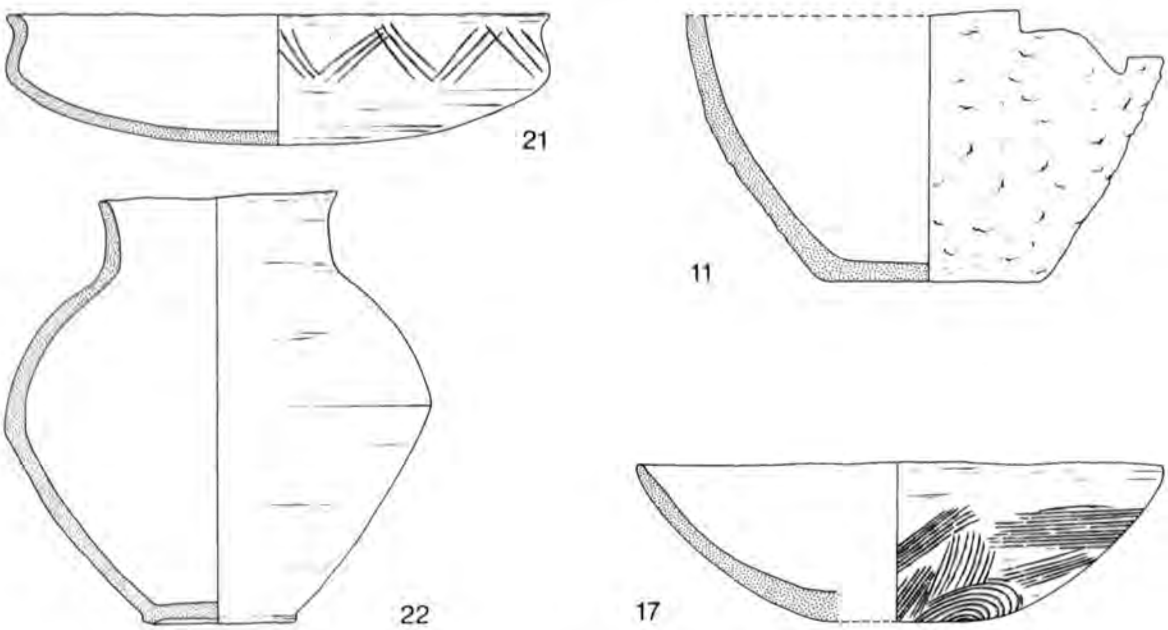


Figure 8. Urns found in the Iron Age graves; with grave numbers; scale 1:4.

dated on the basis of house plan typology[13] or associated finds. In some cases a relative chronology could be inferred from intersections.

7.1.1 House 1

House 1, which had a foundation trench, measured 16.7 × 6 m (fig. 10).[14] The plan was partly two-aisled, partly three-aisled. The remains of two wooden roof supports had been preserved along the central axis of the two-aisled part, which was 9 m long. Inside the three-aisled part, which was 7.7 m long, were two sets of roof supports. The wall, which was probably of wattlework and was founded in the trench, was in some places supported by (paired) wall posts. The house was probably covered by a hipped roof. The northern entrance seemed to have had a protruding structure, the south-east side of which had disappeared when a pit was later dug in that area.

Most of the similar houses whose plans were found at Ussen had roof supports outside the walls and were larger: the minimum length and width recorded at Ussen are 18.3 and 7.2 m, respectively.

The only find assemblage that could be associated with this plan with certainty[15] consisted of four clay sling pellets and 14 fragments of native Roman pottery (phase M-N, AD 0-150, Van den Broeke 1987b, 111).

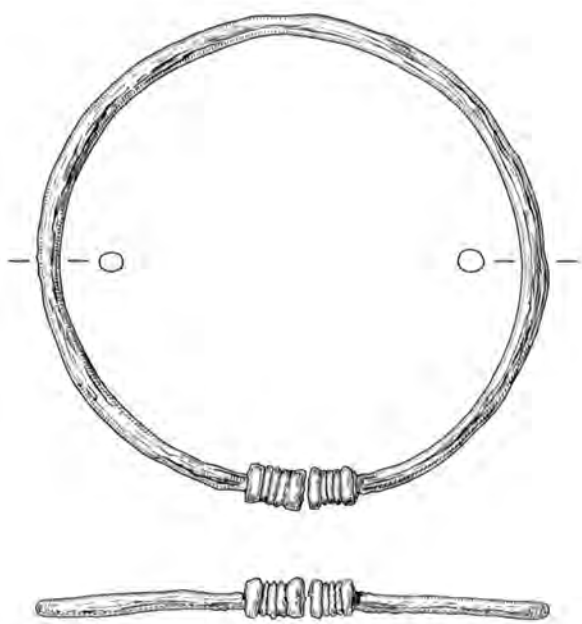


Figure 9. Iron torque found in grave No. 3; scale 1:2.

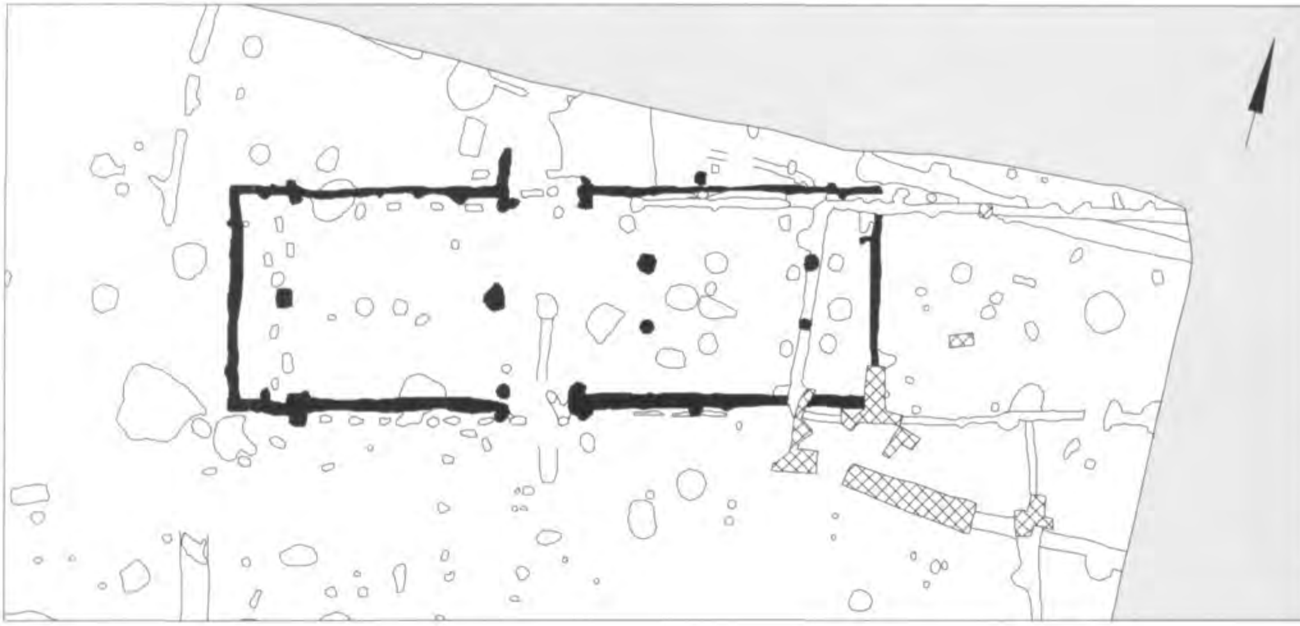


Figure 10. Plan of House 1; scale 1:200.

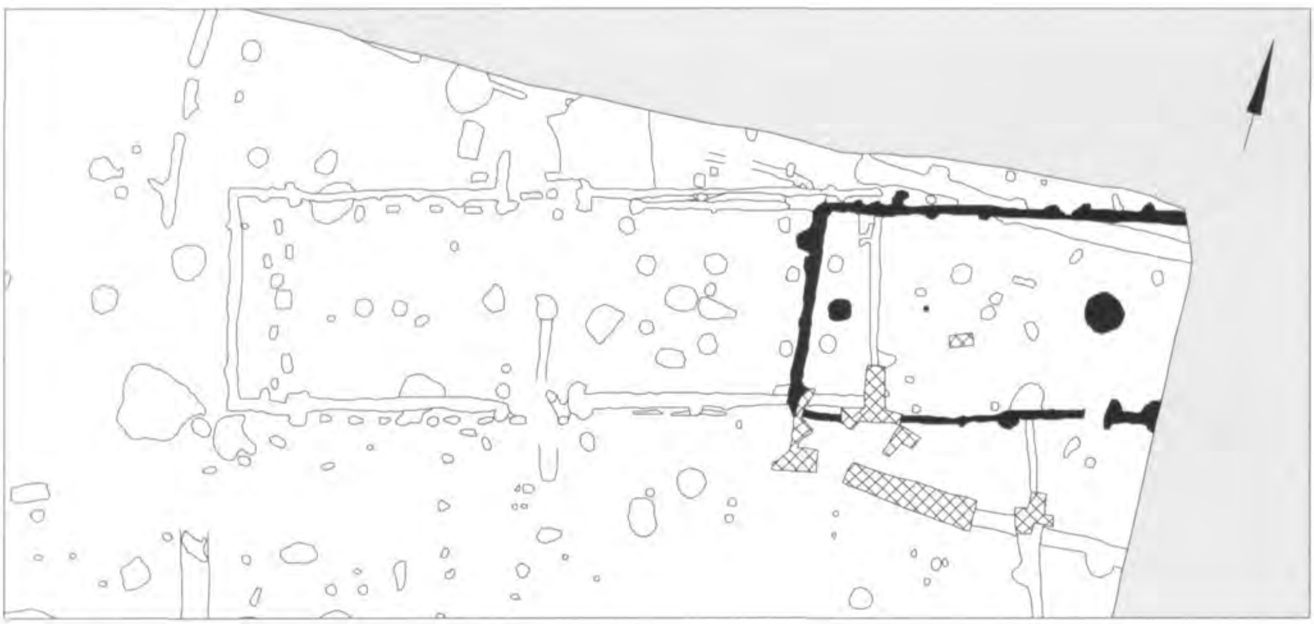


Figure 11. Plan of House 2; scale 1:200.

7.1.2 House 2

The plan of House 1 was intersected by that of House 2, which also had a foundation trench on the east side. The north-east part of this house plan was not excavated (fig. 11), which means that we do not know the original length of the building (>10 m); its width was 6 m. The roof of the two-aisled south-west part was supported by three posts. The entrances were probably in the north-east part, which is also likely to have been two-aisled, since the roofs of two-aisled parts of partly two-, partly three-aisled buildings were usually supported by only two posts. The entrances of such buildings were usually next to the second roof support. The wall was probably of wattlework, supported by wall posts. The excavated part of the house was

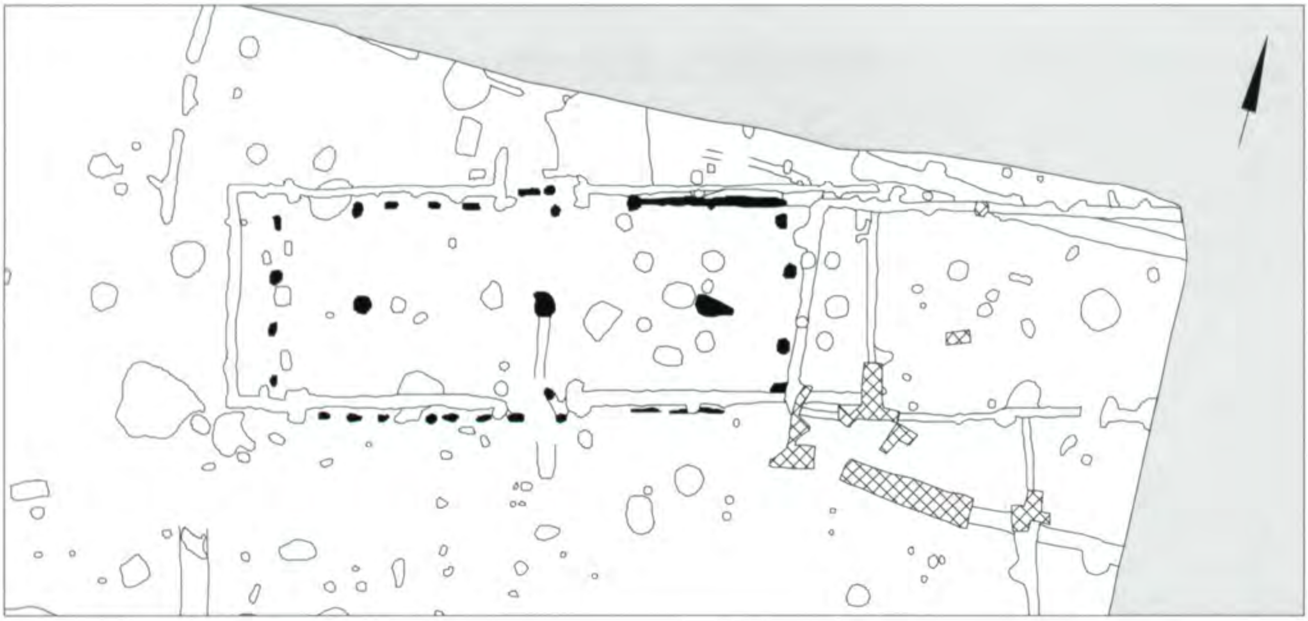


Figure 12. Plan of House 3; scale 1:200.

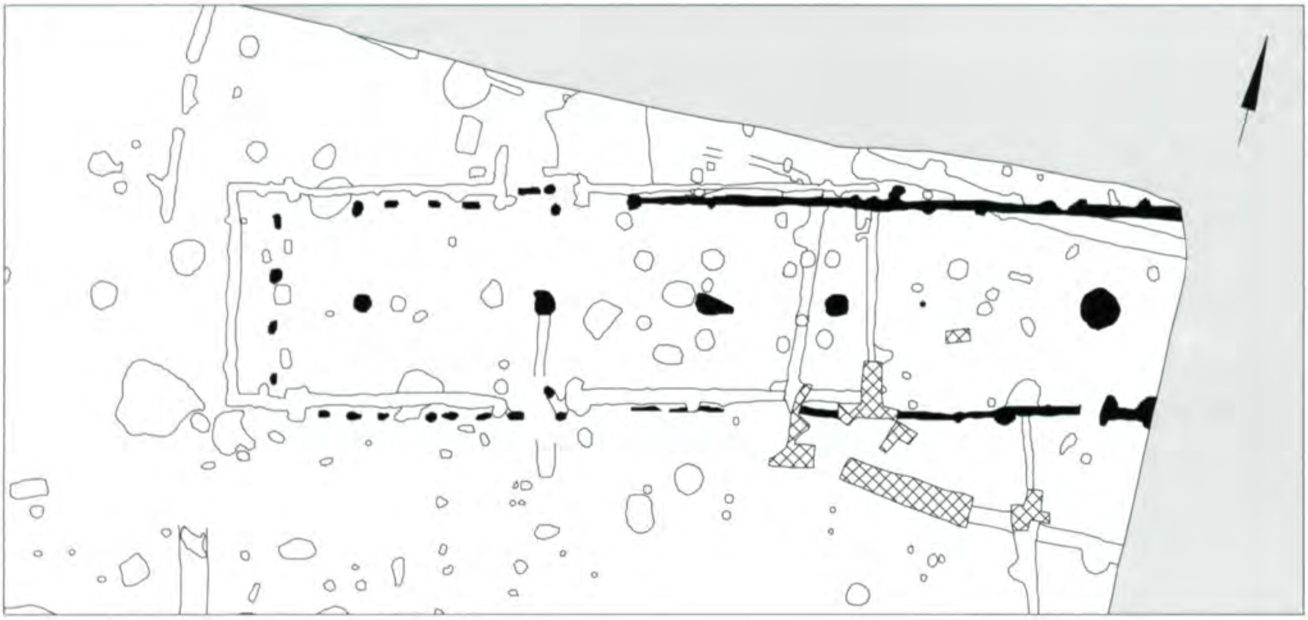


Figure 13. Combined plan of House 2/3; scale 1:200.

covered by a hipped roof; the other part might have had a saddle roof.

This plan did not have any postholes outside the walls. The south-west short wall was somewhat askew.

The postholes and wall trenches of House 2 yielded only four sherds, three of which could be identified as native Roman pottery.[16] The fourth was Roman wheel-turned ware, but could not be identified more precisely.

7.1.3 House 3

The plan of House 3 (fig. 12) was intersected by that of House 1 and is therefore the oldest of the three northern house plans. With its length of 13.5 m and its width of 6 m

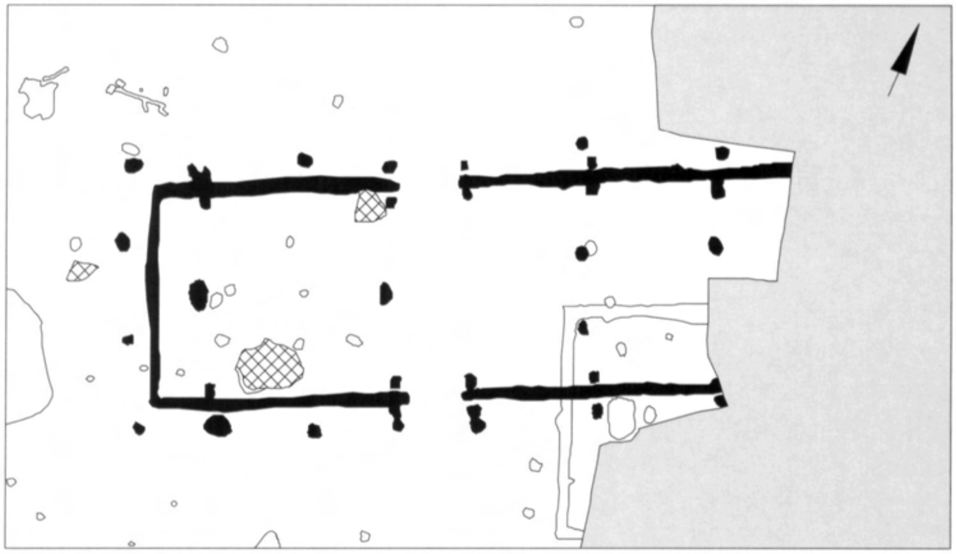


Figure 14. Plan of House 4; scale 1:200.

it is also the smallest of the three. The plan is two-aisled, with a wall trench on the north-east short side. The remains of three roof supports were found along the central axis. The entrances were in the long walls, parallel to the central roof support. There may have been a third entrance in the north-east short side. The building was covered by a hipped roof.

The wall posts may have served to support the roof, as no postholes were observed outside the walls. The posts of the postholes on the south-west side may have stood in a foundation trench originally.

A similar plan, which probably dates from the 1st century AD, was discovered at Beegden (Roymans 1988b, 114).

No finds could be associated with House 3 with any certainty. A piece of quartzite and six fragments of handmade native pottery may have come from one of the postholes (see also note 16).

7.1.4 House 2/3

An alternative reconstruction can be obtained by combining the plans of Houses 2 and 3 (fig. 13). That results in a longer plan of the same type, with a total of six roof supports along the central axis, measuring >24 m × 6 m. The intersections discovered during the excavation allow for this reconstruction, while the (relative) date of the plan does not change either: this plan would still be older than that of House 1. The intersection of plan 1 by plan 2 is solely a result of the reconstruction of House 2: no such an intersection was observed during the excavation. This solution eliminates the problem of the oblique angle of House 2, but it does mean that part of the ditch would have been unused. It may have contained a partition wall in one of the two houses. It is unlikely that this house was much longer than 24 m.

7.1.5 House 4

House 4 measured >17.5 m × 7 m (fig. 14). It had a foundation trench and was partly two-, partly three-aisled, with two roof supports in the two-aisled part and at least two sets of roof supports in the three-aisled part. The north-east end was not excavated; the house may have been two-aisled with a three-aisled middle part. Remains of the oak roof supports were found in the two postholes of the two-aisled part. The entrances were situated opposite one another in the long walls, near the second roof support of the two-aisled part. The foundation trench probably held a wattlework wall supported by evenly spaced paired wall posts. There were roof supports outside the walls. In comparison with similar plans found at Oss-Ussen (with widths of 7.7 - 8.4 m), plan 4 is rather small. The aisles, however, are of more or less the same width as in Ussen (1.7 - 2 m), so the three-aisled part may have been a byre.

The postholes of this house yielded 13 pottery fragments. Eleven sherds could be identified as handmade native pottery. The remaining two were identified as prehistoric and possibly Roman, respectively.

7.1.6 House 5

The south-east corner of plan 4 was intersected by the plan of House 5 (fig. 15). Only a small part of this last plan was excavated (measurements >3.5 m × 6 m). The excavated part of the plan had a foundation trench and at least one posthole along the central axis of the two-aisled south-east part, indicating a hipped roof. Only one posthole may have held a roof support outside the wall.

The find assemblage from House 5 comprised only three pottery fragments: one prehistoric fragment and two handmade (native) sherds.

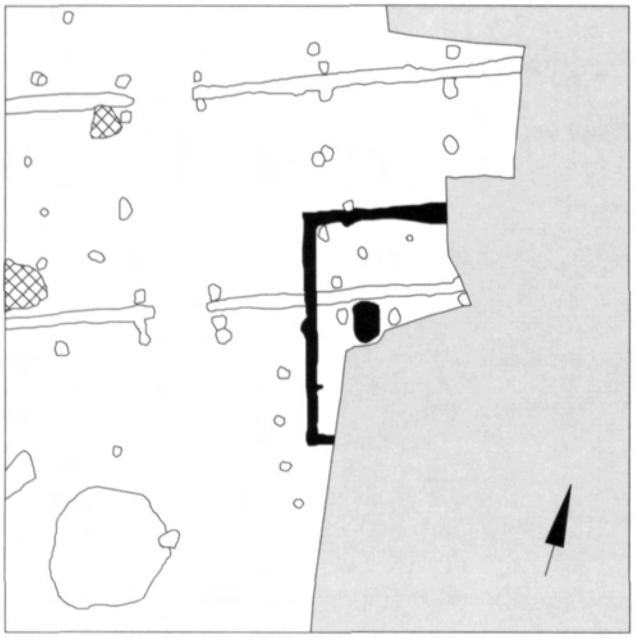


Figure 15. Plan of House 5; scale 1:200.

7.1.7 House 6

House 6 measured 17.5 m × 8.2 m (fig. 16). This two-aisled house had a foundation trench and three roof supports along the central axis. One of the postholes still contained the remains of an oak post. The entrances were situated opposite one another in the long walls, near the second roof support. There may have been a third entrance in the north-east short wall. All around the walls were roof supports at evenly spaced intervals (0.5 - 1 m).

The postholes and wall trenches of House 6 yielded 171 pottery fragments, 153 of which could be identified as handmade native pottery. Twelve sherds, including one piece of Samian ware, proved to be Roman wheel-turned material. The remaining sherds could not be identified. Other finds included pieces of quartzite, part of a spindle whorl, a piece of green glass and an iron nail. A pit discovered inside the house contained 21 pottery fragments, 16 of which were of Roman wheel-turned ware. They included fragments of cooking pots (Stuart 1963, type 201) and a wall sherd of a *terra nigra* 'pearl urn' (Holwerda 1941, type 28). However, since this pit did not form part of the original plan of the house, these finds could not be used to date the house.

7.2 Outbuildings

One of the plans unearthed at the IJsselstraat site was identified as the feature of an outbuilding (fig. 17), mainly on the basis of its proportions (10.4 × 4.8 m), which were too small for a dwelling. The building had the same orientation as the houses, namely north-east/south-west.

The plan was partly two-, partly three-aisled. There was a foundation trench along the north-east side. A roof support had been founded at the centre of this trench. The three-aisled part was only 1 metre long and had contained one pair of roof supports. The entrance, which was in the northern long wall, separated the two-aisled part from the three-aisled part. The outlines of the south-west part of the plan were marked by postholes.

At Oss-Ussen (Schinkel 1994) the plan of a similar building (B2) was found. There too, a roof support had been founded in the trench of the short north-east wall. The Ussen plan was a little shorter though (9.2 m). If the IJsselstraat building extended no further than the second roof support (viewed from the north-west), its length would have been comparable with that of the Ussen outbuilding.

Pottery from the Ussen outbuilding B2 dated it to the Roman period. The IJsselstraat outbuilding did not yield any finds, but in view of its similarity to building B2 and its association with the surrounding structures it too may be dated to the Roman period. The function of the building is not certain; it may have been used for storage or industrial purposes, but no indications of any such activities were found.

7.3 Granaries

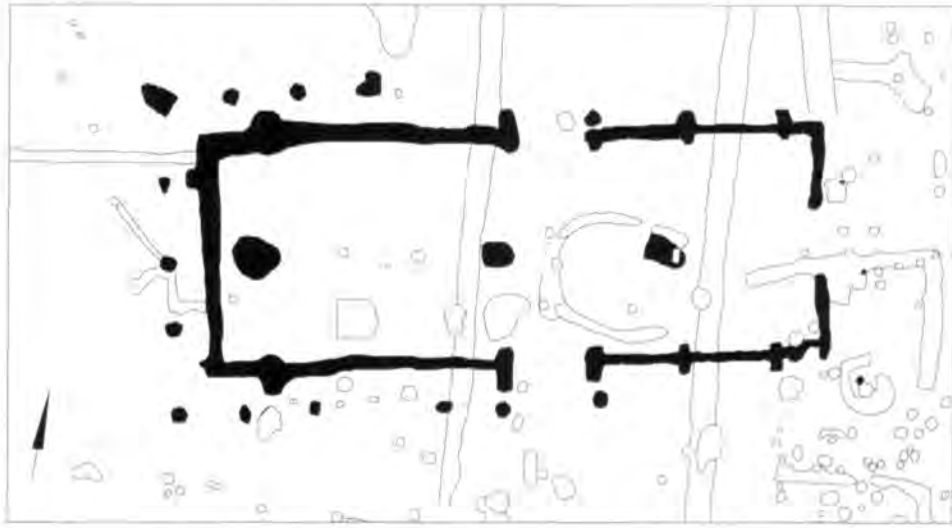
A separate category of small outbuildings is that of the granaries. Four granaries were identified at the IJsselstraat site (fig. 18). Two had a total of four posts, the other two were of a narrower, six-post type. It is quite possible that there were more granaries whose features were not recognised during the excavation; identifying symmetrical posthole configurations in excavation plans requires caution.

The dates of the structures are not certain: only one posthole, belonging to the northernmost four-post granary, contained a find: a wall fragment of (handmade) native pottery. The features could not be dated on typological grounds either, as four- and six-post granaries are known from the Bronze Age, the Iron Age and the Roman period. Moreover, 84% of the granaries identified at Ussen yielded no finds (Schinkel 1994, part II, 143-145). As all of the houses of the IJsselstraat site have been dated to the Roman period, it is plausible — but not certain — that the granaries are of the same date. A more convincing argument for dating the granaries to the Roman period is their possible association with rows of postholes from the Roman period (see section 7.5 below).

7.4 Wells

Six wells from the Roman period were found in the excavated area (fig. 19). Parts of wooden lining had been

Figure 16. Plan of House 6; scale 1:200.



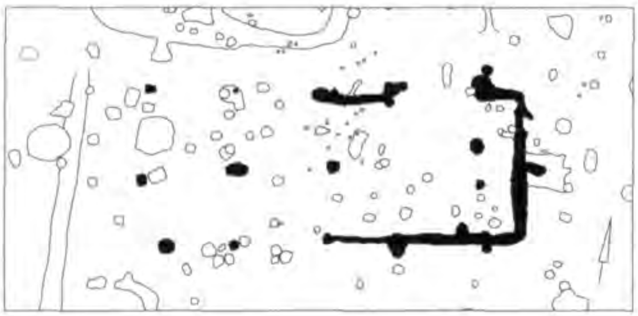


Figure 17. Plan of an outbuilding, scale 1:200.

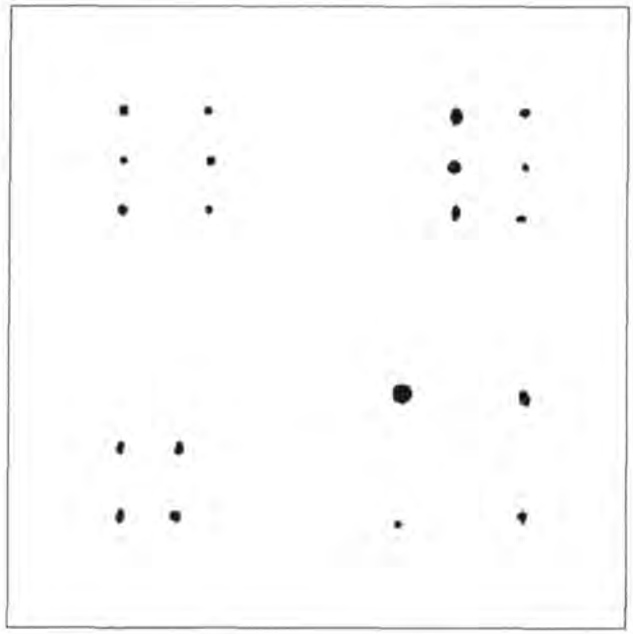


Figure 18. Plans of four granaries, scale 1:200.

preserved in five of these wells. The lining of the sixth well may have been removed. Almost all types of linings of the Roman period were represented in the IJsselstraat: wattlework, a hollowed-out tree trunk and timber planks forming a well with a square cross section. Almost all of the linings were of oak[17], which was the most popular kind of wood for Roman wells (Schinkel 1994, part II, 29). Alder had been used twice: for part of the wattle in well No. 46 and for a peg in well No. 303. Wells Nos 48 and 303 both yielded a piece of willow, but unfortunately it is not clear from the records whether they formed part of the linings.

During the excavation the finds recovered from the soil overlying the wells were not kept separately from the finds from the fills and therefore the wells cannot be dated precisely. None of the wells can have been completely filled up before AD 150 (fig. 20). The native: imported pottery ratio can be used to obtain an indication of the relative age of the wells. According to that ratio, well No. 48 could be older than the nearby well No. 46. It is striking that well No. 353, which contained the largest amount of imported pottery, also yielded the earliest C14 date.

The C14 dates obtained for the timber linings (shown in tab. 2 with a probability of 95.4%) indicate a *terminus post quem* for the construction of the wells. Where no C14 date was available the earliest possible date for the imported pottery was used. Together these dates indicate the periods from when the wells were constructed and started to be used until they were finally filled up. In table 2 the date AD 175 is used as a rough estimate of the time when the

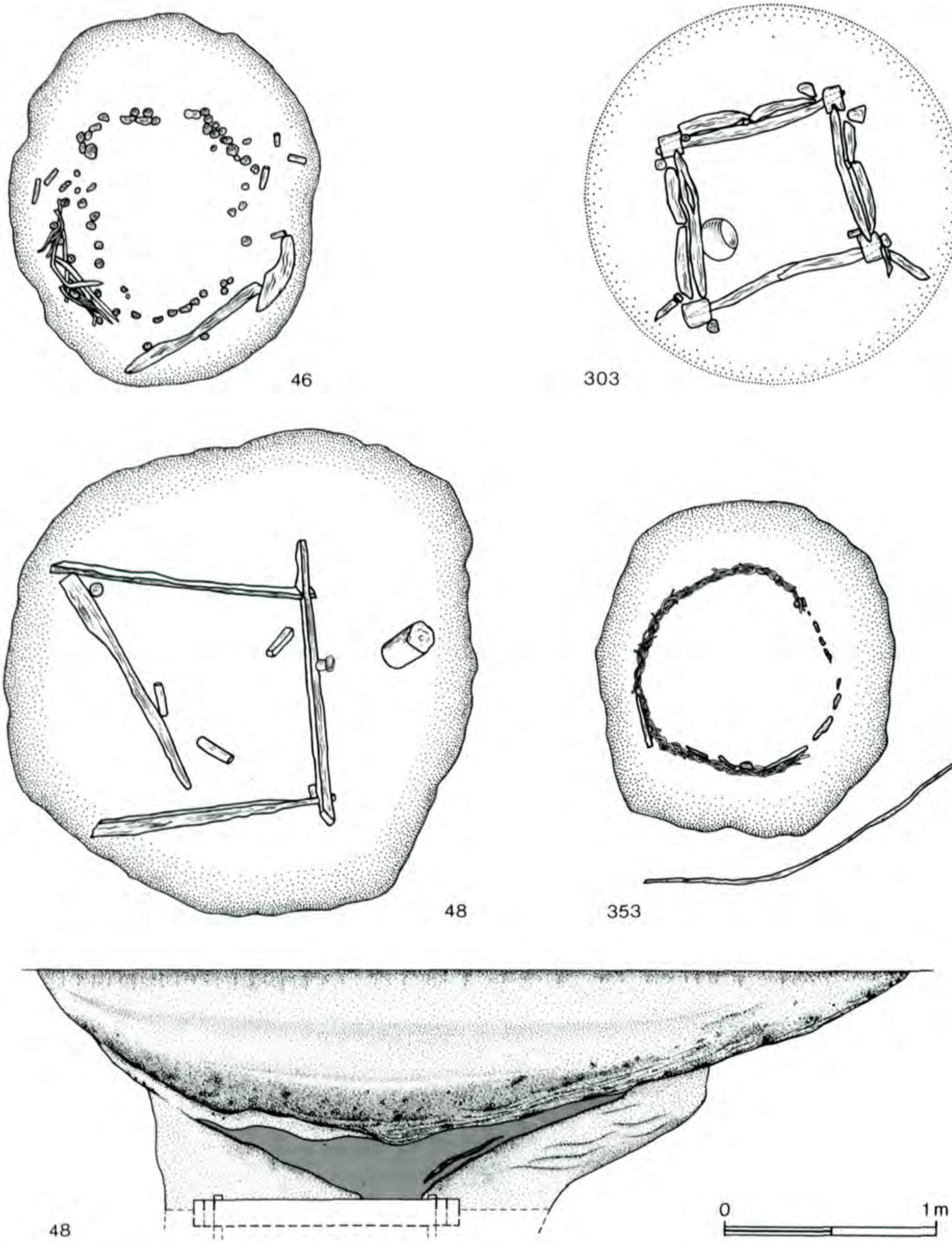


Figure 19. Plans and one section of four wells, showing the construction.

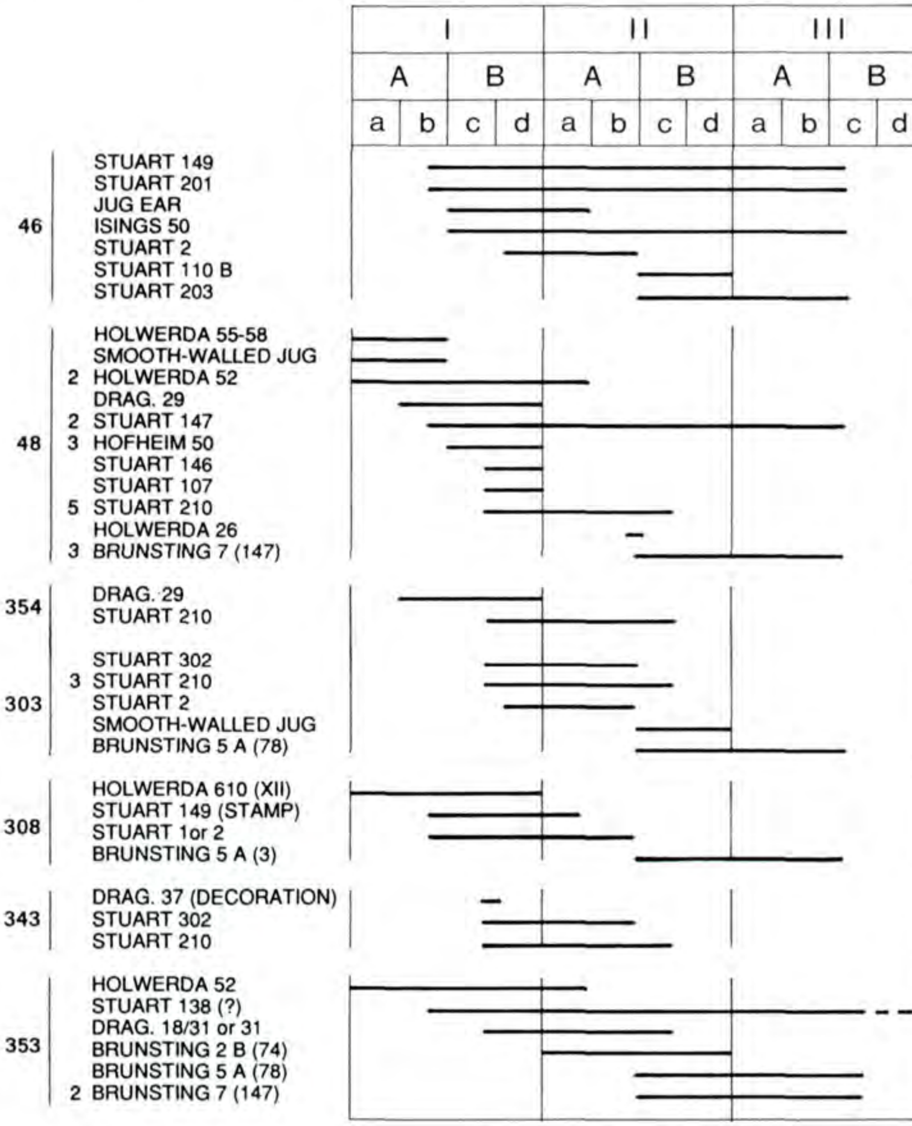


Figure 20. Oss-IJsselstraat: dating of the Roman wheel-turned pottery from wells (well numbers on the left).

Table 2. The wells from the Roman period

well number	diametre (cm)	depth (cm)	C14 date	period
46	320	50	GrN-10703: 1845±40 BP (AD 82-316 cal.)	AD 82-175
48	400	110	GrN-10704: 1980±35 BP (AD 40-116 cal.)	AD 40-175
303	400	?	-	AD 70-175
308	350	50	GrN-10705: 1895±30 BP (AD 72-218 cal.)	AD 72-175
343	360	?	-	AD 70-175
353	340	?	GrN-10706: 2045±35 BP (156 cal. BC - AD 62 cal.)	AD 50-175

wells were ultimately filled up; theoretically this could have been any date after AD 150.

Very little is known about the length of the periods of use of (Roman) wells. Wood rot (Knippenberg 1965, 80) and the gradual silting up of the pit will have greatly limited the life of a well; it seems unlikely that a well was used for more than 5-10 years[18]. That would mean that the IJsselstraat wells were not necessarily used simultaneously.

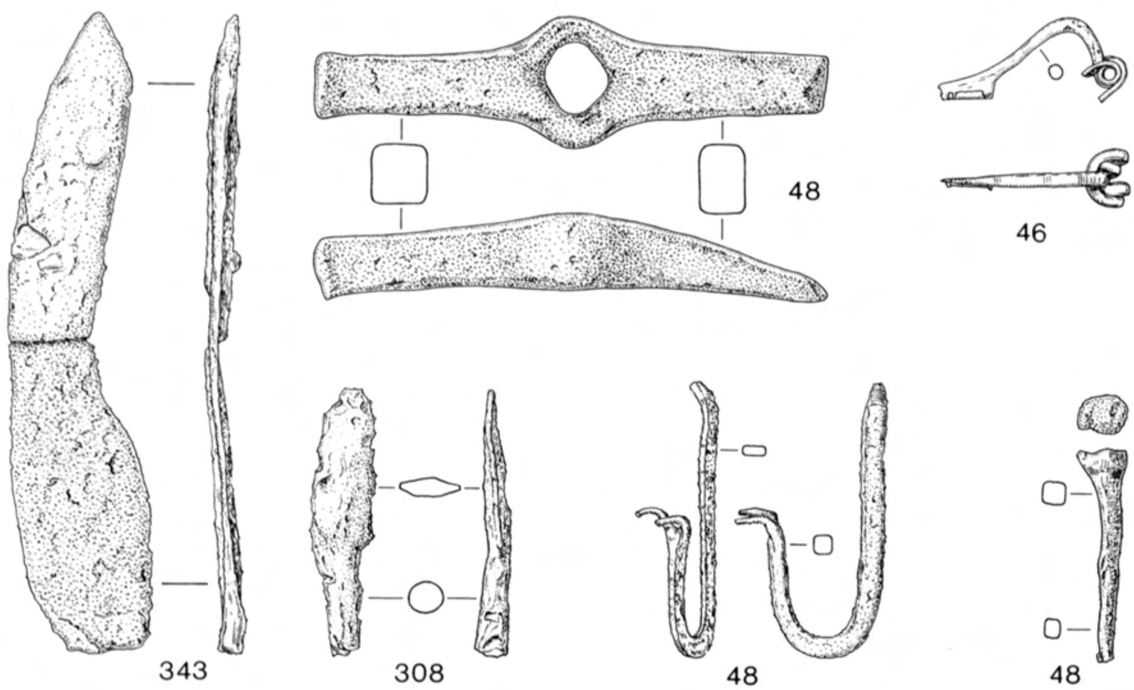


Figure 21. Metal objects from wells; scale 1:2.

The depth of the wells was not always recorded and in only three cases was the section of the well drawn.
The figures in table 2 only indicate the depth down to the (present-day) groundwater level; the depth of the wooden structure was not recorded either.

The lining of well No. 46 consisted of wattlework, held together by wooden stakes, arranged in two circles. Some of the stakes had been split lenghthwise.

Clay sods had been piled against the outside of the wattlework. A wooden log with a notch was found in the layer of soil overlying the edge of the well.

The finds from this well consisted of 57 fragments of native pottery (including coastal pottery), 106 fragments of Roman wheel-turned pottery, a lump of basalt lava, some quartzite, various boulders, slate, a fragment of an animal molar, a piece of green glass (probably part of the base of a bottle), part of a glass *La Tène* bracelet (Haevernick 7a; see also Peddemors 1975, 120, 134) and a bronze wire fibula (fig. 21).

A structure with a square cross section, made of horizontally arranged timber planks, beams and roundwood, was discovered in well No. 48.

The finds consisted of 267 fragments of native pottery (including coastal pottery), 204 fragments of Roman wheel-turned pottery, part of a kiln (?), two small clay balls, a clay sling pellet, some quartzite (possibly parts of a grindstone), various lumps of clay, possibly including wattle and daub, sandstone, basalt lava, an iron nail, an iron hook (possibly a key), an iron hammer-axe (fig. 21), a fragment of a glass *La Tène* bracelet (Haevernick 3b; see also Peddemors 1975, 120, 134), fragments of glass tableware and part of a dark-blue glass bead. There was also a small amount of charcoal and eight fragments of animal molars.

Well No. 303 was lined with a structure with a square cross section comprising both horizontally and vertically placed planks, connected via dowelled joints.

The finds from this well included 136 fragments of native pottery, 54 fragments of Roman wheel-turned pottery, a small piece of iron (probably part of a nail), several lumps of loam, fragments of animal molars and a grindstone or polishing stone.

The lining of well No. 308 consisted of a hollowed-out oak tree trunk with a diameter of 90 cm.

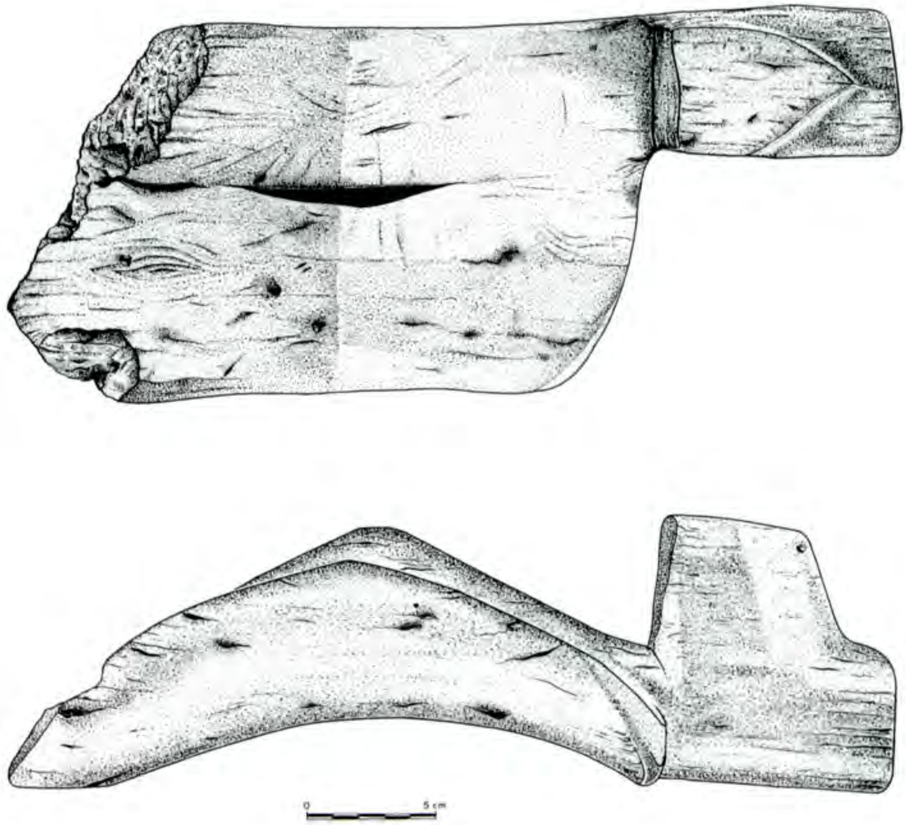


Figure 22. Wooden yoke from well No. 308.

The finds included 10 fragments of native pottery, 24 fragments of Roman wheel-turned pottery, an iron spearhead, lumps of basalt lava, loam, a lump of granite, what may have been a fragment of a rooftile and part of a wooden yoke (fig. 22; see also Van den Broeke/Verwers 1977).

No lining was found in pit No. 343. As no drawing was made of the section of the well we do not know whether there was never a lining in the well or whether there had been one originally, which was later removed. The feature was recorded as a well during the excavation and it will therefore be regarded as that here.

This pit yielded 96 fragments of native pottery, 25 fragments of Roman wheel-turned pottery, a fragment of a spindle whorl, a fragment of a basalt lava quern, fragments of grindstones made of sandstone and quartzite, a retouched flint flake, a fragment of a bronze fibula, an iron knife (fig. 21) and three iron nails.

Well No. 353 was the second well with a round cross section lined with wattlework held together by wooden stakes. Several wooden planks had been placed around the edge of the well, probably as a form of reinforcement.

The finds from this well included 2 fragments of native pottery, 42 fragments of Roman wheel-turned pottery, a retouched flint flake (possibly an arrowhead) and a fragment of a basalt lava grindstone.

The (relative) dates of the wells (tab. 2, fig. 20) do not provide any clues as to which well was associated with which house. The relatively small distance between wells Nos 48 and 46 and the small difference in date suggest that No. 48 was the predecessor of No. 46. This interpretation is in accordance with the layout of the site: House 5 (with well No. 46) may have been the direct successor of House 4 (with well No. 48). A number of other combinations can be made in the same way: House 6 with well No. 303 or well

No. 305, House 1/2/3 with well No. 343 or well No. 303 and the outbuilding with well No. 308. That way, all the wells would be situated to the west of the buildings.

Little is known about the position of the wells with respect to the houses or about the distance between the houses and the wells. Moreover, as the settlement was not completely excavated, the original number of houses in proportion to the number of wells may have been different from what can be concluded from the plan of the excavated area.

7.6 Rows of postholes

Two rows of postholes were found which may have held the posts of fences or palisades. From the south side of well No. 48 a row of postholes extended in a south-westerly direction, probably beyond the limit of the excavated area (fig. 23). The postholes had an average diameter of 25 cm and an average depth of 16 cm (originally about 60 cm); the distance between the postholes varied from 150 to 200 cm. At one point the distance between two postholes was 370 cm; there may have been a gap in the fence or palisade at this point. In some places the posts were paired.

The posts of this row probably served to mark the limits of a yard. Similar associations between postholes and wells were also observed at Ussen (Fokkens 1991c, 100; Schinkel 1994, part II, 227), where the fences are thought to have served to keep the cattle away from the wells. The (wide) spaces between the posts of the IJsselstraat fence must have been filled up with wattlework or horizontal beams. The row of postholes had the same orientation as House 4 and lay in line with the house's southern long wall. The feature of a four-post granary was observed parallel to the palisade. All these features (well, house, granary) lay to the north of the row of postholes. Cattle may have been driven out through the southern opening or through a (not excavated) opening in the north-east short wall of what is thought to have been the byre.

The postholes did not yield any finds; they were dated to the Roman period on the basis of the association with House 4 and well No. 48.

The second row of postholes was also oriented north-east/south-west. It extended from the short end of House 6 in a north-easterly direction, possibly beyond the limit of the excavated area (fig. 23). The average diameter of the postholes was 20 cm, the average depth 17 cm. The distance between the postholes varied from 20 to 110 cm. Some of the posts may have been paired.

Although its structure will have differed slightly, the fence that was supported by the posts of this row of postholes may be compared with the fence discussed above. In this case too, the nearby house plan (House 6) had the same orientation. The association with this house was reinforced by the fact that the row of postholes extended into the entrance in the north-east short wall. And in this case too the feature of an (undated) granary was observed parallel to the palisade. Unlike the house, the granary lay to the south of the row of postholes. House 6 had no three-aisled part, but may have contained a byre at its north-east end. If so, cattle may have been driven out through the entrance to the byre, the fence serving to keep the animals away from the granary. South of the granary a short row of postholes was found to run parallel to the palisade. They may have held the posts of a fence-like structure, associated with the palisade and the granary.

The association with House 6 dates the row of postholes to the Roman period, which is neither denied nor confirmed by the few finds.

7.7 Ditches

The excavation plan shows about ten ditches and stretches of ditches. None of those ditches form part of house plans. Their lengths vary from 1 m to 23 m; not one of the ditches had been preserved in its entirety. Most of them were shallow, which suggests that an unknown number of ditches may have been completely or partly overlooked in the excavation. Originally, however, the ditches will have been about 40 cm deeper (see section 3) and hence not as shallow as they seemed at the time of the excavation.

Some of the ditches could be associated with a feature (well or pit). The same explanation as proposed for the rows of postholes above may apply for those associations. However, none of the associations is clear enough to alow any conclusions to be drawn about the layout of the settlement site.

It is possible that the IJsselstraat settlement was enclosed by boundary ditches. As only part of the site was excavated, the only ditches that could be interpreted as parts of such a settlement enclosure are those observed in the southern and western parts of the site, where the limits of the settlement may have been reached.

The southern ditch, a rather irregular ditch which came to light *c.* 10 m to the south of well No. 316 (figs. 3, 5), could hypothetically have marked the southern limit of the settlement. It had an average width of 50 cm and an average depth of only 15 cm; it contained no finds. With the exception of the feature of a six-post granary there were very few features to the south of the ditch. On the whole, however, this is not enough evidence to justify an interpretation of the ditch as part of a settlement enclosure. Its small dimensions and irregular layout in particular make such a function unlikely. The ditches that enclosed a similar settlement at Ussen (Zomerhof) had an average depth of 40 cm (Raemaekers 1993, 31), which would have been about 70 cm originally.

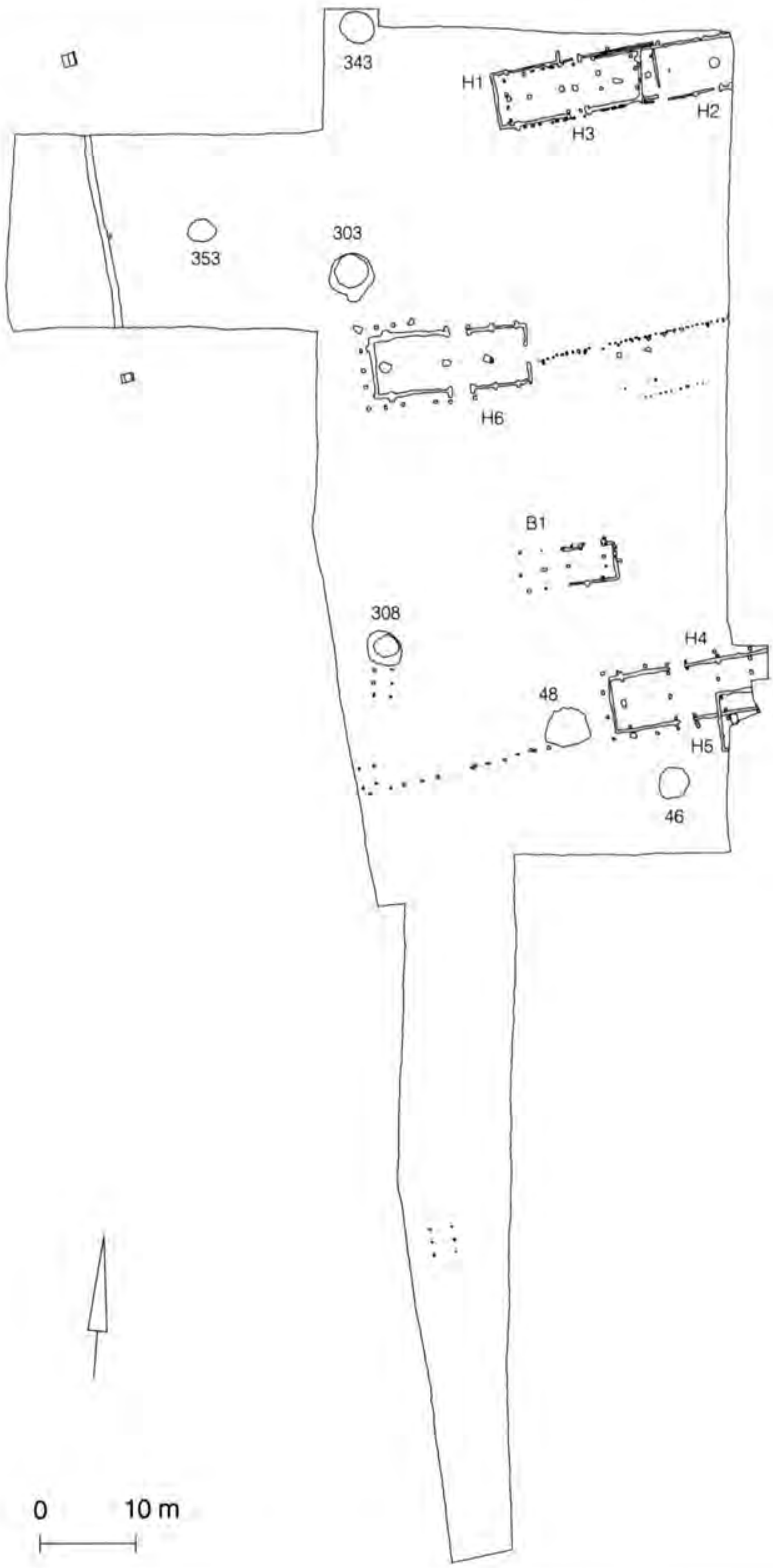


Figure 23. Oss-IJsselstraat: plan of the native Roman settlement.

The western ditch (fig. 23), which was oriented north-west/south-east, may have marked the western limit of the settlement. Two small trial trenches showed that this ditch extended at least 7 m beyond the limits of the excavated area in both directions, which brings its total length to at least 33 m. The ditch had a width of 80 cm and an average depth of 25 cm, both measured from the excavation level. A protrusion was observed along the eastern border of this ditch and may have formed part of the feature of the ditch. The ditch ran parallel to the short ends of the house plans. As only a small area was excavated to the west of the ditch we do not know whether the number of features decreased beyond this possible enclosure.

The finds from this ditch consisted of four fragments of native pottery and one smooth-walled base sherd of Roman wheel-turned ware. They would suggest a date in the Roman period for the ditch, but that is not certain. The ditch was intersected by a second, east-west oriented ditch, which yielded two fragments of native pottery and 19 fragments of Roman wheel-turned pottery. They include two rim sherds of plates of coarse ware, Stuart 1963, type 215/216, which are usually dated AD 40-120. The second ditch, which ended rather abruptly and did not seem to be associated with any other features, would have to be dated later in the Roman period than the ditch that may have marked the boundary of the settlement. The association of the latter ditch with the settlement is clear, but whether it actually served as an enclosure is uncertain.

7.8 The dating evidence provided by the pottery

Some more attention will be given to the dating evidence provided by the pottery recovered from the IJsselstraat site, as the sites of Oss-Ussen were dated mainly by studying this particular find category (Van den Broeke 1987a, 1987b). In total, 8597 sherds dating from the Roman period were found. Approximately 50% of these were of the native handmade kind of earthenware, the other 50% consisting of fragments of Roman wheel-turned pottery.

To start with the handmade category: the majority of these sherds were originally identified as 'Iron Age or native Roman pottery'. On the basis of the associated features they have since then been dated more precisely to the Roman period. Since his identification of the IJsselstraat finds, P.W. van den Broeke has distinguished a typological sequence based on the pottery found at Ussen. The assemblage from the IJsselstraat site can be placed in this sequence. Characteristic of the Roman period (phase M-N, representing the first 150 years AD) is the relative predominance of pots of type II (a closed type without a neck; see Van den Broeke 1987a, 32). This is apparent in figure 24, which shows the types of handmade pottery found in well No. 48. Other characteristics of the Roman period are the frequent occurrence of rims thickened on the outside (P.W. van den Broeke pers. comm.) and the rims decorated with spatula impressions.

Of only a small percentage (approx. 6%) of the fragments of wheel-turned pottery could the specific type of vessel to which they had belonged be identified (fig. 25). The range of types dates the settlement to the period IB-IIIA (AD 50-250). None of the plans of buildings, wells or other features could be dated more precisely. The greater part of the datable material came from the hand-dug topsoil. The spatial distribution of these finds yielded no additional information: there were no areas characterised by a predominance of pottery from a particular period.

8. Synthesis: the native Roman settlement of Oss-IJsselstraat

8.1 Size

The IJsselstraat settlement was not excavated in its entirety. A slight decrease in the number of features in the western and southern parts of the excavated area and what may be part of an enclosing ditch in the west suggested that the western and southern limits had been reached. Two small rescue excavations[19] were carried out in the area around the southern part of the original excavation. The results, consisting mainly of observations made in modern foundation trenches, indicate that the IJsselstraat settlement did not extend further southwards than the six-post granary. In the north and east the settlement extended beyond the limits of the excavation, as could be concluded from the incomplete house plans. This was confirmed by observations in building trenches directly east of the excavated area.

Local archaeologists made observations during building activities in various parts of the 'Noord' industrial estate. In most cases they recorded one or two postholes, sometimes containing pottery. Houses or other structures could not be reconstructed. The distances from the areas where these observations were made to the excavated area varied from 70 to 100 m. Spatial analysis of the Ussen data showed that those distances are too large for the features to be directly associated with those observed in the excavated area.

8.2 The settlement

The part of the settlement that could be studied comprised the remains of three farmyards, which may have been in use at the same time (fig. 23). In two of these farmyards the houses had been rebuilt on the same spot at least once. The yards were partly enclosed by rows of postholes. Scattered across the settlement were six wells, five of which contained remains of the wooden lining still *in situ*. If Houses 4 and 6 were contemporary, the exact

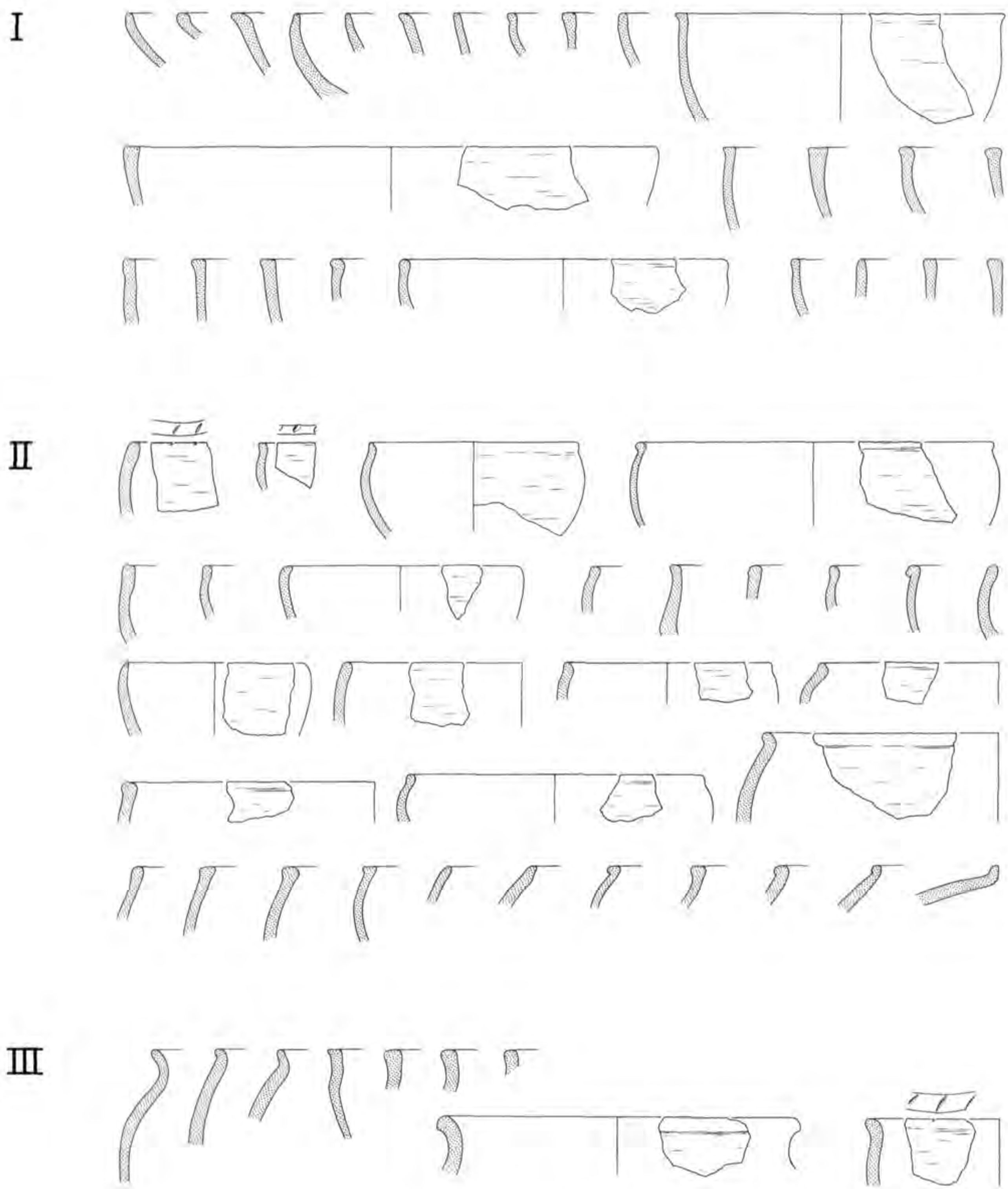


Figure 24. Oss-IJsselstraat: handmade native pottery forms from well 48; scale 1:4.

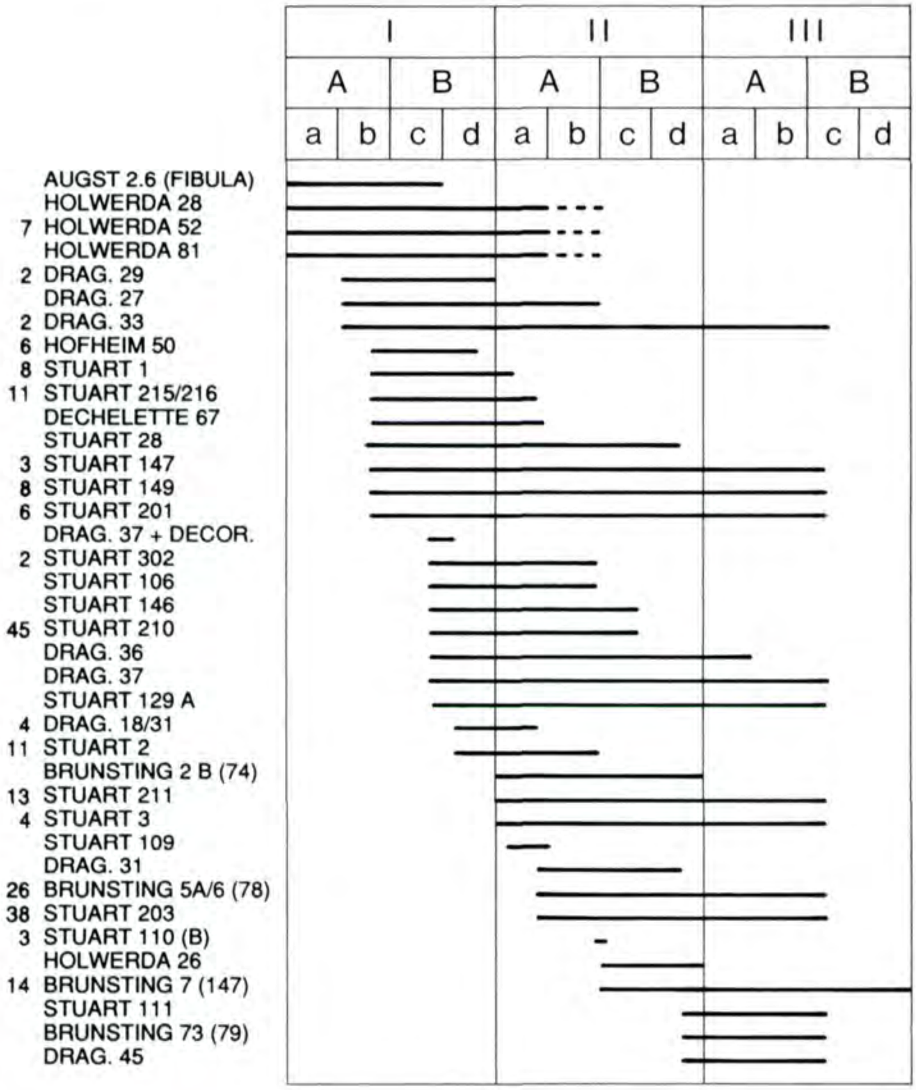


Figure 25. Oss-IJsselstraat: dating of the Roman wheel-turned pottery.

layout of their yards is uncertain. House 4 seems to have been situated south of the yard associated with it, but the southern entrance of House 6 also opened onto that area. Moreover, the granary associated with House 6 lay in the same yard. It is tempting to assume that the area between the two houses, including the outhouse and possibly one well, was communal. In that case both fences will have served to keep cattle out of the yard. What the yard of House 1/2/3 looked like is not clear, partly because the features of this farmstead lay at the edge of the excavated area.

The settlement was simple in character. Its layout was not complex and shows no signs of any hierarchy. It may have been enclosed by a shallow ditch. There is little difference between the individual house plans: none of them provided evidence for a different building style or the use of Roman building material. The material culture also gives an impression of simplicity: the Roman imported pottery (around 50%) included no unusual types (fig. 25). Other luxury goods, like glass, coins or jewellery, were found in very small quantities only.

8.3 The settlement system: some ideas

The IJsselstraat settlement is comparable in character with the Zomerhof settlement, a native Roman settlement at Ussen that was also excavated in part only (Fokkens 1993, fig. 45; Van der Sanden 1987, 59). The nine houses of the Zomerhof settlement were all two-aisled or partly two-, partly three-aisled. Five timber-lined wells were found within the excavated area (approx. 115 × 125 m). Like the IJsselstraat settlement, this settlement contained no luxury imported goods or Roman building materials. The

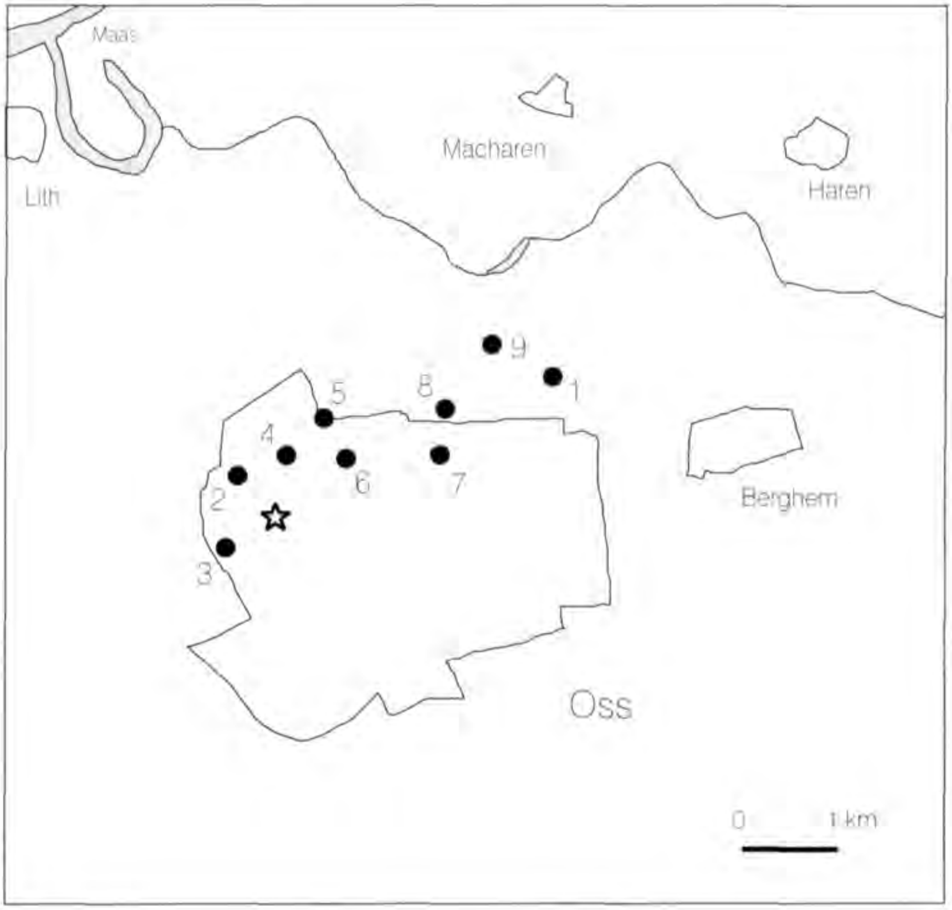


Figure 26. Oss: location of the Roman period sites.
1= IJsselstraat, 2 = Vijver, 3 = *Zomerhof*, 4 = *Westerveld*, 5 = Schalkskamp, 6 = Zaltbommelse weg, 7 = Eikenboomgaard, 8 = Horzak, 9 = Elzenburg, ☆ = cemetery.

Zomerhof settlement comprised three farmyards, which were probably in use at the same time. During a period of 150 years (*c.* AD 75-225) the farmsteads were rebuilt on the same spot. Along its western perimeter at least the settlement was enclosed by a ditch with an opening (Raemaekers 1993, 32). The two settlements' situations relative to the larger, enclosed Westerveld settlement (Van der Sanden 1987, 61-66) differed: the IJsselstraat settlement lay much further away from the Westerveld settlement (3000 m) than the Zomerhof settlement (1000 m) (fig. 26).

Small settlements like those of Zomerhof and IJsselstraat are assumed to have ranked lowest in the regional hierarchy of rural settlements (Van der Sanden 1990, 101). On the basis of their small dimensions and the evidence for continuity of habitation in one place they can be categorised in the class of 'small rural settlements' of the period AD 70-260 in the settlement hierarchy distinguished in the Maas-Demer-Scheldt area by Slofstra (Slofstra 1991, 158). The next category distinguished by Slofstra is that of the 'enclosed settlements, villas and proto-villas'. Of the settlements discovered in the Oss area only that of Westerveld can be placed in this category. Slofstra arrived at this classification of settlements at a time when the IJsselstraat data had not yet been published and the ditches surrounding the Zomerhof settlement had not yet been interpreted as parts of an enclosure.

Recent research carried out as part of the Maaskant project has shown that the Westerveld settlement was not the only enclosed settlement in this area. In addition to the enclosing ditch of the Zomerhof settlement and the assumed enclosing ditch of the IJsselstraat settlement an enclosing ditch has been discovered around the 1st-century settlement of Schalkskamp, in the northern part of the town of Oss (Fokkens 1991a, 1991b, 1992). This enclosing ditch may even have been connected to one of the ditches surrounding the Westerveld settlement (Fokkens 1991a, 5, 1991b, 124; Raemaekers 1993, 25). These new data imply a more complex settlement system than that proposed by Slofstra.

The presence of the ditches isolating the settlements from the 'outside world' distinguishes the settlements of

Zomerhof and Schalkskamp and possibly also that of IJsselstraat from the settlements of Vijver and Zaltbommelseweg, which have also been categorised as 'small rural settlements' (Slofstra 1991). However, the former settlements do not fit into Slofstra's category of 'enclosed settlements, villas and proto-villas' either, because they yielded no evidence for some form of hierarchy within the settlement, such as the remains of a proto-villa.

Did these three settlements differ from those without enclosing ditches in other respects, too, and, if so, did they hence belong to a higher category of settlements not distinguished in Slofstra's classification? It must be born in mind that only very small parts of the Vijver and Zaltbommelseweg settlements were excavated. Slofstra himself indicated the difficulty of identifying 'small rural settlements' in relatively small-scale excavations (Slofstra 1991, 45). The distance of the individual settlements to the Westerveld settlement may also have been an important factor in the regional hierarchy. Hopefully further research into the (native) Roman settlements in the Maaskant region will provide answers to the above questions and lead to a better understanding of the settlement system of this area.

Acknowledgements

I should like to thank the following people for their help in preparing this article: G. van Alphen and G. Smits (Oss) for providing me with their personal documentation on the IJsselstraat excavations, P. van den Broeke (IPL) for identifying some of the handmade pottery for the second time in 20 years, and K. Schinkel, who trusted me with the unpublished text of his Ph.D dissertation and was always available to discuss it. The drawings were made by J. Boogerd (figs 4, 6, 8, 9), H. de Lorm (figs 1, 2, 20, 25), and G. Tak (figs 19, 21, 22). The english text was corrected by S. Mellor.

notes

1 This research project is being supported by the Foundation for History, Archaeology and Art History, which is financed by the Netherlands Organization for Scientific Research (NWO), file No. 280-51-062. The Iron Age features were analyzed by C. Schinkel (Schinkel 1994). In the past few years several shorter articles on Oss have been published, many of them by W.A.B. van der Sanden (*e.g.* 1988, 1990 and with P.W. van den Broeke 1987).

2 So far a number of shorter publications have been presented on the IJsselstraat excavations: Van Alphen 1975; Beex 1973, 1974; Verwers 1978; Verwers/Beex 1978a. Furthermore, specialist studies have been published on part of a wooden yoke (Van den Broeke/Verwers 1977), botanical analysis (Bakels 1980, 1988) and a Bronze Age well (Verwers 1981).
The analysis of the finds and data was started immediately after the first campaign. P.W. van den Broeke did a great deal of work as a student assistant. He recorded and dated the handmade pottery. The Roman wheel-turned pottery was identified by P. Stuart. G.J. Verwers analysed the house plans. J.P. Boogerd and G.R. Tak made many drawings, including those of finds and wells illustrating this article. Some finds were sent to specialists to be identified; Professor J.E. Bogaers interpreted the epigraphics.

3 The Maaskant region is the area that is bordered by the river Meuse to the north and by an imaginary line between the towns of 's-Hertogenbosch, Oss and Herpen to the south.

4 The IJsselstraat excavations marked the beginning of a fruitful cooperation between the IPL and local archaeologists in and around Oss united in the '*Heemkundekring Maasland*', later the '*Archeologische Werkgroep Oss*'. Piet de Poot, Gerard van Alphen and Gerard Smits deserve special thanks for their assistance during the IJsselstraat excavations. A large part of the excavation was carried out independently by the '*Heemkundekring*'.

5 The 1974 excavation was carried out under the supervision of Professor P.J.R Modderman and G.J.Verwers. G.R. Tak was the field technician. In 1974 the field training course for undergraduate students was for the first time given at Oss. In 1975 more undergraduates worked at the IJsselstraat site under the same supervisors.

6 Co-ordinates: 165.830/421.100 (Topographical map of the Netherlands, sheet 45E).

7 This is only an estimate, based on the local thickness of the *plaggen* soil and the depth of the features.

8 See also Verwers 1981, who published an article on this well.

9 Calibrated (Van der Plicht/Mook 1989) with a probability of 95.4%, this is 1514-1416 cal. BC.

10 Measured from the inside walls of the enclosing ditch.

11 The possibility that one or more graves date from the Roman period cannot be excluded. Most of the datable pottery came from the graves without enclosures. The small amount of pottery that was recovered from the ditches could only be vaguely identified as 'datable to the Iron Age or the Roman period'. However, the torque and a couple of sherds from grave No. 2 prove that some of the enclosed graves at least date from the Iron Age.

12 The cremated remains from grave No. 16 were analysed by M. Teeuwisse (letter dated 26-11-1986). They were found to be the remains of a male aged 30-40 years.

13 C. Schinkel (Schinkel 1994) has drawn up a house plan typology for Oss-Ussen, which, on the basis of the present evidence, seems to be representative of the southern part of the Netherlands. His study has been published after this article was written and therefore no use has been made of the Oss-Ussen typology in the descriptions of the IJsselstraat plans. Suffice it to note that all the IJsselstraat plans are of types 8 (A or B) and 9 (A or B).
The same goes for Schinkel's typologies for pits (wells), granaries and palisades: they have not been used either.

14 The measurements were obtained by measuring the outermost features from heart to heart. That means that in cases where there

were postholes outside the walls the measurements do not represent the (dwelling) space enclosed by the walls.

15 The origin of eight sherds and a piece of quartzite could not be traced. They came from either House 1 or House 3, whose plan was intersected by that of House 1.

16 Almost all of the pottery that is categorised as 'native (Roman)' here was originally identified as 'pottery from the Iron Age or Roman period' by Peter van den Broeke. It is often hard to make a distinction when identifying handmade pottery. The original interpretation was adjusted after consideration of the find context.

17 The wood remains were identified by P. Baas of the Dutch State Herbarium in Leiden.

18 This assumption is based mainly on evidence from experimental reconstructions (Prehistoric Open Air Museum Eindhoven). Unfortunately there is hardly any other information.

19 Known as 'Borgo I' and 'Borgo II', these excavations were carried out by the '*Archeologische Werkgroep Oss*' in 1986 (by G. van Alphen, P. Haane and H. Pennings) and 1994 (by G. van Alphen and H. Pennings), respectively.

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Large-scale excavations versus surveys: examples from Nevis, St. Eustatius and St. Kitts in the Northern Caribbean[1]

This paper is an attempt to combine the insights of large-scale excavations with information derived from settlement surveys. For this the islands of Nevis, St. Eustatius en St. Kitts in the Northern Caribbean were selected. The conclusion is that the surface information is a poor reflection of the sub-surface situation and that the chronological units and agents are not fine-grained enough to arrive at detailed temporal classifications of sites.

1. Introduction

This paper is an attempt to synthesize archaeological information on inter-site (or: intra-island) and inter-island level, in particular the patterning of settlements in the most important occupational periods of the islands of Nevis, St. Eustatius (or Statia), and St. Kitts. The focus on the archaeological record of these three islands makes it possible to combine the insights of large-scale excavations on St. Eustatius with the information derived from settlement surveys on these islands. The selection of these three islands is based on geographic parameters discussed more in detail in the next chapter: the islands are united by a relatively shallow submarine ridge and they are each other's nearest neighbours (fig. 1).

Surveys by Allaire (1974), Goodwin (1979), Haviser (1985), De Josselin de Jong (1947) and Wilson (1989) are the most important on these islands. Large-scale excavations were done at the Golden Rock (Versteeg/Schinkel 1992), and Smoke Alley sites on St. Eustatius. The Smoke Alley data are presented here for the first time. Data on settlement organization and house shape were collected through a program of archaeological research similar to that used at Golden Rock. Some settlement data are available for Nevis.

It is clear that in our attempt to use both evidence from large-scale excavations and surveys, data of very different quality are compared. Generally speaking, surveys specifically yield information:

1. On an inter-site level: settlement patterning: data on the specific position in the landscape of each site, data on soil, distance from and elevation in respect to the seashore. The quality of the finds is the basis for the settlement's chronology. Fairly reliable conclusions can be derived from surveys on these subjects: the limited scale of the observations does not influence the results too much, unless important intra-site differences exist.
2. Intra-site information on the content of the midden and on the size of the midden in three-dimensional respect usually is limited. The number of observations is too low per site to make this possible.
3. Usually there is limited information on post-depositional processes, although the surroundings of sites may give some hints on effects such as coastal erosion (for instance the windward beach coast on St. Eustatius) and other obvious landscape changes. Usually the time-frame of such gross changes is difficult to estimate on the basis of observations that are possible during surveys.

In general, a small midden in the archaeological record may reflect a habitation occupied for a short period of time, or used by a small group of inhabitants; a large midden may reflect a long period of habitation by a small group or a short period of habitation by a large group. Detailed knowledge of the chronology of sites is of course desirable, but at present, tight chronological control is rare in the Caribbean. Cultural phases, based on pottery typology, seem to have continued for many centuries. It is possible that different islands had sites with similar artefacts in different time periods. Many basic chronological problems remain unsolved in the Caribbean (Versteeg/Schinkel 1992, 72). For this reason, it is nearly impossible at present to make reliable estimates whether a site was occupied during a short or long period of time.

2. Physical Setting

Five volcanic islands line a tectonic subduction zone in the northeastern Caribbean. They are, from southeast to northwest, Montserrat, Nevis, St. Kitts, St. Eustatius and Saba (fig. 1). They are somewhat set apart from the sedimentary islands to the north and east, especially at the northeastern end of the chain. Of the five islands discussed, Nevis, St. Kitts and St.Eustatius share a relatively shallow submarine ridge. These three islands are the nearest neighbour of each other: Nevis is only 4 km from St. Kitts. St. Eustatius is situated at 20 km from St. Kitts. It is likely

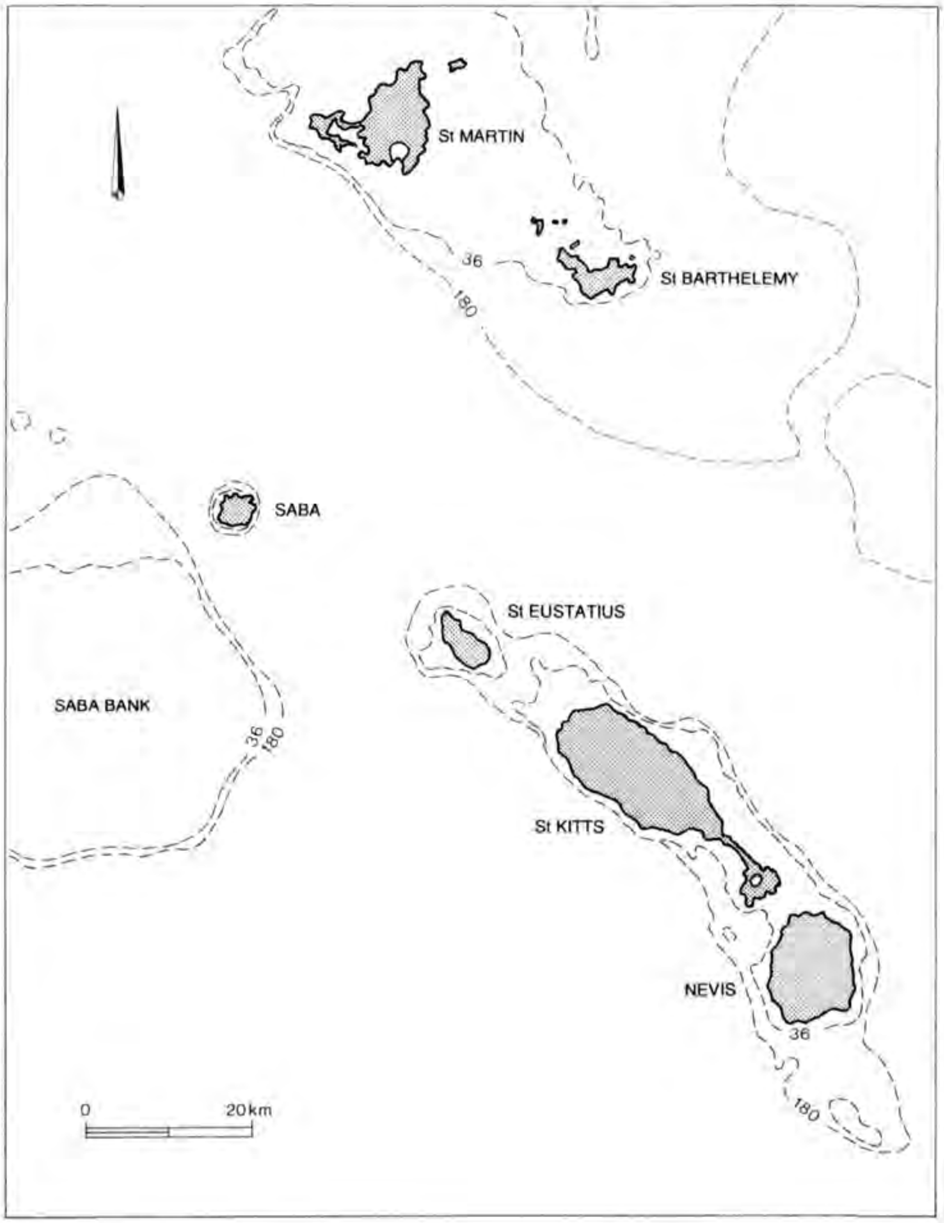

Figure 1. Map St. Eustatius, Nevis, St. Kitts; depths in meters.

that prehistoric people from the St. Eustatius - Nevis arc interacted more with one another than with people from other islands.

Montserrat is separated from Nevis by 48 km of deep water (> 500 m), and Saba is separated from St. Eustatius by about 35 km of deep water. Montserrat is closer to Antigua (39 *vs.* 48 km away) than to Nevis. At present, however, it is unclear which of the neighbours of the three islands discussed here (Montserrat, Antigua, Barbuda, Guadeloupe, St. Barths, St. Martin, Anguilla, Saba) interacted most. It must be kept in mind, however, that the sea distances between any of the islands and these more distant neighbours (max. some 70 km) were probably not considered consequential voyages by prehistoric Caribbean sailors.

All of the islands in this arc are volcanic and have relatively high altitudes (fig. 2). These volcanic mountains produce orogenic rainfall; sugar was cultivated successfully on all of the islands except Saba and Anguilla in the recent past, and before extensive clearing for cultivation in the 17th century, the islands would have been heavily forested. Although of similar geomorphological origins, Nevis,

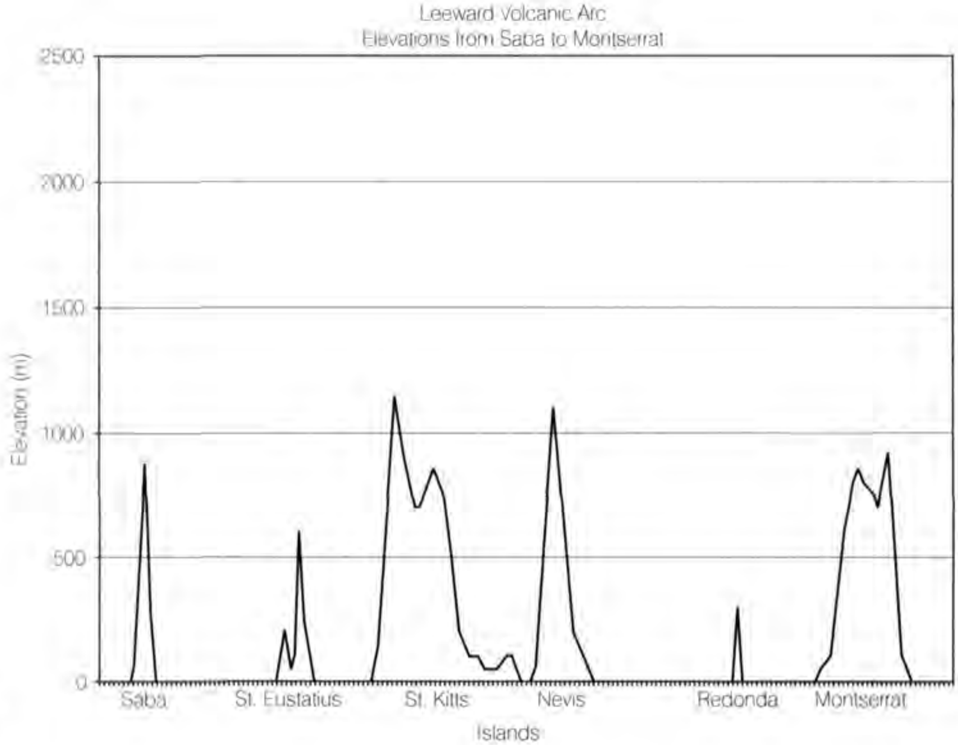

Figure 2. Nevis, St. Eustatius, St. Kitts and the neighbors Montserrat and Saba form the Leeward Islands Volcanic Arc. Elevations in meters.

St. Eustatius and St. Kitts differ significantly in the abundance of some resources.

Fresh water, arable soil, and coastal resources are three such critical variables. Today Nevis has about 4 permanent streams (fig. 4), but like St. Kitts, which has 7 permanent streams (fig. 3), it would have had more and larger fresh water resources prehistorically, since today much of the fresh water runoff is captured higher on the mountain, before it reaches the sea. St. Eustatius (fig. 5) has no permanent surface streams at present, and probably had none in prehistory. Still, wells or pits dug at the leeward shore could provide sufficient fresh water for the Indian population (Versteeg/Schinkel 1992, 21).

The soils were similar on the three islands due to the similarity in volcanic parent material, but on all three islands, the soils have been changed by damaging sugar-cultivation practices in the 17th through 20th centuries. St. Kitts has suffered least; it is the most fertile and productive of the islands today, and probably was so in the past. About 70 km^2 of St. Kitts' 175 km^2 are being used for cultivation today. Nevis has about 20 of its 124 km^2 under cultivation. Statia's arable land amounts to 5.6 of its 21 km^2; not much of this is under cultivation today (Verstappen *et al.* 1972).

The coasts of the three islands are different in scale and in the nature of available resources; St. Kitts has over 100 km of coastline, with about 30 km of beach. Nevis has a 44 km coastline, with about 12 km of beach, and St. Eustatius has a 21 km coastline, and about 6 km of beach. Beaches were probably not very important as sources of food, although turtle nesting grounds may have been significant. Reefs seem to have been much more productive.

But like arable land and water, they were important resources in decisions concerning where to locate settlements. Even where there was attractive land and water, it was a serious problem when canoes could not land at a beach safely, or where they were vulnerable from the sea, or where there was another village sharing the same beach.[2] The present-day populations of the islands offer some measure of the general productivity of the islands. Although modern economies are quite different from those of prehistoric peoples — subsidized by energy imports, tourism, and buffered against inadequate local production by trade in food — the productive potential of the islands is still reflected in their modern populations. With other factors mentioned above, population information is shown in figure 6.

3. The archaeological record

Some of the difficulties that arise in this paper are due to the fact that the data from the three islands were collected at different times for different reasons and are not always comparable.

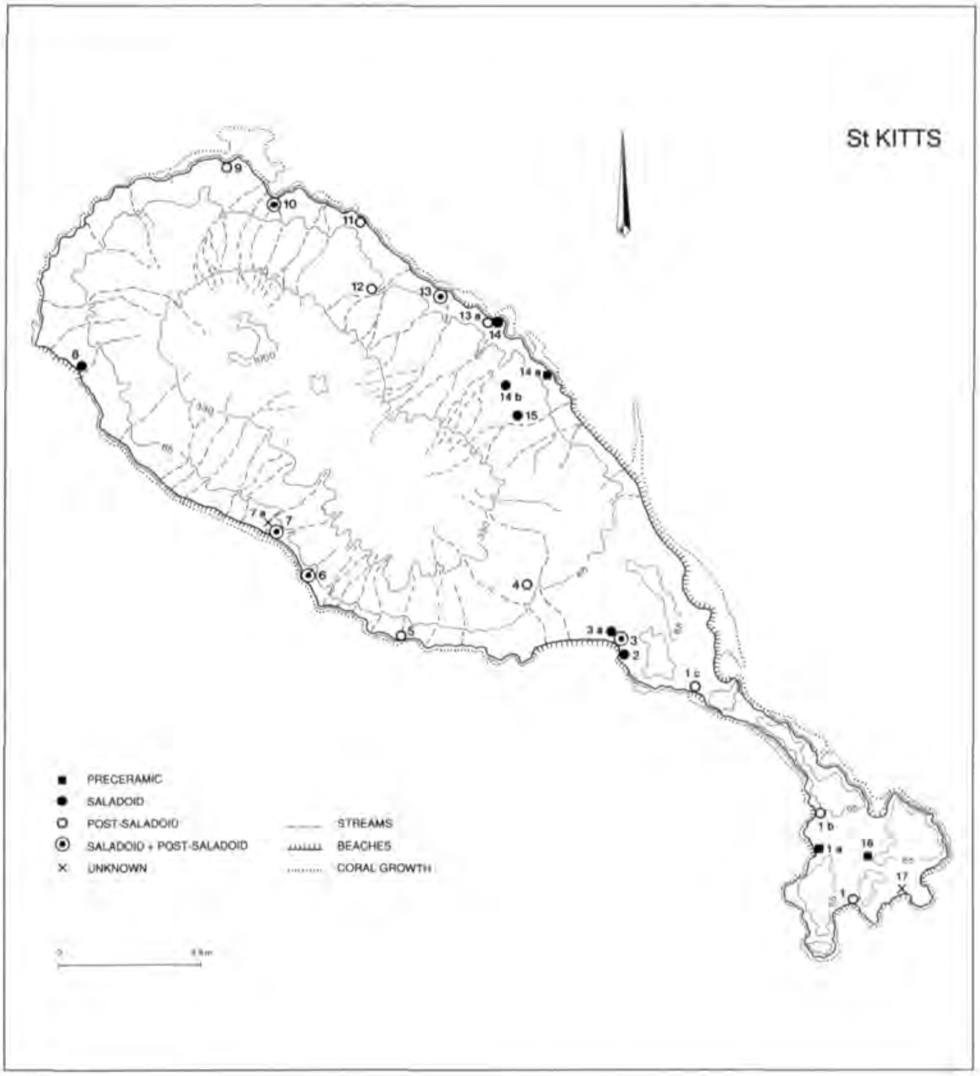

Figure 3. St. Kitts archaeological sites. Elevations in meters.
1 = Majors Bay-1/2
1a = Ballast Bay
1b = Whitehouse Bay-1/2
1c = Frigate Bay
2 = Sugar Factory Pier
3 = Pond Estate
3a = Basseterre
4 = Shadwell
5 = West Farm
6 = Stonefort River
7 = Old Road
7a = Wingfield Estate
8 = Cranstouns
9 = Dieppe Bay
10 = Sandy Bay
11 = Black Rocks
12 = Tabernacle
13 = Christ Church
13a = Mills Estate
14 = Lodge Gut
15 = Cayon
16 = Great Salt Pond
17 = Cockelshell Bay

For example, on St. Kitts, Branch (1907), Fewkes (1922), and Allaire (1974) reported site locations and descriptions of some of the artefacts found. Goodwin (1979) recorded site locations and mapped the artefact scatters that fell within his survey transects, and gave more extensive artefact descriptions. The sites he reports, however, were found through multi-stage sampling of 65 survey transects (100 × 500 m) on St. Kitts. His research was not designed to find all of the sites that still exist on the island.

On Nevis, Wilson (1989) surveyed all of the coast and inland drainages and recorded site areas as reflected in the surface scatter of prehistoric material. Many small sites were found in the coastal part of this island. On St. Kitts, Goodwin's survey and the investigations of Allaire, Branch, and Fewkes did not deal intensively with the coast. It is likely that sites similar to the smaller post-Saladoid sites on Nevis exist on St. Kitts, but they are underrepresented in our sample. Similarly, on St. Eustatius, De Josselin de Jong (1947) recorded the areal extents of the densest artefact scatters. Haviser (1985) surveyed the Cultuurvlakte on Statia and some of the hilly parts of the island. As this island only is one-sixth the size of Nevis (one-eighth the size of St. Kitts) it is easiest to survey. The reported sites probably are a fair representation of what exists. Some extremely small sites with a few undecorated sherds and some shell are mentioned in the survey reports. Several are mentioned in figure 5, for instance sites 10, 12, 13, 14, but there exists doubt on the importance of the sites, and on their cultural affiliation.[3] In total 21 sites are on Nevis, 30 on Kitts, and 13 on St. Eustatius.

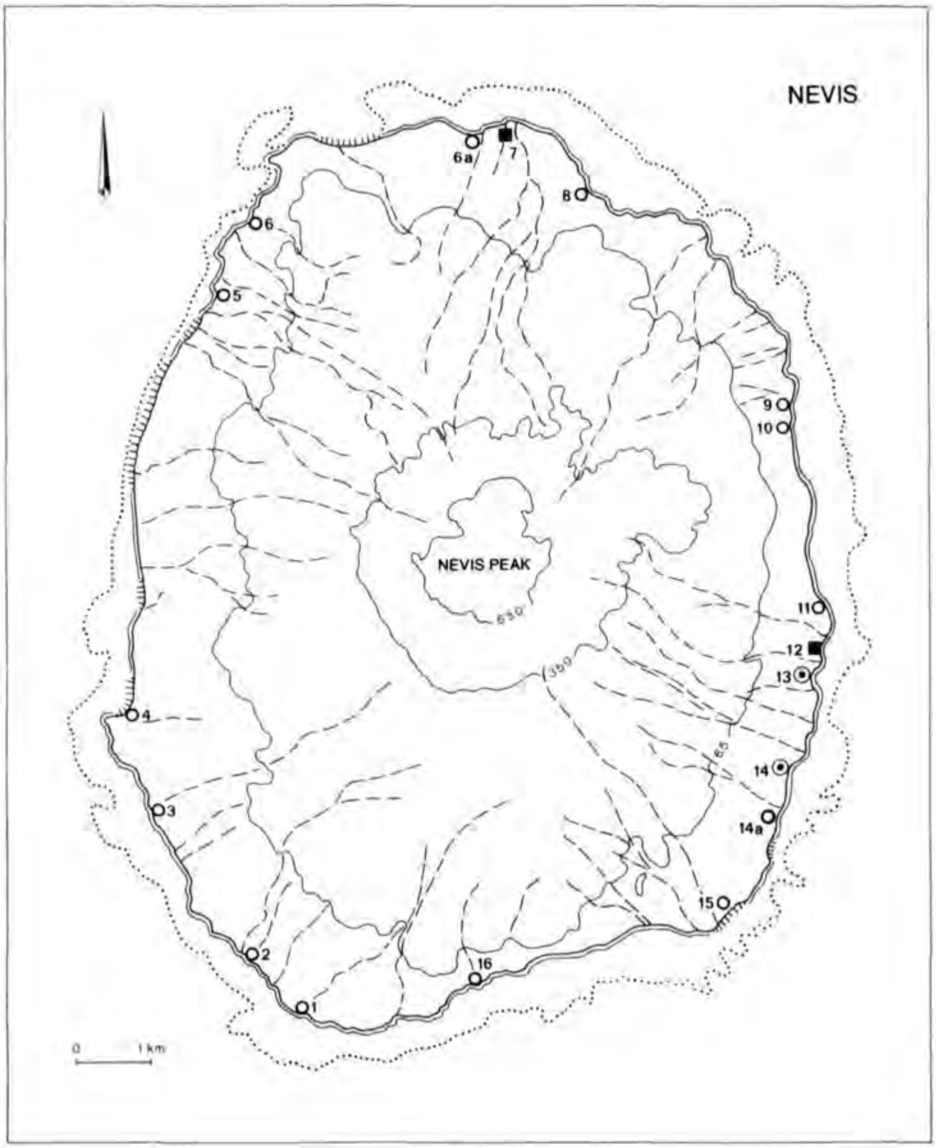

Figure 4. Nevis archaeological sites. See figure 3 for key to symbols.
1 = Lighthouse
2 = Sulphur Gut
3 = Bath Plain 1
4 = Bath Stream mouth
5 = Nelson Springs
6 = Cades Bay
6a = Newcastle
7 = Nisbetts
8 = Hick's Cove
9 = Tittle Gut
10 = Butlers
11 = Cocoanut Walk
12 = Hichmans' Shell Heap
13 = Hichmans'
14 = Indian Castle N/S
14a = White Bay N.
15 = Indian Castle Estate
16 = Whitewall Estate

Sixty-four sites are known from the three islands, and 50 of them have an estimated aceramic or ceramic association. Less than 10 have been radiocarbon dated, and we do not feel that we are able to date the sites with much precision on the basis of the ceramics, or other artefacts, at present. In order to attempt to draw more general inferences concerning the culture history of the region, however, we feel that the sites containing ceramics can be roughly divided into two periods: Saladoid and post-Saladoid.

Doing so presents several problems: it reflects the boundary between Saladoid and post-Saladoid periods and treats them as distinct and relatively synchronic units.[4] In fact, the transition may have been gradual, with decorative traits like white-and-red painting and zoned-incised-crosshatched incision being abandoned at different times in different places, with little impact on other kinds of behaviour or activities.

Of the 64 known sites, 8 are aceramic. Two are on Nevis, 4 on St. Kitts[5], and 2 on St. Eustatius. Two of the Kittittian sites are on the southeastern peninsula, 1 at Hermitage Estate on the windward coast, and 1 is at Dayfords Estate. Figure 7 shows the number of sites by period on the three islands. It is striking that on all three islands, the preceramic sites are situated near important reef locations. Another study will deal with the question whether the archaeological record of these sites indeed reflects a reef-orientation[6].

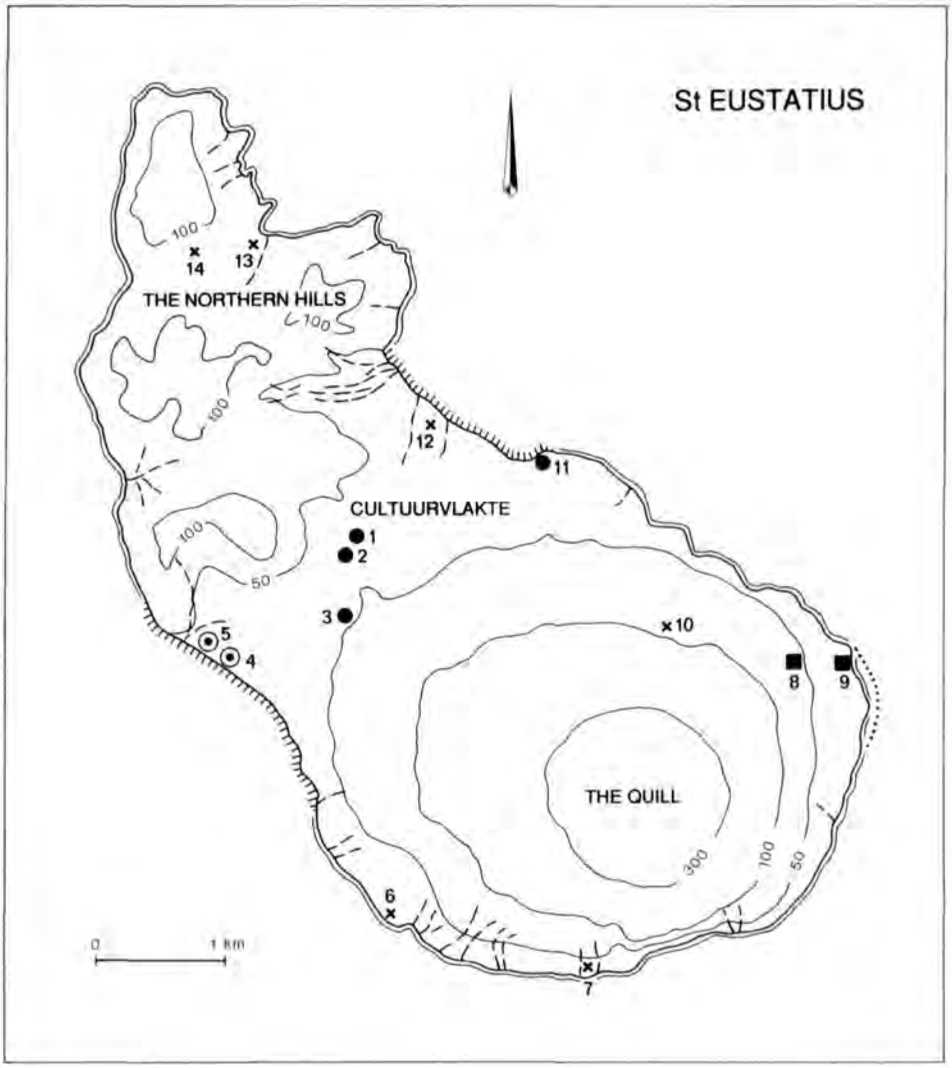

Figure 5. St. Eustatius (or Statia) archaeological sites.
See Fig. 3 for key to symbols.
1 = Golden Rock
2 = Golden Rock -1
3 = Golden Rock A
4 = Smoke Alley
5 = Godet
6 = SE-72
7 = SE-73
8 = Corre Corre Bay 1
9 = Corre Corre Bay 2
10 = SE-36
11 = SE-80
12 = SE-82
13 = SE-113
14 = SE-120

Fifteen of the sites with ceramics have ceramic decorations considered diagnostic of the Saladoid period. Of these sites, 8 also have a post-Saladoid component. Thirty-eight sites have a post-Saladoid component, and on 29 of the sites there appears to be only a post-Saladoid occupation. This implies there are 7 single-component Saladoid sites, 8 sites with both Saladoid and post-Saladoid components, and 29 single-component post-Saladoid sites (tab. 1).

On Nevis there are two sites with unmistakable Saladoid components — Hichmans (GE-5), a site of about 1 ha, and Indian Castle North (GE-1N). On St. Eustatius there is the Golden Rock cluster in the Cultuurvlakte (fig. 5). On St. Kitts there are 11 sites with Saladoid components, 6 on the northeastern coast, and 5 on the southwestern coast. Five of St. Kitts' 11 Saladoid sites also have a later component, 3 on the northeastern side and 2 on the southwestern side of the island. Although the dating of sites is not yet adequate, the suggestion made by Goodwin (1980, 54, 63) and others that Saladoid colonists located their sites inland to take advantage of high-quality farmland and other terrestrial resources does not find support in these data.

Apart from Cayon, the 10 other Saladoid sites on St. Kitts and Nevis are all within 100 m from the coast. From the three islands, the site that is the next most distant from the sea is the Golden Rock site, which probably is one of the latest in the Caribbean. The sites with both Saladoid and post-Saladoid components average 23.5 m from the coast, while those with only a Saladoid component average over 75 m from the coast.

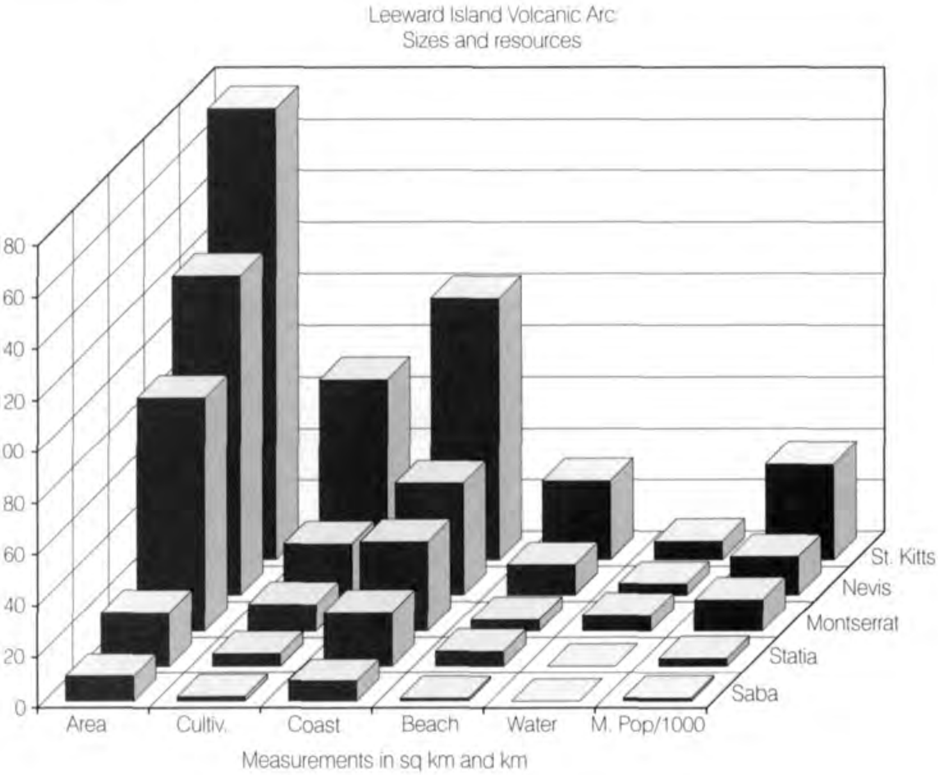

Figure 6. Leeward Islands Volcanic Arc. Sizes & Resources. Millennia of the M(odern) Pop(ulation) are indicated in the right column of this graph.

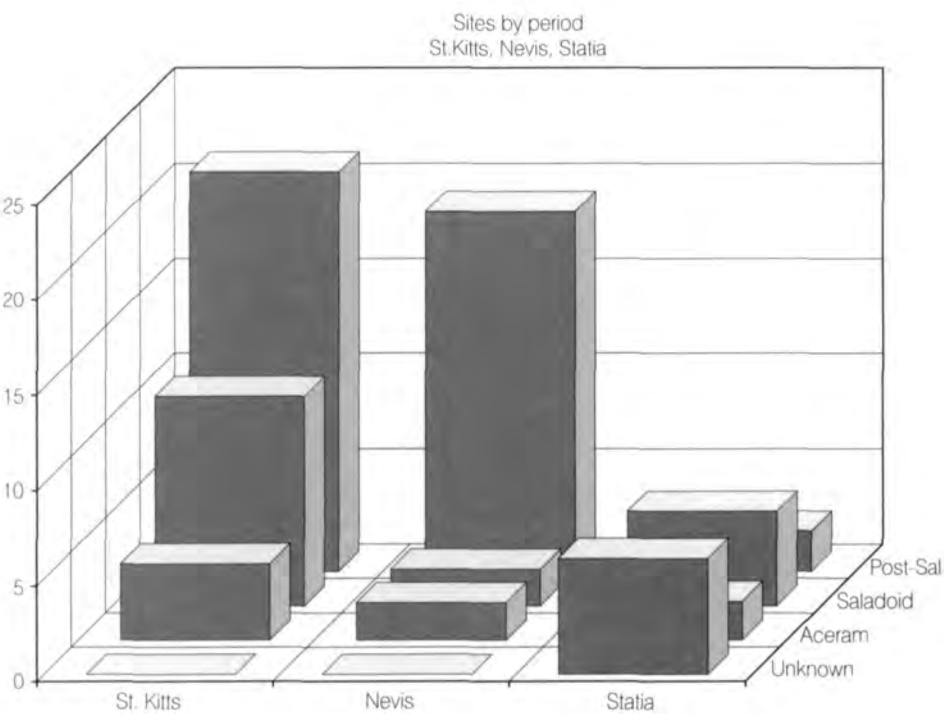

Figure 7. Sites St. Eustatius (Statia), Nevis and St. Kitts by period.

Table 1. Archaeological sites Nevis, St. Kitts, St. Eustatius. Archaeological period; ocurrence of Zoned-Incised-Crosshatched and White-On-Red pottery; East, West or central position on the island; area in m^2 of the site, depth of archaeological deposits; distance from the coast in meters; elevation above average sea level and references.
1: Allaire 1974; 2: Branch 1907; 3: Fewkes 1922; 4: Goodwin 1979, 1980; 5: Josselin de Jong 1947; 6: Versteeg (various, see bib); 7: Wilson 1989; 8: Armstrong 1980; 9: Haviser 1985.

isle	name/code	A-Ceramic	Saladoid	Post-Saladoid	Zoned-Incised-Crosshatched pottery	White-On-Red pottery	position	area (m^2)	depth (cm)	distance coast (m)	elevation (m)	references	code
Nevis	Nisbetts	1					west	270	25	100	10	7	
Nevis	Hichmans' Shell	1					east	250	40	5	8	7	
Nevis	Hichmans'		1	1	1	1	east	8800	50	100	30	7	
Nevis	Indian Castle North		1	1	1	1	east	1375	50	20	5	7	
Nevis	Indian Castle South		1				east	68750	60	0	10	7	
Nevis	Butlers			1			east	8400	40	10	5	7	
Nevis	Cocoanut Walk			1			east	5500	70	30	15	7	
Nevis	White Bay North			1			east	3750	30	30	8	7	
Nevis	Tittle Ghut			1			east	3200	40	25	15	7	
Nevis	Indian Castle Est.			1			east	2450	40	25	8	7	
Nevis	Sulphur Ghut			1			west	1200	70	5	5	7	
Nevis	Bath Plain 1			1			west	1000	60	5	5	7	
Nevis	Hick's Cove			1			east	750	25	10	15	7	
Nevis	Hick's Cove			1			east	625	25	10	10	7	
Nevis	Lighthouse			1			west	600	70	5	5	7	
Nevis	Newcastle			1			west	450	25	30	10	7	
Nevis	Whitehall Est.			1			west	300	25	5	5	7	
Nevis	Cades Bay			1			west	300	25	5	5	7	
Nevis	Nelson Springs			1			west	250	40	10	10	7	
Nevis	Hick's Cove			1			east	250	25	10	10	7	
Nevis	Bath Stream mou			1			west	150	40	6	15	7	
Kitts	Cayon		1		1	1	east			1500		1,3,4	F0621
Kitts	Christ Church		1	1	1	1	east			25		1,2,4	D0241
Kitts	Lodge Gut		1			1	east			5		4	D0451
Kitts	Stonefort River		1	1	1		west			5		1,3,4	Bloody Point, G0371
Kitts	Sugar Fac.Pier		1		1	1	west			5		4	SFP1
Kitts	Sandy Bay		1	1			east			5	5	4,1	B0221
Kitts	Old Road		1	1			west			5		4	E0461
Kitts	Cranstouns			1			west			5		4	A0181
Kitts	West Farm			1			west	100		550		1,2,3,4	Two Mile Cut, G0361
Kitts	Tabernacle			1			west			375		4	D0071

isle	name/code	A-Ceramic	Saladoid	Post-Saladoid	Zoned-Incised-Crosshatched pottery	White-On-Red pottery	position	area (m^2)	depth (cm)	distance coast (m)	elevation (m)	references	code
Kitts	Majors Bay 1			1			central			5	10	4	I0331
Kitts	Whitehouse Bay			1			west			150		4	fds
Kitts	Shadwell			1			west			1000		4	I0261
Kitts	Frigate bay			1								1	
Kitts	Pond Estate		1	1		1	east			5	5	1	
Kitts	Basseterre		1		1	1	west					1	
Kitts	Dieppe Bay			1			east			30	10	1	
Kitts	Black Rocks						east			10	15	1	
Kitts	Wingfield Estate			?			west					3	
Kitts	Mills Estate			1			east					3	Lodge Gut?
Kitts	Brighton Estate		1			1	east					3	(near Cayon)
Kitts	Dayfords	1										3	
Kitts	Hermitage	1					east					3	
Kitts	Ballast Bay	1		1			west			50	4	8	SK19180001
Kitts	Great Salt Pond	1					central			1000	10	8	SK17290001
Kitts	White House Bay 1			1			west			5	5	8	SKI6930001
Kitts	White House Bay 2			1			west			5	5	8	SKI6930342
Kitts	Majors Bay 1			?						10	5	8	SKI9460001
Kitts	Majors Bay 2			?						300	15	8	SKI7380001
Kitts	Cockelshell Bay			?						20	5	8	SKI7400001
Statia	Golden Rock 1		1		1	1	central	3800		1000	50	5,6	GR (c)
Statia	Golden Rock		1		1	1	central	8850		1200	36	5,6	GR (b)
Statia	Golden Rock A		1				central	50		900	38	5	GR (a)
Statia	Smoke Alley		1	1	1	1	west	100		50	8	6	
Statia	Godet		1	1	1	1	west	1000		50	5	6,9	
Statia	Corre Corre Bay 1	1					east	100		475	70	6,9	
Statia	Corre Corre Bay 2	1					east	20		40	20	6,9	
Statia	SE-36						central?			750	130	9	
Statia	SE-72						west	15		40	25	9	
Statia	SE73						west			40	25	9	
Statia	SE-80		1				east	15		50	20	9	
Statia	SE-82						east	30		60	15	9	
Statia	SE-102									900	50	9	
Statia	SE-113									200	15	9	
		8	**18**	**38**	**11**	**13**							

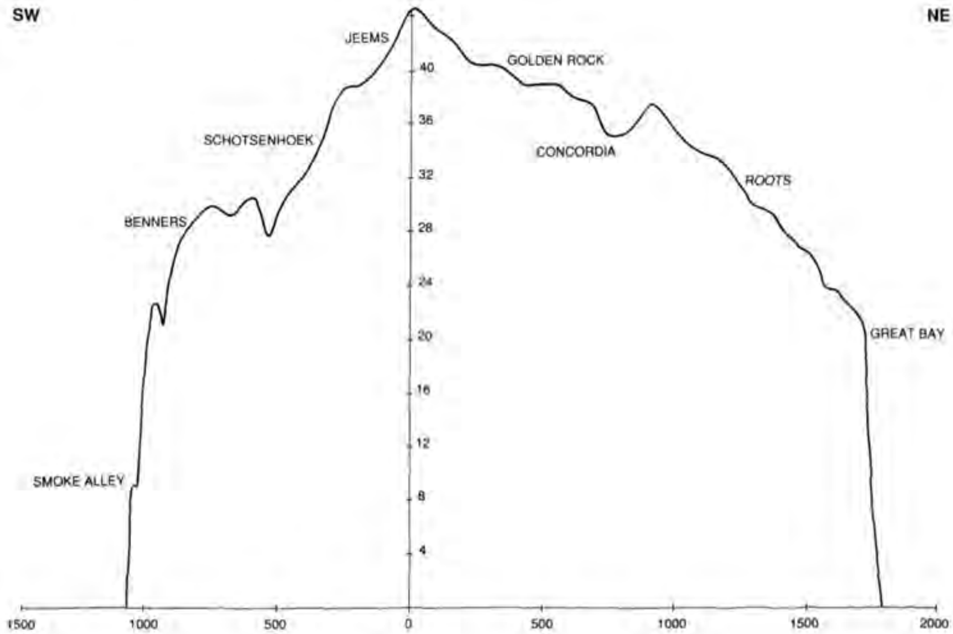

Figure 8. South-west to north-east section of St. Eustatius over Smoke Alley and Golden Rock (see fig. 5 sites 4 and 2). Sizes in meters.

Both of the Saladoid sites on Nevis are on the windward coast, while on Statia the Golden Rock site is in the centre of the island.[7] On St. Kitts they are more or less evenly spread over the windward and leeward coast, while a minority is situated slightly inland. Such differences seem to reflect quite diverse settlement strategies.

The mainly post-Saladoid sites on Statia (Godet and Smoke Alley, see note 7) are situated on the leeward coast of the island. The post-Saladoid sites on Nevis and St. Kitts share the coastal orientation of the Statia sites. They are, however, to be found both on the leeward and windward coasts.

Summarizing: preceramic sites on all 3 islands have a coastal, and more specific, a reef-orientation. All post-Saladoid sites have a coastal location, windward and leeward on the two larger islands, only leeward on Statia. Saladoid sites have inland and coastal locations, on Nevis only windward coastal, on St. Kitts inland and coastal (both leeward and windward). Settlement strategies seem to be more uniform for the preceramic and post-Saladoid inhabitants of the islands. Saladoid people demonstrate more diverse settlement strategies.

Statia differs from the two larger islands: the smallness of the island probably made the whole island exploitation area of the inhabitants of one settlement in one period, and did not permit two groups of any size to live on the island together and exploit it. During the preceramic period one group lived in the Corre Corre Bay area, leaving us two archaeological sites, of which site 8 is relatively large and site 9 (fig. 5) relatively small. During the Saladoid period one group lived at Golden Rock (sites 1 and 2) while small-size remains were left at the sites 3, 4, 5, and 11. During the post-Saladoid period one group lived at the Godet-Smoke Alley area which may be considered as two sub-sites left us by one post-Saladoid group, in view of the nearness of both (sub-)sites and similarity of artefacts (see below).

4. The results of large-scale excavations: two examples from St.Eustatius

Both surveys and large-scale excavations were carried out on Golden Rock (GR) and Smoke Alley (SA), the former a Saladoid site in the middle of the island, the latter (mainly) a post-Saladoid site near the leeward beach (fig. 8). Differences between the results of these types of investigation have an implication for the understanding of Caribbean pre-Columbian sites, both post-Saladoid and Saladoid. First a summary of the results of the investigations at SA and GR will be given.

4.1 THE SMOKE ALLEY SITE

A survey by Van der Valk of the Smoke Alley site near the leeward coast (fig. 9) resulted in the observation that a post-Saladoid midden was situated on a small terrace (*c.* 60 × 20 m) some 8 m above the sea at a distance of 50 m from the sea. It is situated 250 m south of the coastal Godet site (Haviser 1985; Versteeg *et al.* 1986), discovered by A.E. Figueredo (1975) in 1975. Both sites share a number of characteristics: both are predominantly post-Saladoid, judging from the ceramics, but both have a small number of

Figure 9. Gallows Bay near Smoke Alley site. North to south view. Often a sandy beach is recorded at this spot. Hurricanes remove the sand. After hurricanes the sand is slowly deposited again until the next hurricane interferes with the accumulation process.

Figure 10. Smoke Alley: machine-made excavation pit. View northwest - southeast in the direction of the sea.

typical Saladoid sherds. At least 90% of Godet is covered under a 1.5 - 2 m overburden dating from the early Colonial Period when large-scale deforestation activities caused landslides and other erosion effects.

The Smoke Alley site, less prone to colluviation, only received some 40 cm of soil overburden. More 18th century buildings are near the site; the terrain was still used in this century for agriculture. The archaeological context of the artefacts in the site has been greatly disturbed by this agricultural activity. Insight into the total sub-surface area of the Smoke Alley terrace suggests that these large-scale disturbances destroyed all archaeological information that was not protected by the midden. South of the midden 18th century building made prehistoric remains invisible, and north of the midden a whitish-coloured fill predominated.

Excavation of five 1 m^2 test pits established that the midden was approximately 10 × 10 m in size. Excavation

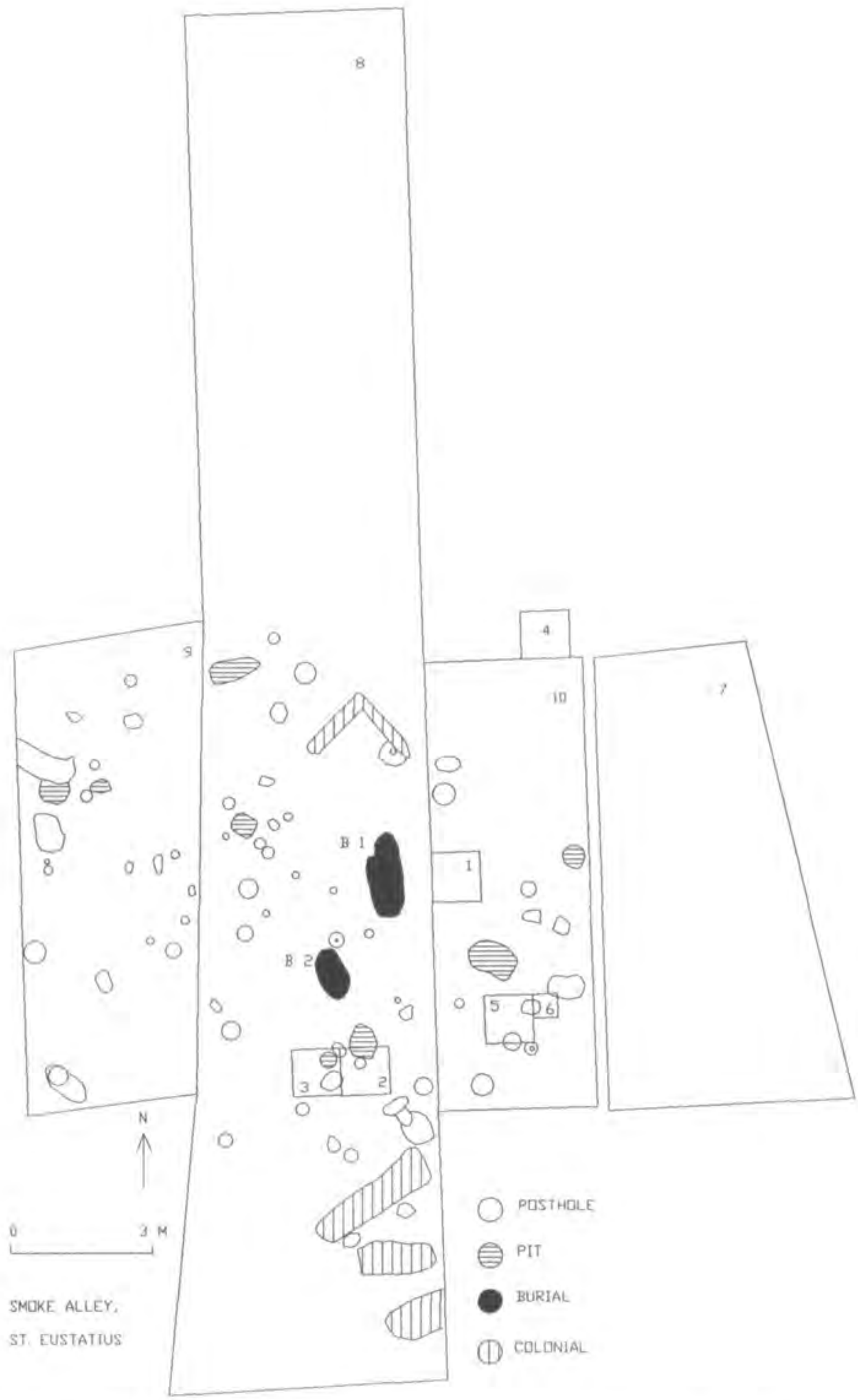

Figure 11. Map excavation pits Smoke Alley. The 1 × 1 m pits 1-6 were excavated by hand. Pits 7-10 were excavated by a loader. Subsequently the surface was scraped and the features were sectioned manually.

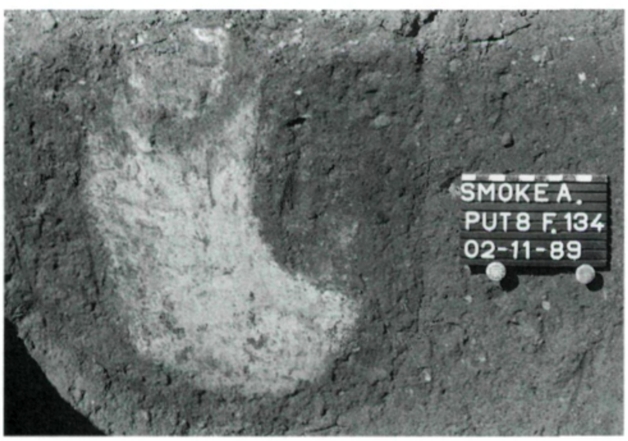

Figure 12. Section Features 25 and 134. Both proved to be postholes of a depth of 91 and 32 cm, respectively. They belong to a 10-m-diameter structure (fig. 13). The depths are values below the level excavated by the loader. For uncertainties on the original level of the surface see figure 13.

of four large machine-made (255 m^2, figs 10, 11) pits resulted in the discovery of 80 features. Sixty-five of them proved to be postholes (fig. 12). Twelve postholes belong to one slightly oval 10 m diameter house, 7 others belong to a round 8 m diameter house (figs 13, 14).

The Smoke Alley pottery from the test pits and from the features of the machine-made pits was studied by C.L. Hofman and T. Hamburg (Hamburg 1992). This study was on 2077 pottery sherds from the excavation pits and 187 from the features. Of these sherds, 6 are certainly decorated Saladoid ones. If the average of the Golden Rock relation between decorated — undecorated Saladoid sherds (*c.* 21%) is used (established on a sample of more than 40,000 sherds, see: Versteeg/Schinkel 1992, 64) for this sample, then some 30 sherds of the total were Saladoid. Even allowing for the uncertainty of the low number of six, it is improbable that more than 5% of the Smoke Alley ceramics are of Saladoid origin.

Thirty-three decorated post-Saladoid sherds were found, representing about 1.5% of the total pottery recovered. This figure is supported by field observations of the Godet excavations, where, among thousands of post-Saladoid sherds, only a very small percentage was decorated (see Putker in: Versteeg *et al.* 1986).[8]

Typical post-Saladoid decorative modes such as wide-line incisions and wide-line curved patterns ending in punctations are characteristic of the Smoke Alley decorated sherds (fig. 15). Some of these patterns are reminiscent of Esperanza pottery (Hamburg 1992, 4). Three test pits (Nos 1, 3, 5) had many West Indian Top Shells (*Cittarium pica*) and some conches (*Strombus gigas*). The same three pits featured most pottery sherds.

Two features (fig. 16) in the margin of the midden contained a Hawksbill turtle (*Eretmochelys imbricata*), and a zemi. Several layers of West Indian Top Shells (*Cittarium pica*) and crab pincers were found. This latter complex is interpreted as a cache.

It is striking that both houses and also two burials are situated exactly at the location of the midden. The refuse of the inhabitants of the houses was probably thrown down the slope, and from there subsequently was washed into the sea or into areas lower on the slope where erosional material was accumulating. The Smoke Alley midden itself probably originates from one or more houses higher on the slope (fig. 8). Dating the houses and associated archaeological features has presented some problems. There are three C14 samples: one is recent (160 ± 70 BP; GrN-18448) and obviously not associated with Indian activities. One is bone material of the human burial F. 50 (fig. 17). This sample reflects the age of the post-Saladoid activities on Statia: 1105 ± 30 BP (GrN-17070), which, after adjustment for Marine Reservoir Effect (- 130 y) and calibration, results in an age between

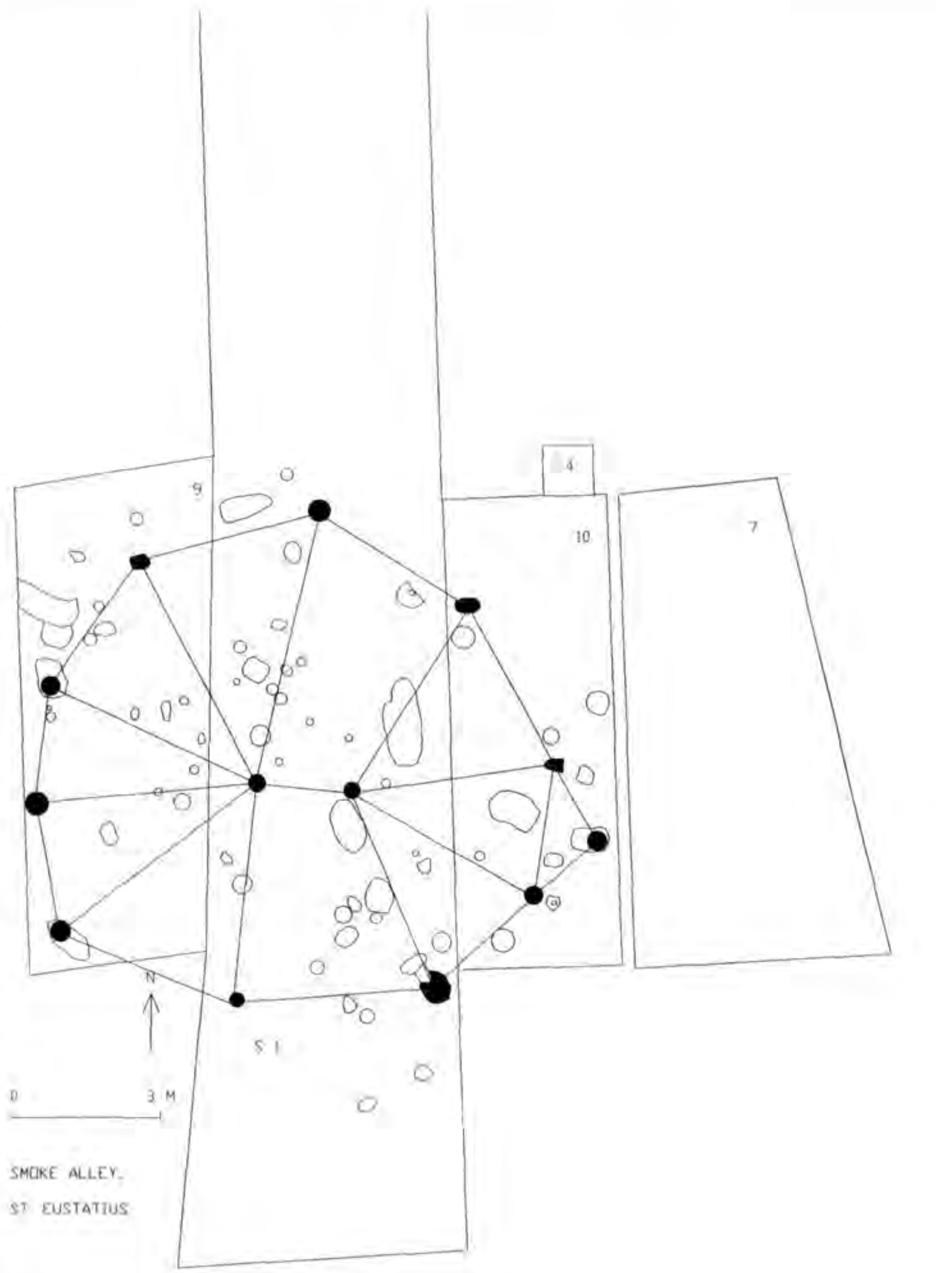

Figure 13. Smoke Alley, 10-m-diameter house. Depth postholes of the outercircle varies from 32 - 93 cm (average 60 cm; the central postholes had a depth of 10 and 40 cm) below the level excavated by the loader. Note that the original depth of the postholes may have been considerably larger. There is some information from the highest situated *in situ*-caches in the same area of the excavation: a seaturtle cache and Indian burial found in pit 2/3. These were situated ca 60 cm above the machine prepared surface. This, however, is no proof for the original depth of the postholes as the houses may be younger or older than these features, and, consequently, the surface then may have been higher or lower.

c. 1000 - 1160 AD.[9] A third sample, charcoal from the lowest level of the midden, was dated at 1720 ± 30 BP (GrN-17072), which, after calibration results in an age between *c.* 250 - 400 AD.[10] This result reflects the age of the Saladoid, and not post-Saladoid activities. The latter date corresponds very well with the earliest dates (samples GrN-11512 and 11513, *cf.* Versteeg/Schinkel 1992, 204) from Golden Rock.[11] These relatively old charcoal samples may be the result of the first Saladoid activities on Statia, such as clearing the vegetation of settlement locations.

The postholes of both houses contain no charcoal, and little pottery or shell. The houses obviously did not burn down. They were built before the midden, and their life cycle ended before the midden accumulated. This implies that they are either Saladoid (but up to now no Saladoid refuse of any extent has been found in this part of the

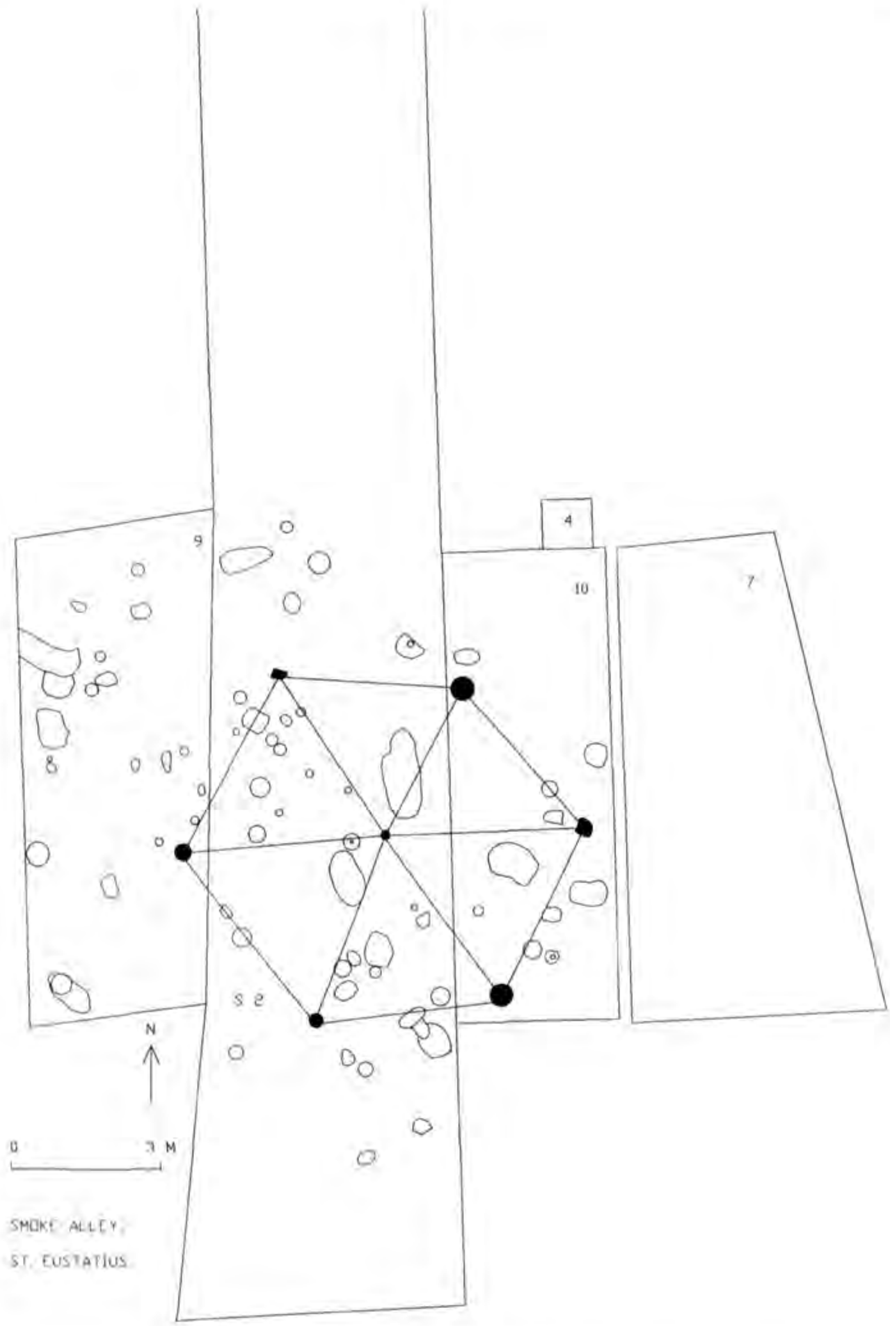

Figure 14. Smoke Alley, 8-m-diameter house. The depth of the postholes of the outercircle varies from 22-30 cm (on the average 26 cm). The central posthole had a depth of 5 cm. Measurements below the machine prepared surface.

island), or post-Saladoid, but older than the Smoke Alley post-Saladoid midden.

4.2 THE GOLDEN ROCK SITE

This site is situated in the middle of the Cultuurvlakte, at *c.* 1.5 km from both the leeward and the windward coasts (figs 5, 8). De Josselin de Jong (1923, 1947) discovered and surveyed the Golden Rock site. In spite of his complaints about the local vegetation, he was able to make a field drawing of 5 clusters of artefact concentrations visible on the surface (fig. 18). Haviser (1985) and this papers first two authors were able to check De Josselin de Jong's site map and conclusions (Versteeg/Schinkel 1992, fig. 178). Haviser could trace De Josselin's site C on the basis of

Figure 15. Smoke Alley pottery. Size 1:2 except lowest fragment 1:4.

surface finds during the 1981-survey, but he was not able to draw a more detailed conclusion than "a thick and prolific midden still is present at that location."

In 1984 the grass vegetation rendered insights in the extent of the midden area difficult. Therefore, sixteen 1×1 m test pits were dug over an area of 70 m (N-S) $\times$ 40 m (E-W). It soon turned out that post-depositional effects (especially Colonial period and more recent agriculture) had caused considerable damage to the archaeological information from the top 20 cm of the site: eroded soil from higher up the slope had covered part of the site; soil and archaeological material from the site had been eroded to near-by locations; the vegetation cover made all of this virtually invisible except at places where cattle had removed the grass. In fact, on the basis of the surface finds, it was possible to state that a Saladoid site was present at location C of De Josselin de Jong (= GR-1). This conclusion was drawn as well by De Josselin de Jong as Haviser.[12]

During large-scale investigations of the midden in 1984 and 1985 several charcoal and shell samples yielded ages of the midden around 1500 BP (Versteeg *et al.* 1984, 1986). Really valuable information on this site was gathered when

Figure 16. Smoke Alley. Sea turtle cache.

during the 1985 and subsequent field seasons large-scale investigations of the area around the midden yielded sets of postholes (fig. 19).

These proved to be floor plans of Saladoid period houses, ranging from small one-family compounds (8 m in diameter) to *malocas* 19 m in diameter (figs 20, 21). Dating of the well-preserved large charcoal samples from several of the postholes resulted in a tight framework of chronological control for the site (both the midden and the houses) and a chronological sequence for the houses, ranging from *c.* 600 AD to *c.* 900 AD (Versteeg/Schinkel 1992, 202). A *plaza* with ceremonial caches related to burials was situated to the north of the houses, and the midden was situated south of the houses, slightly uphill from the flattest part of the plain (fig. 19).

There is no doubt that midden, *plaza* and houses are structural elements of one settlement. Several phases in the subsequent use of the houses could be distinguished. Once informed by the large-scale excavations at Golden Rock, we must conclude that the observations based on the surface finds, the test pit excavations, and the excavation of the complete midden (256 m^2), provided only a very small amount of information on the site. Even the chronological data obtained did not reflect the whole period of occupation of the site.

4.3 Implications St. Eustatius investigations

From the excavations on St. Eustatius, two aspects are clear: first, there is strong evidence for post-depositional disturbance at all of the sites discussed, and this has implications for evaluating archaeological survey data from the other islands. Second, there seems to be a significant continuity between the Saladoid and post-Saladoid occupations. Although the pottery changed (decoration patterns and percentage of decorated sherds, see Versteeg/Schinkel 1992, 72) and some other aspects might have changed, such as the size of houses and settlements, and perhaps the preferences for settlement location, the Golden Rock and Smoke Alley data argues for overall cultural continuity (for example the similarities in Hawksbill turtle [*Eretmochelys imbricata*] caches, zemis, *etc.*).

On Nevis, we have very similar kinds of archaeological material as on St. Eustatius, with parallels in ceramics, evidence of house construction with deep and shallow posts, and corresponding radiocarbon dates. In contrast to St. Eustatius, where there was a large and extensive Saladoid settlement and smaller post-Saladoid sites, on Nevis we have the opposite situation. Only two sites with Saladoid components have been found, compared to 19 sites with post-Saladoid components.

On St. Kitts, where the complete inventory of sites is not as well known as on the two smaller islands, there are 11 sites with Saladoid components, 17 with post-Saladoid components, and 4 sites that probably are post-Saladoid (Goodwin 1979).

Of the Nevisian sites, three merit special discussion, both to demonstrate similarities with the archaeological data from St. Eustatius, and because the three sites have the greatest potential for yielding information on living areas of the settlements away from the middens.

Figure 17. Smoke Alley. Burial F. 50. The dating of bone material of this individual that was buried in a flexed position, resulted in 1105 ± 30 BP.

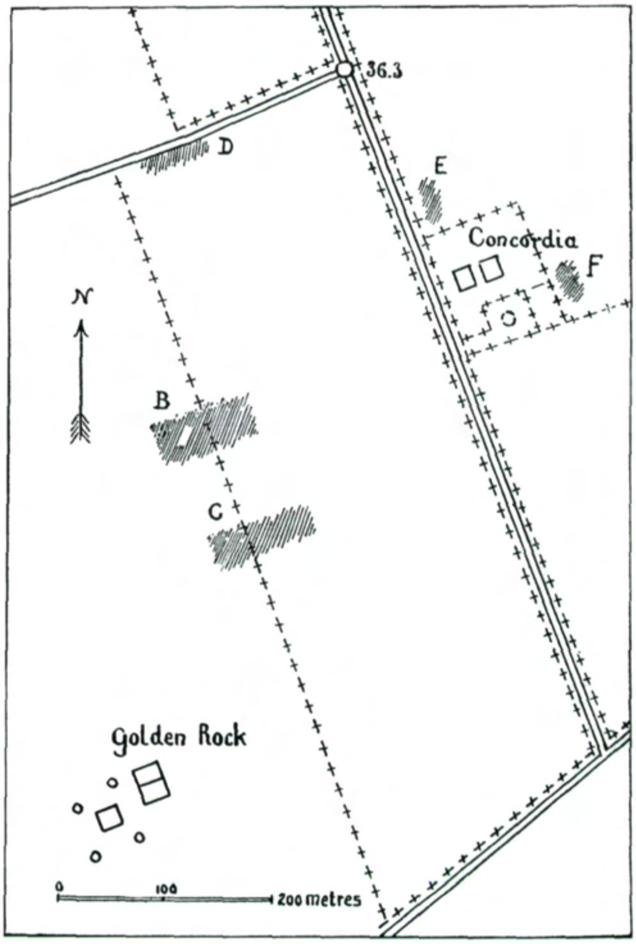

Figure 18. Drawing Golden Rock area by de Josselin de Jong. The hatched zones yielded archaeological finds. White spots in B and C indicate the 1923 excavation pits (after De Josselin de Jong, 1947, fig. 14).

The site of Hichmans (GE-5) appears from surface remains and limited test excavations to have a large Saladoid component with a post-Saladoid component above it. It is the largest Saladoid site on the island. Test excavations have revealed a midden with a maximum depth of 160 cm, with post-Saladoid material in top 40 cm. Although large parts of the site, especially on the coastal side, are badly eroded, it is likely that houses and other structures could be found on parts of the site's flat terrace upon which the midden rests.

The site of Indian Castle (GE-1) is located about 2 km south along the southeast coast of Nevis. It is the largest post-Saladoid site on the island, with a surface scatter of pottery and other artefacts extending over a 6 ha area. On the coastal side soil erosion has uncovered an area of subsoil approximately 400 m long and 30 m wide, in which 22 postmolds have been located. At present, we cannot assign the postmolds to specific structures, but it is clear they belong to more than one structure. The postmolds ranged from 20 to 30 cm in diameter and 20 to 60 cm in depth below surface. Based on this limited sample, and on the absence of very large posts, the Indian Castle postmolds appear to be more like those from Smoke Alley than those of Golden Rock.

The large plain that lies inland from the coast has been badly disturbed by colonial cultivation and subsequent erosion, but some of the surface and subsurface from the time of aboriginal occupation are likely preserved. The site of Sulphur Ghaut is a post-Saladoid site dating from the 10th to the 12th century AD. There is a flat plain about 12 m above sea level with a sparse scatter of post-Saladoid ceramics and other artefacts. On the slope between the plain

Figure 19. Golden Rock site with structures (S1-14), burials (B1-11), caches C1-4), hearths (h1-3), and midden areas (grey).

and the sea is an extensive midden. It was badly damaged by Hurricane Hugo in 1989, and an 80 m long stratified midden more than 1 m deep was revealed along the profile. Although no postmolds were discovered in the 1991 season, it is probably that structures were located on the flat plain, and the midden area on the slope was where the site's refuse was dumped.

5. Conclusions

Judging from the evidence of both the GR-1 and SA site, it is striking that these sites prove to be much more complicated to understand than their surface finds and survey results suggest. At Golden Rock the most important archaeological information (including chronological information) was recovered from areas outside the midden. In precisely that area only few surface finds occurred! In Smoke Alley midden and houses are at the same location, most probably they are *not* synchronous. In both sites surface finds did not to any extent correspond to the subsurface reality. At Godet 90% at least of the site is covered by artefact-free soil material. To some extent the same is true for GR and SA.

It seems our Caribbean sites are pretty complicated. Artefacts of any kind that are characteristic for chronological units of limited extent seem to be missing in our area of study. Zoned-incised-crosshatched and white-and-red pottery is found in sites dated 100 AD (Indian Creek, Antigua) and 800 AD (GR, St. Eustatius). Artefact collections from the sites and datings obtained suggest long-standing cultural continuity, for sure in the Saladoid period.

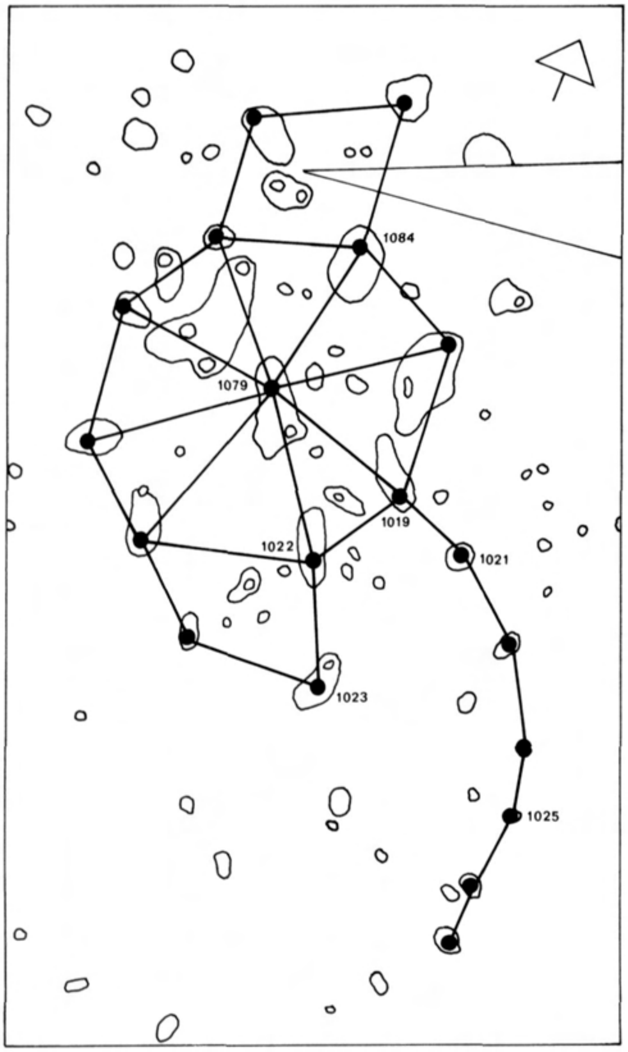

Figure 20. Golden Rock, floor plan 8-m-diameter house S1.

Did anything change after the Saladoid period, except the pottery decoration and the percentage of decorated ceramics?

The present authors doubt that on the basis of the GR and SA data. Finding a site, taking a pottery sample and dating a few charcoal samples obviously is not enough to arrive at an exact time-frame of the site. The present authors fear that more sites than Golden Rock and Smoke Alley are multi-component or were used for very long periods. This is strikingly in contrast with observations on the duration of village-occupation in the ethnographical record. Most recorded life-cycles are of extremely short duration. The archaeological record of Amazonia also suggests long-period occupation in many sites (see for instance Roosevelt 1980, 1989).[13]

The excavation and survey data suggest that surveys of prehistoric Caribbean sites meet two problems:

1. The surface information is a poor reflection of the sub-surface situation.
2. The chronological units and agents are not fine-grained enough to arrive at detailed temporal classifications of sites.

In fact, sites can only be classified to preceramic, Saladoid, and post-Saladoid in this part of the Caribbean.

Acknowledgements

The authors first and foremost want to acknowledge the counterparts of the investigations: the St. Eustatius Historical Foundation, the Nevis Historical and Conservation Society and the St. Kitts Historical Foundation.

Bert van der Valk discovered the Smoke Alley site: he made drawing no. 8. Leiden University students Odette M. Brouwer, Saskya M. Bott, Richard P. Exaltus and Jeroen Flamman helped during the Smoke Alley excavations. Tom Hamburg and Corinne Hofman studied and reported on the Smoke Alley ceramics. Jan Pauptit's immaculate lab work made the best of the field photographs, and he made photographs of artefacts in Leiden. Henk de Lorm and Ben Claasz Coockson made the drawings.

notes

1 A first draft of this paper was presented at the Annual Meeting of the Society for American Archaeology, during the symposium The Late Ceramic Age in the Northeastern Caribbean, in April 1992. The first draft was titled: Inter- and Intra-site settlement patterning on Nevis, St. Kitts and St. Eustatius.

2 At least today Caribbean fishermen will walk a long way to the beach of their village, rather than use a closer beach that "belongs" to another village.

3 Some of them may even not be pre-Columbian.

4 If the substantial evidence for a use of the Golden Rock site on St. Eustatius by Saladoids up to *c*. 900 AD indeed reflects the prehistoric reality, two possibilities exist:
1. The generally accepted end dating for the Saladoid period in the Lesser Antilles is incorrect.
2. Some Saladoid sites, among which Golden Rock, strictly stick to the Saladoid pottery repertoire. Other sites, however, do not manufacture Saladoid pottery in the 8th and 9th century AD.
We classify those as post-Saladoid or Elenoid.
José Oliver (1992) suspects his Saladoid site on Culebra Island to have conserved Saladoid parameters, while in near-by Puerto Rico post-Saladoid sites are dated in the same period of time.

5 The Dayfords site is mentioned by Fewkes (1922, 162). It is not sure where this site was situated. Dayfords is not known on St. Kitts today. Perhaps it is a misspelling for Bayfords, a location

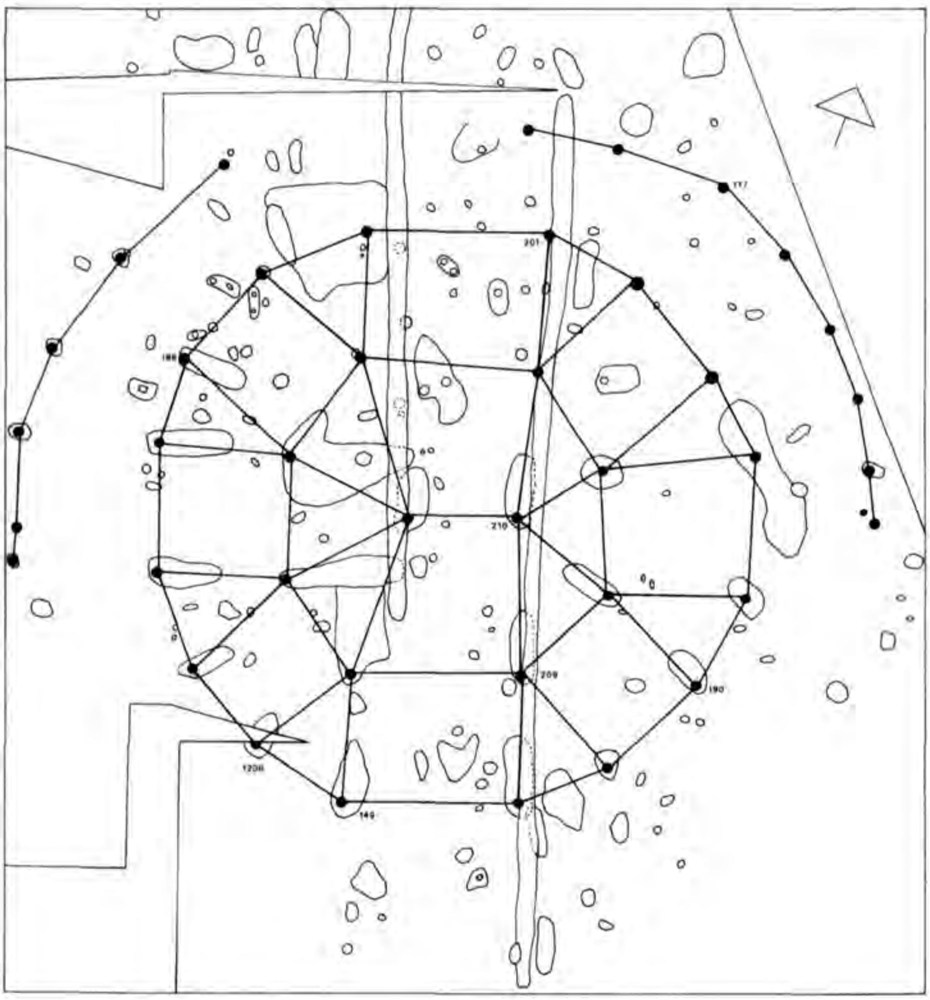

Figure 21. Golden Rock, floor plan 19-m-diameter *maloca* S4.

north of Cayon. As a consequence the Dayfords site is the only site mentioned in table 1 that is not indicated on figure 3. Other problems exist about the interpretation of this site and Hermitage, also mentioned by Fewkes as aceramic. The stone objects from Dayfords and Hermitage do lack a *ceramic context*, but it is doubted whether these sites can be compared with preceramic sites such as Great Salt Pond and Ballas Bay on St. Kitts, the Corre Corre Bay sites on Statia, and the Nisbetts and Hichmans' Shell Heap on Nevis.

6 The two Corre Corre sites on Statia will be excavated in Fall 1997. The procedures aim at a total recovery of at least part of the sites.

7 It should be noted that two Statia sites with an extremely small Saladoid component (Godet and Smoke Alley) are situated on the leeward coast. In both sites the Saladoid component is so small that it is doubted whether this can be the reflection of a (small) village. The area of both sites is the most attractive canoe landing area of the island. Statia's site 11 also is very small.

8 This sample will be studied in the near future by Hamburg and Hofman.

9 The Marine Reservoir Effect for this sample is - 130 years (p.c. G.J. van Klinken). Calibration *cf.* Van der Plicht and Mook (1988) results in AD ages between 1012 - 1042/1094 - 1114/1144 - 1152 (1 σ; probability 68.3%). Two σ (probability 95.4%) results in AD ages between 996 - 1058/1072 - 1126/1134-1160)

10 Calibration *cf.* 1 σ (probability 68.3%) results in an AD age between 252 - 300/318 - 346/364 - 374. Calibration *cf.* 2 σ results in an age of 244 - 390 AD. (Van der Plicht/Mook 1988)

11 These samples are believed to originate from a first burning down of the vegetation in the Golden Rock area, prior to the building of the houses (Versteeg/Schinkel 1992, 202). These oldest Saladoid datings (of GR and the oldest one from Smoke Alley) may reflect the time of arrival and first exploitation of St. Eustatius by Saladoid groups.

12 Although De Josselin de Jong (1923, 63) spoke of *remarkable white and red pottery* in this pre-Rouse period.

13 Also Suriname mounds and other coastal sites such as Kwatta Tingiholo, and Peruvia suggest occupational periods of several centuries (Versteeg 1985; Versteeg/Bubberman 1992).

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Kelbey's Ridge 2, A 14th Century Taino settlement on Saba, Netherlands Antilles

Archaeological research has revealed 1000 years of Amerindian habitation on the island of Saba on the northern Lesser Antilles from 450 AD to 1450 AD.[1] The latest phase is represented by the pre-colonial settlement site of Kelbey's Ridge 2. Culturally affiliated with the so-called Taino culture, the site is, presumably, to be considered a peripheral settlement of one of the chiefdoms on the Greater Antilles. In this paper the presence of a Taino site on the northern Lesser Antilles will be further explored and several hypotheses are presented as to the possible mechanisms behind this expansion during late pre-Columbian times.

1. Introduction

Saba is the smallest island of the Lesser Antilles with a surface area of 13 km^2. It is situated approximately 150 km from the U.S. Virgin Island of St. Croix, which is considered to be the eastern outpost of the 'Classic Taino interaction sphere' during late prehistoric times (Allaire 1987; Hatt 1924; Morse Faber 1991; Rouse 1992) (figs 1, 2). During this period, between 1200 and 1500 AD, an increased level of social differentiation and political complexity is evidenced on the Greater Antilles with the rise of the Taino chiefdoms (Rouse 1992; Wilson 1990). The developments on the northern Lesser Antilles are so far unknown for this period; no evidence has yet been found of a ceramic complex that would post-date 1200 AD. However, recent archaeological research has proved that the ceramic developments on the northern Virgin Islands (Lundberg *et al.* 1992) and also on Saba (Hofman 1993) parallel those of the Chican Ostionoid subseries on the Greater Antilles. The pottery, although simpler and less sophisticated, can be assigned to be an offshoot of the developments in the Taino centre meaning that the eastern border of the Chican-Ostionoid subseries should be shifted down to Saba. The location of a Taino settlement outside the centre of the Greater Antilles suggests an extension of the Taino occupation to the south-east. Economic or socio-political incentives are proposed here as possible mechanisms behind this expansion.

2. Site location

The site of Kelbey's Ridge 2 is situated in the north-eastern part of the island on an elevation of 140 m msl (= mean sea level) (fig. 3). Kelbey's Ridge is a cone-shaped volcanic dome (Westermann/Kiel 1961, 38). Towards the east, the dome is extended by a ridge which represents the northern border of the Spring Bay basin. The site is located on a triangular, slightly sloping terrain of approximately one hectare between the ridge and the lava flow of Flat Point in the north. The substrate consists predominantly of agglomerates and tuffs, covered by debris from the ridge and the lava flow.

The site location will have provided pre-Columbian people with easy access to a wide range of ecological zones and resources. Kelbey's Ridge 2 is located 300 m from marine resources on the coast. In addition, the occupants of the site would have had access to the rainforest on the higher slopes, a resource of wild fruits, birds and small mammals.

Due to its elevated position Kelbey's Ridge provides a good view of the neighbouring islands and permanent control can be exercised over the sea.

3. Archaeological fieldwork

A survey on Kelbey's Ridge was executed in 1988 and revealed two artefact clusters, labelled as Kelbey's Ridge 1 and 2 (fig. 4), and artefacts and remains testifying of a colonial occupation. The colonial component includes low stone walls, a collapsed cistern and a stone structure.

Kelbey's Ridge 1 appeared to be an oval distribution of pottery and shell fragments with a surface area of 150 m^2. Excavations revealed that the site consists of a discard area of settlement refuse and a distinct, small crab midden. A sample of exoskeletons of landcrab was submitted for radio-carbon dating and indicated an age in the seventh century (GrN-16033 1280 ± 60 BP). The pottery belongs to a late phase of the Cedrosan Saladoid subseries (Hofman 1993).

Kelbey's Ridge 2 consists of a long, curved scatter along the ridge with a surface of 2000 m^2 of which 382 m^2 were excavated between 1988 and 1991. This is about 19% of the total surface area of the site.

The sections of the excavation units showed a simple stratigraphy: on top of the sterile subsoil there is a very thin (5-10 cm) level with dispersed artefacts, which contains only pre-Columbian material: potsherds and low quantities

Figure 1. Map of the Caribbean Region.

of subsistence debris. This layer seems to represent the remainder of a living surface. On top of this layer there is a ploughzone 30-40 cm thick containing most of the pre-Columbian artefacts, nearly exclusive potsherds, and colonial artefacts. Part of the actual living surface was taken up in the ploughzone due to colonial and recent agricultural activities.

The pottery in the living surface and the ploughzone is unevenly distributed over the excavated area of the site. Pottery occurs in large quantities in two concentrations (see fig. 5). The quantities of pottery diminish towards the ridge and the central area of the terrain. The excavations revealed many features: hearths, burials and a large number of quite shallow postholes. The pattern in the pottery densities and the arrangement of the features provide insight into the settlement structure and spatial organisation of the site.

4. Radiocarbon and accelerator mass spectrometry (AMS) dates

Seven charcoal and one shell sample obtained from three postholes and three of the hearths (F503, F524 and F526) have been submitted for radiocarbon dating (for the location of the features see fig. 6). One of the hearths (F526) appeared to belong to the colonial occupation of the site. The determinations of the other samples point to a calibrated age in the 14th century (see tab. 1). Besides conventional radiocarbon dating there are determinations by the accelerator mass spectrometry (AMS) technique. For this technique collagen samples have been extracted from the molars of six individuals. Six burials were dated by this method. Primarily the AMS analysis is executed for the dietary reconstruction, specifically the contribution of marine resources in the diet, but it also provides

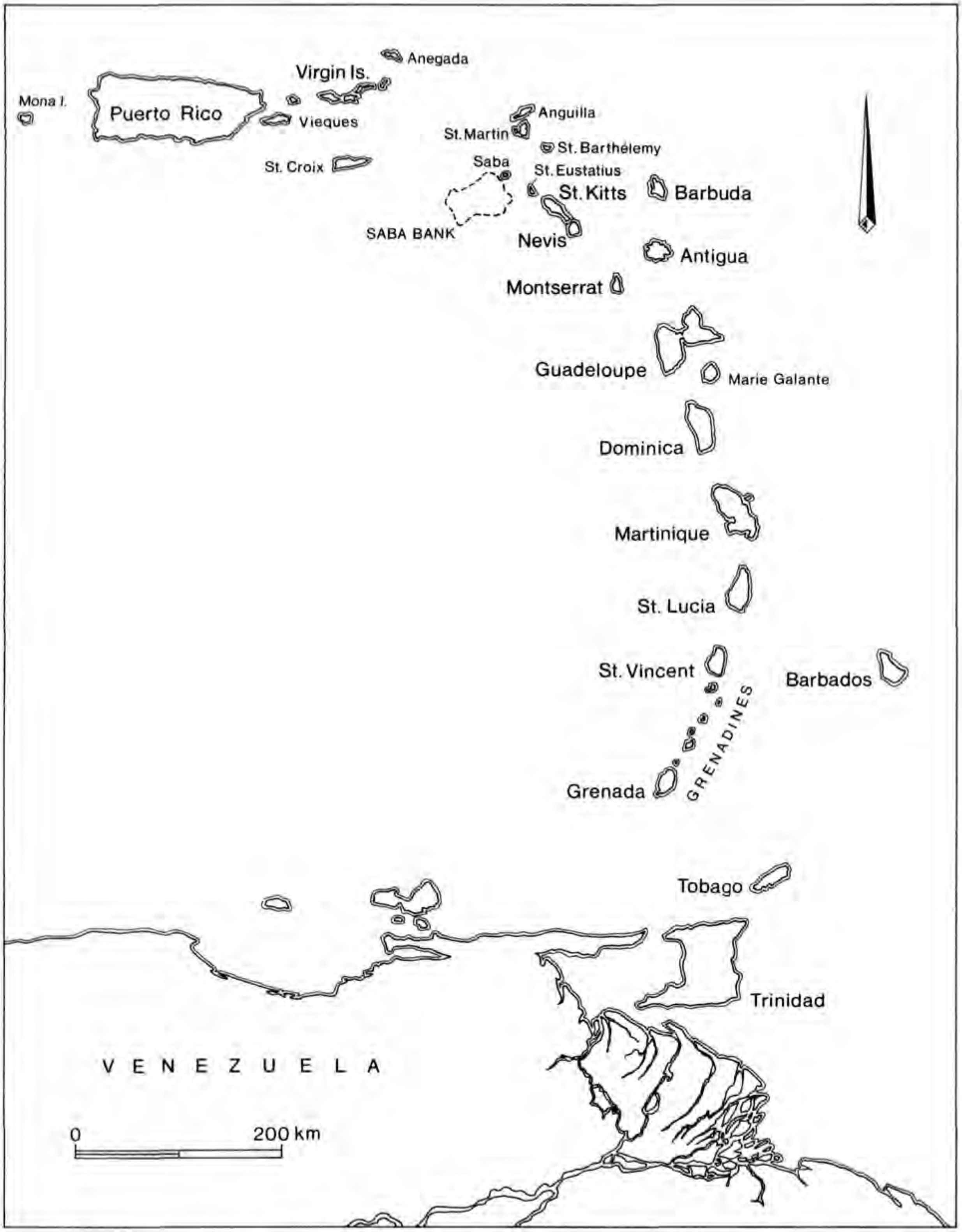

Figure 2. Map of the Lesser Antilles and Puerto Rico.

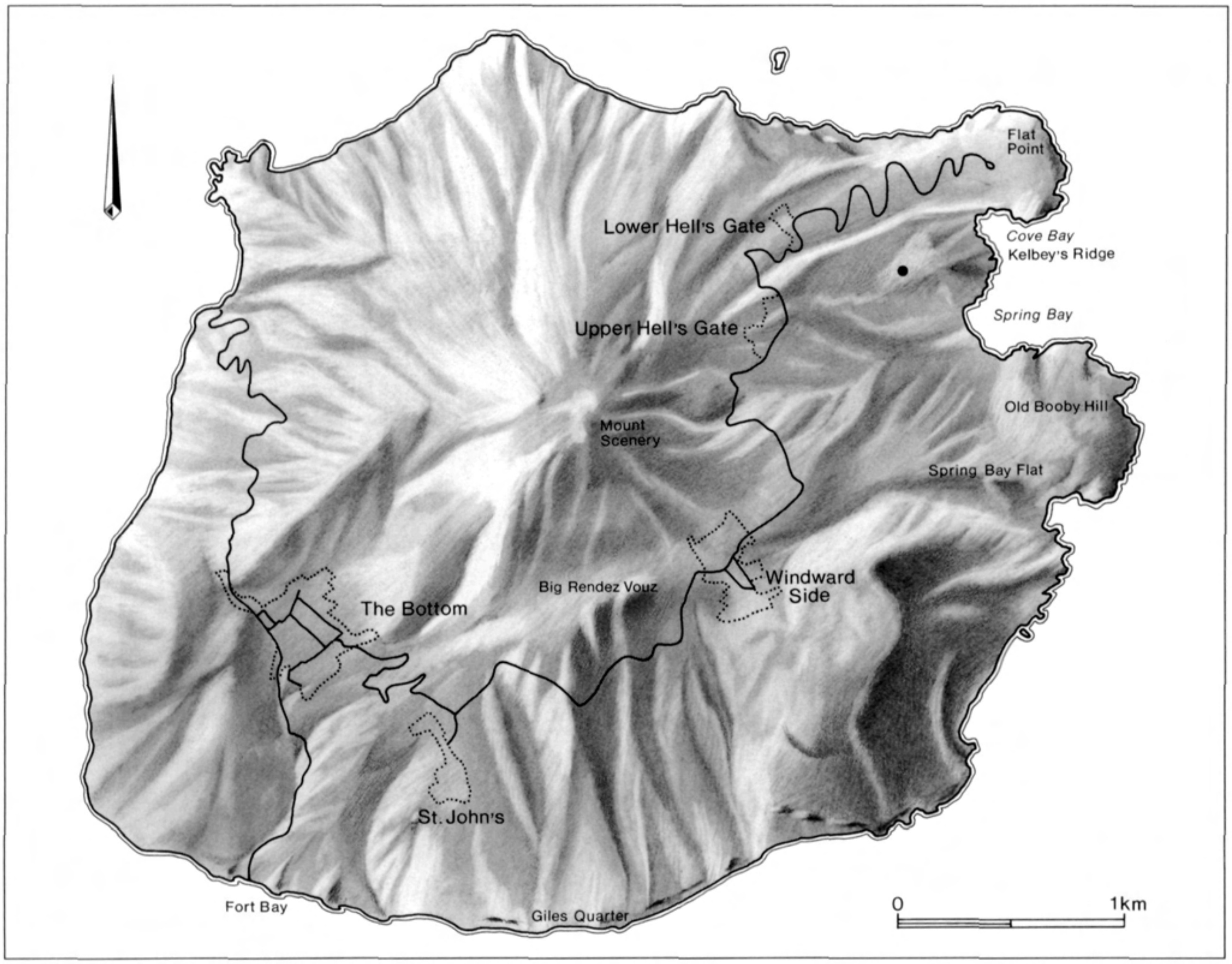

Figure 3. Map of Saba showing the location of the prehistoric site of Kelbey's Ridge.

radiocarbon dates. The results, however, lack the consistency of the conventional dates. The interpretation of the AMS dates is complicated because the determination has to be corrected for isotope fractionation ($\delta^{13}C$) and the population reservoir effect. The latter stems from the marine food component of the diet, especially reef fishes (Van Klinken 1991, 100-102). The problem is even more complex because of the possibility that the diet also consisted of C-4 plants as maize, which results in an isotope signature which is similar to reef food. The contribution of C-4 plants to the isotope fractionation, however, does not require a correction for the marine reservoir effect. As long as the ratio reef food and C-4 plants in the diet and the variety within the population are unknown, the dates of the collagen samples are difficult to interpret.

5. The features

Some 562 features were documented of which 230 appeared to be natural features such as shallow humic depressions, animal burrows and tree roots. The remainder are cultural features consisting of postholes (180), shallow pits (114), burials (7), hearths (4) and various (27).

5.1 Postholes

The postholes can be grouped to depth, shape, etc. in several classes. When these are plotted several configurations can be discerned. These can be interpreted as the traces of five more or less circular hut structures (see Hoogland in prep.). These structures are not contemporaneous because the floor plans overlap. At this stage it can only be stated that the structures are constructed with posts that were shallowly sunk into the ground. In this sense the

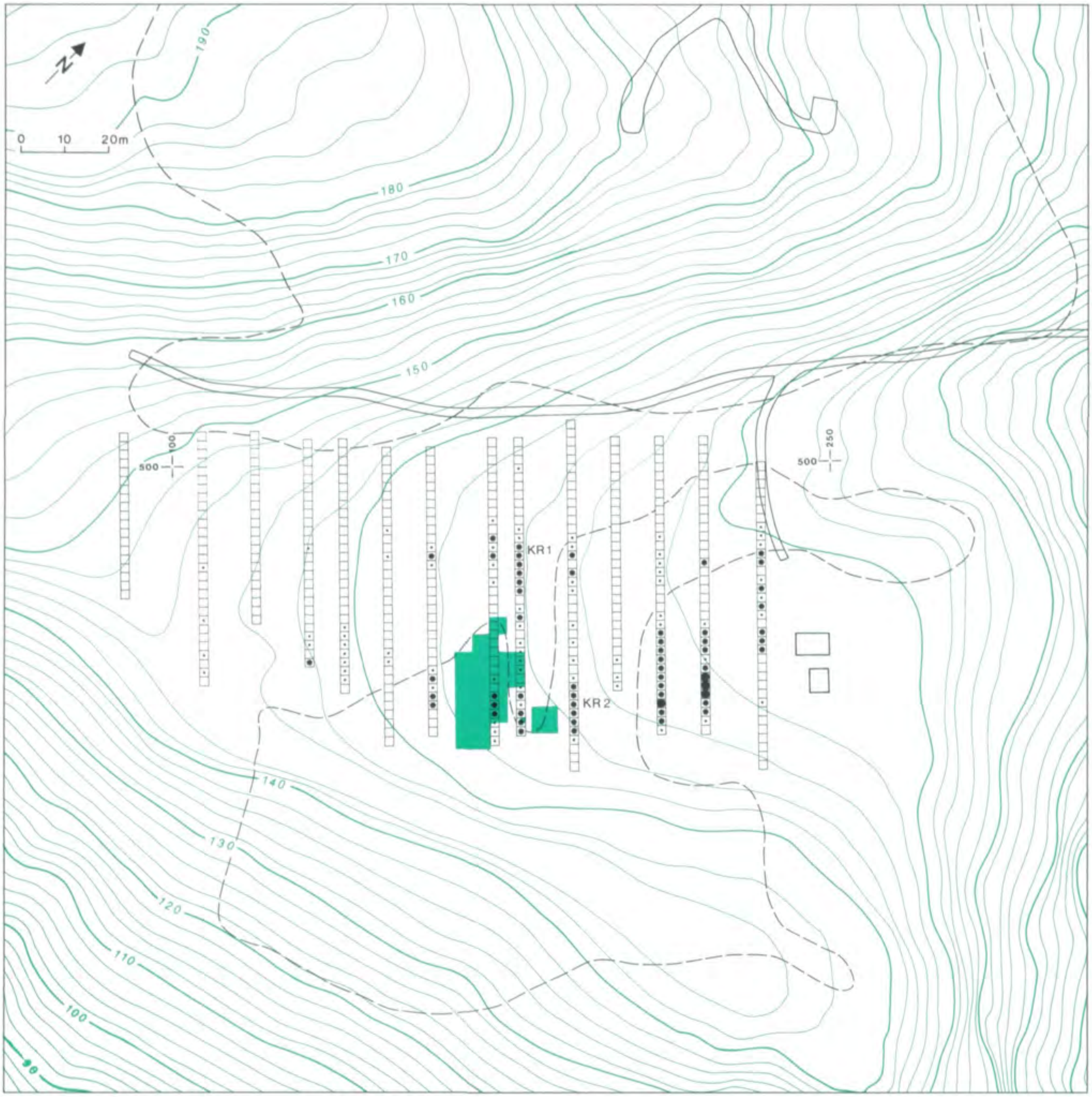

Figure 4. Kelbey's Ridge site plan showing the surface distributions of pottery sherds in the sites Kelbey's Ridge 1 and 2.

structures have in no way the solidity as was documented for the Golden Rock houses on the island of St. Eustatius (Schinkel 1992). In the literature there are only a few reconstructed houses known from the Taino period (Curet 1992a) and none of the floor plans is unequivocal. For example, at the late prehistoric site of Playa Blanca 5, Puerto Rico, excavations have revealed a configuration of postmoulds and burials arranged around a hearth pit. The configuration is interpreted as a 16 m diameter habitation unit with three concentric activity spaces. It was not the definite layout of the posts, but the distribution of the related structural features that have led to this interpretation. Rodríguez and Rivera (1991, 545) assume that the layout of a structure could be obscured by repair or enlargement.

Table 1. Radiocarbon and AMS dates for Kelbey's Ridge 2 (GrN=Groningen, OxA=Oxford). The dates are calibrated by means of the Groningen Radiocarbon Calibration Program Cal15, version april 1993, Center for Isotopes Research, Groningen University (Van der Plicht 1993). The charcoal dates are calibrated using the calibration dataset by Stuiver and Pearson 1993 and for the shell date the calibration dataset of Stuiver and Braziunas 1993 is used.
The samples KR2 38-A-3, 38-A-4-a and 38-A-4-b were collected from F504.
Sample KR2 44-D-4 was collected from F516.

Lab. number	Sample name	Material	^{14}C determination	Calibrated age (1σ)	Calibrated age (2σ)
GrN-16032	KR2 22-A-5	charcoal	595 ± 30 BP	cal AD 1312-1350, 1390-1402	cal AD 1302-1366, 1376-1412
GrN-16775	KR2 38-A-3	charcoal	610 ± 30 BP	cal AD 1308-1354, 1386-1398,	cal AD 1302-1370, 1372-1404
GrN-16776	KR2 38-A-4-a	shell	1084 ± 35 BP	cal AD 1286-1334	cal AD 1268-1384
GrN-16777	KR2 38-A-4-b	charcoal	630 ± 30 BP	cal AD 1302-1318, 1340-1368, 1374-1394	cal AD 1298-1398
GrN-18736	KR2 44-D-4	charcoal	172 ± 17 BP		
GrN-18737	KR2 50-F008	charcoal	597 ± 18 BP	cal AD 1316-1343, 1393-1399,	cal AD 1309-1352, 1387-1404
GrN-18738	KR2 52-F017	charcoal	625 ± 25 BP	cal AD 1304-1322, 1336-1362, 1378-1394	cal AD 1302-1398
GrN-18739	KR2 56-F059	charcoal	646 ± 13 BP	cal AD 1302-1307, 1356-1371, 1373-1385	cal AD 1299-1312, 1349-1390
OxA- 2951	KR2 57-F068	dentine	500 ± 65 BP		
OxA- 3617	KR2 56-F148	dentine	900 ± 60 BP		
OxA- 3618	KR2 60-F166	dentine	modern		
OxA- 3619	KR2 65-F313	dentine	690 ± 65 BP		
OxA- 3843	KR2 61-F132	dentine	795 ± 60 BP		
OxA- 3844	KR2 67-F337	dentine	450 ± 60 BP		

The double and triple posts at Kelbey's Ridge 2 attest to probably similar processes.

5.2 HEARTHS

Four prehistoric hearths were uncovered in the south-eastern part of the site of which three were completely excavated. The hearths consist of a 5-20 cm thick ash layer with an average size of 2 × 3 m. The colour ranges from very dark grey near the fringe to light grey in the centre. The ash layer has an extremely fine texture and all except feature 503 have a loose structure. In two of the hearths (F503 and F284) stones were uncovered which might have served as cooking stones as they show fire cracks. As the ash layer and the area around the hearth contained a large number of partly-burnt faunal remains of terrestrial animals, fish and shells, it can safely be assumed that the hearth was used for food preparation.

There are indications that the hearth locations were not used contemporaneously. The ash of one of the hearths (F503) is embedded in a matrix of clay and gave the impression of belonging to an earlier occupation episode than feature 524. The ash layers of features 283 and 284 both had a very loose and untouched appearance and this pair of hearths could belong to the final occupation of the site.

Two hearths (F283 and F284) were situated on a subsoil under a gradient of four to nine degrees. Apparently, a sloping area was not an objective in the choice of the location of these hearths.

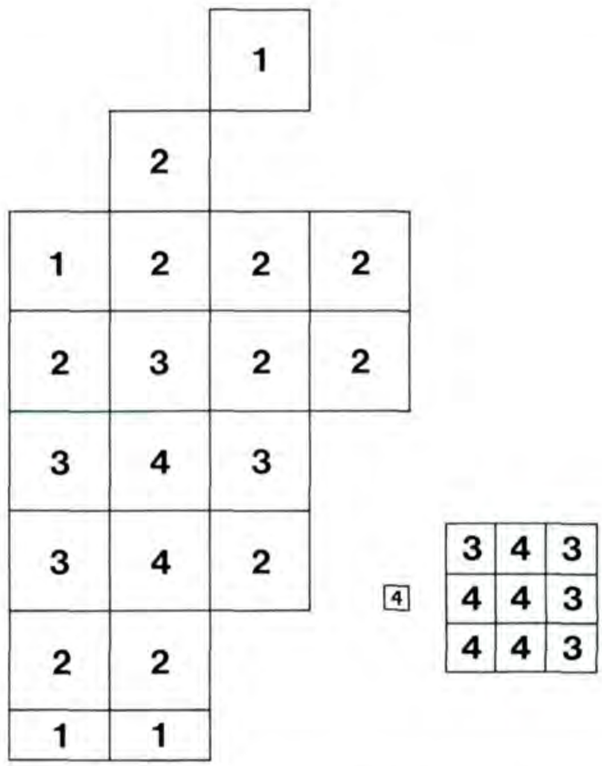

Figure 5. Kelbey's Ridge 2 site plan showing the pottery densities in the excavated areas.

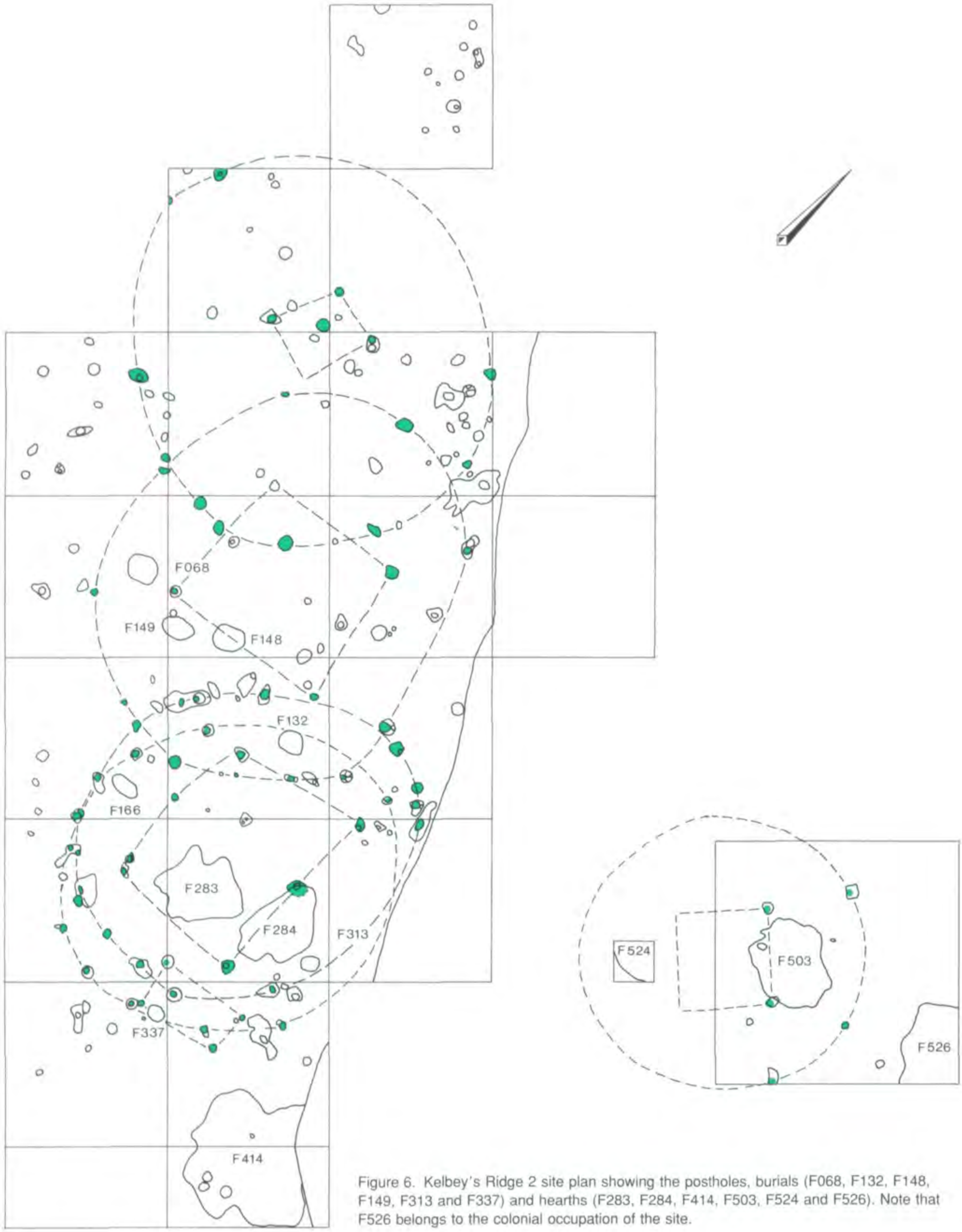

Figure 6. Kelbey's Ridge 2 site plan showing the postholes, burials (F068, F132, F148, F149, F313 and F337) and hearths (F283, F284, F414, F503, F524 and F526). Note that F526 belongs to the colonial occupation of the site.

Feature 414 consisted of a large accumulation of ash spread over an extent of 3 × 3 m, in which three 1.00 to 1.20 m deep holes were dug. The filling of these features contained a homologous mass of ash and very fine charcoal particles. As such this feature is not interpreted as a hearth and its function is still unclear.

5.3 Graves

Seven graves were uncovered of which one (F166) revealed a date in the colonial period. The position of the skeleton, however, is in many respects similar to the other graves: flexed position, one arm stretched along the body and the other bend under the legs, and the orientation in the grave. For these reasons grave F166 is regarded belonging to the pre-Columbian period despite the outcome of the radiocarbon dating.

The burials occur in two small clusters; five associated with one or two of the structures and two near the hearth locations.

The deceased were all buried in a strongly flexed seated position, the knees bent towards the chest. The grave pits were adapted to this position; the grave pits of the adults were oval, measuring only 85 by 60 cm (F068), or round with a diameter of 70 cm (F148). The grave pits of one of the children is round with a diameter of 35 cm (F337), and the sizes of features 149 and 313 could not be reconstructed as these graves were disturbed. The orientation of the deceased in the grave was either with the head to the north-east (F132, F313 and F337) or the south-west (F068 and F148). The burials vary in complexity and both inhumation and cremation occur. Three types of burials are distinguished: single, composite and secondary burials.

5.4 Single burials

The four single burials concern the interment of one adult female (F148), one child of approximately two years old (F337) and two children of 12 years old (F313 and 166). The three skeletons of the children are incomplete; the skeleton of feature 337 lacked the right humerus. Since the skeleton is well preserved the humerus was certainly removed on purpose. A smooth oval pebble was deposited under the head as a burial gift. The skull of grave feature 166 was missing and it is assumed that it was removed. The skeleton of grave of feature 313 appeared to be dislocated to some extent. It concerns the upper half of the body and moreover, the skull was taken from the grave. A smooth piece of coral was associated with this grave.

5.5 Composite burials

Two composite burials were uncovered. In both cases it concerns an adult with a child. Feature 132 is the grave of a 50-year old female and an infant aged only a couple of weeks (fig. 7). The female was facing to the south-west and the body was turned on the left side. The disarticulation of the feet can be explained by the disturbance caused by the burial of the infant. At the time the infant was interred the grave of the adult was filled up, partly or entirely. The digging of the grave of the infant halted at the level where the bones of the feet and both knees were encountered. The infant lay on the back with the arms stretched along the body and the legs were bent.

The section over the grave showed that the grave pit had been filled up in several stages. A shallow and faded ash deposit implies that subsequent to the burial of the infant a fire was burnt on or close to the grave. It is hypothezed that the function of the fires burnt at the grave could be to improve the conservation of the corpse. A second ash deposit was uncovered more superficially at the upper level and probably indicates one of the final stages of the burial practice.

The human remains of the second composite burial (F068) belong to a male adult of about 50 years old and a five-year old child (fig. 8). The burial ritual comprised at least two stages. In the first stage the male was interred in a tightly flexed position, slightly turned on his right side with the legs on the chest. After the interment of the deceased a fire was burnt on or in the close vicinity of the grave as evidenced by ash and charcoal spots on the bottom of the grave pit. Afterwards the burial pit was partly filled up, on purpose[2] or by natural processes. The next stage included the removal of the left femur, tibia and fibula and the right hand. It was done without disturbance of the joining bones so the ligaments must have been decayed at that moment. An interval of at least several weeks after the interment seems plausible. Subsequently, in the left half of the chest of the male, space was created by the removal of the third to the seventh rib. The disturbance of the other bones such as the collar bone, upper ribs and left foot was limited, which implies that the position of the skeleton in the grave was still perceivable. In the chest cavity the cremated bones of an approximately five year old child were interred. The cremation was constricted to an oval cluster, which suggests that it was deposited in a piece of cloth. The bones of the right hand were spread over the cremation and three of the removed ribs were put next to the cremated remains. Finally, the bones of the lower leg, tibia, fibula and patella, were arranged more or less in the right position, but the left femur was not replaced. This bone was kept out of the grave and probably served for the relatives as an oracle.[3] As the configuration of the cremation and the skeleton gave no further evidence of displacement or disarticulation, it is believed that the grave pit was filled up at this stage.

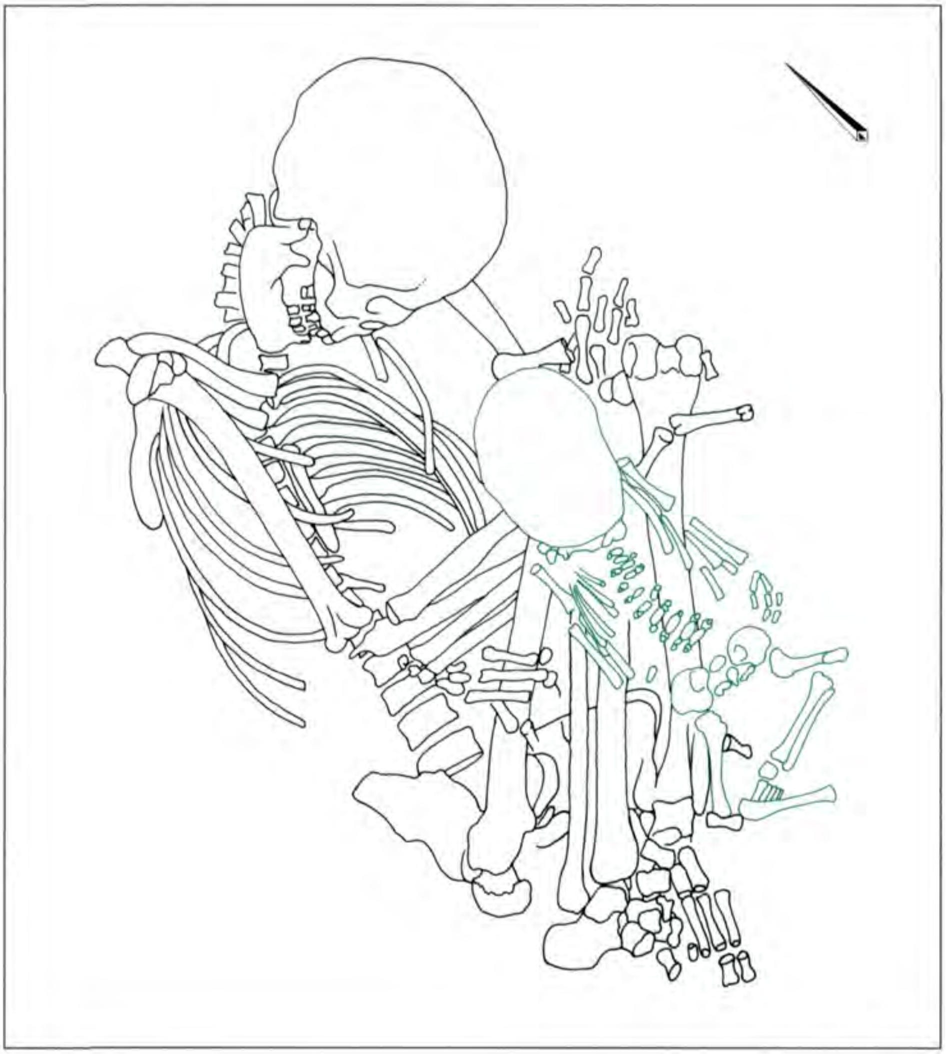

Figure 7. Burial F132, composite burial with female adult and young born child.

5.6 SECONDARY BURIAL

The third type or secondary burial consists of the secondary deposition of bones of a child of about five years old. Feature 149 appeared to be a very shallow grave containing disarticulated human remains. The bones are in an excellent state of preservation and physical anthropological traits point to an age of approximately five years. The skeletal remains are very incomplete and comprise a remarkable set of bones as only parts of the axial skeleton (vertebrae, ribs and pelvis), small bones such as phalanges and loose epiphyses are present. Some distinct categories of bones are completely missing; these are the skull, the mandible and all the long bones.

The irregularity of the outlines and the disarticulation of the remains provide evidence that the child had been exhumed. During this process the original outlines of the burial pit were altered, which were still present at a 10 cm lower level. The position of an articulated sacrum and the right half of the pelvis suggest that the child was originally deposited as a primary burial facing towards the west.

The comparison of the inventory of this burial and the cremation of feature 068 yielded interesting results. The two inventories are complementary so far as the fragments of the cremation could be identified. Most of the fragments belong to the skull and the long bones, which certainly do not occur in feature 149. As the results of the determination of the age of the cremated remains and human remains of feature 149 are the same, the conclusion that the remains from both burials belong to one individual, a five-year old child, seems to be well-founded. Another detail of the cremation supports this conclusion; namely the absence of

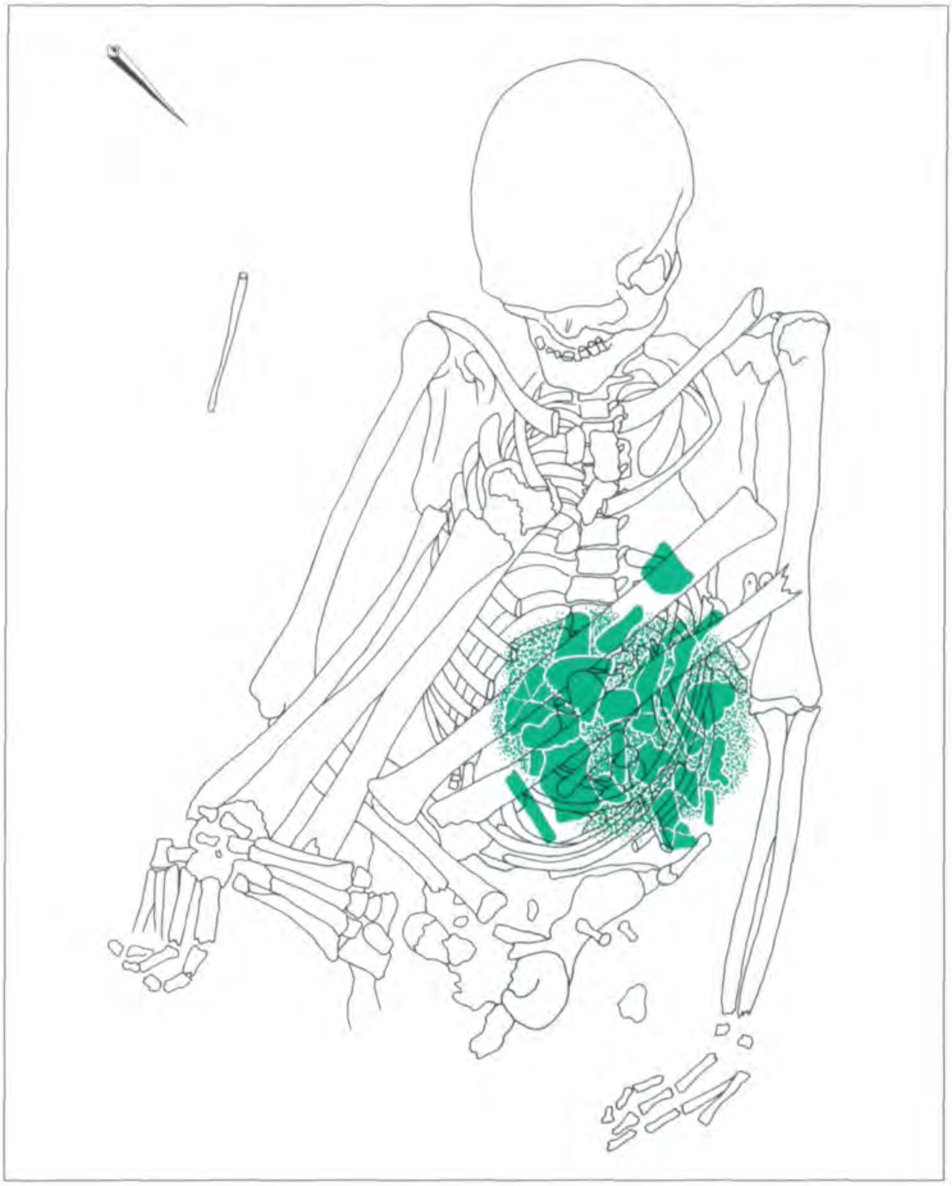

Figure 8. Burial F068, composite burial with a male adult and the secondary deposition of the cremated bones of a five year old child.

transverse fracture lines on the long bones, which are characteristic for the cremation of bones covered with flesh. The absence means that the bones were already in a dry state before cremation.

All these data point to the fact that the child was at first inhumed in grave feature 149 and after some time exhumed. The skull, the complete set of long bones and only a part of the axial skeleton and smaller bones were collected and cremated. As a secondary burial the cremated bones were interred in the grave of the 50-year old male (F068) and during this process the right femur of the male had been removed. The precise sequence of the stages of this ritual are difficult to reconstruct, but these practices are evidence of a complex, multi-stage burial ritual.

6. Subsistence

The faunal samples recovered from the hearths consist of the remains of vertebrate species and marine shells. The terrestrial animals include lizards, birds and a relatively high percentage (24%) of rice rats (*Oryzomyine*). The exploitation of marine resources includes the inshore waters (sea turtles), reefs and probably offshore banks. The most common fish of the reefs are surgeonfish (Acanthuridae), triggerfish (Balistidae) and groupers (Serranidae), the latter two may have been caught on the Saba Bank though they also occur in shallower waters close to shore (Wing n.d.). Shells are represented by rather small shells like chitons, *Fissurella* and *Nerita* which occur in large numbers as well as by the more substantial species like *Citarium pica* and *Purpura patula*. The smaller species could easily be collected on the rocky shores, but contributed to the daily food ration to a minor extent.

The values of the stable isotopes point to the fact that the broad spectrum exploitation of terrestrial and marine resources provided sufficient quantities of proteins. It is generally accepted that the diet of the Tainos was supplemented with manioc and to a lesser extent with maize. The griddles in the archaeological deposits confirm the dependency on manioc for a sufficient intake of carbohydrates.

The outcome of the isotopic analysis of the Kelbey's Ridge 2 population suggests that there is an increased reliance on marine resources compared with the Saladoid population of the island of St. Eustatius and the post-Saladoid population of Saba (Van Klinken 1991, 99). If it is assumed that maize made no contribution to the diet the average percentage of marine reef food items is 41%. However, it is more probable that the δC^{13} value is increased by a contribution of C-4 plants such as maize.

7. Pottery

The pottery assemblage of Kelbey's Ridge 2 belongs to the Chican Ostionoid subseries (Hofman 1993). Although Saba seems to have followed the local developments of the other northern Lesser Antilles known as Mamoran Troumasoid in the preceding centuries, the island seems to be culturally incorporated in the Greater Antillean influence sphere during the 14th century. Although no other pottery complexes have been dated after 1200 AD. Chican decorated pottery is occasionally reported from other Leeward islands (Hamburg 1992; Petersen pers. comm.) where they appear in Mamoran Troumassoid assemblages. These may probably be interpreted as intrusive elements as a result of exchange (Hofman 1993, 156). In a similar way Chican pottery also spread towards the west as far as eastern Cuba and to the north-east into the Bahamas where it is also considered to be exchange items among the Meillacan and Palmetto ceramic styles (Alegría 1976; Veloz Maggiolo 1972).

Characteristic decoration on the pottery shows strong affiliation with the Taino culture, and more specifically with the Esperanza, Capá and Boca Chica styles from Puerto Rico and Hispaniola.

Only 0.7% of the pottery is decorated and decoration consists predominantly of incision and modelled appliqués and to a lesser extent of punctation. Painted decoration is lacking, which is in contrast to the earlier Cedrosan Saladoid pottery on which white-on-red and polychrome painting are the dominant decoration modes and to the subsequent Mamoran Troumassoid pottery on which painting is still present although in low quantities (Hofman 1993).

Incision consists of deep narrow lines often ending in punctation or arches similar to those on Esperanza and Capá pottery. The incisions were applied with a sharp-pointed tool when the clay was still very soft which resulted in deep and sharp lines with a serrated edge (fig. 9d). Incised motifs are linear lines, V-shaped motifs or scrolls and are only very rarely applied on a red slipped surface. Pairs of parallel lines either semi-circular or straight are diagnostic and a fine horizontal line is found above these motifs, bordering the rim. The incised decoration is most often applied on the upper part of the body directly under the rim (figs 9a, c).

Modelled appliqués with geometric, anthropomorphic and zoomorphic designs are characteristic for this assemblage. Geometric appliqués consist of notched fillets, applied to the vessel as vertical or horizontal strips with incisions (fig. 9b). Anthropomorphic head lugs representing Taino deities and zoomorphic head lugs with the representation of iguanas, frogs, bat and monkey heads belong to decorated ceremonial vessels and are typical elements in the Taino mythology (figs 10a-c). The bat, for example, was thought to represent the spirit of the dead (García Arévalo 1988). However, many of the designs appear to have been revived from the earlier Cedrosan Saladoid pottery (Rouse 1986).

Punctated lips are common and the punctation is applied on bevelled or double thickened lips. These vessels are often covered with a red slip.

A few fragments with a white-polished clay slip seem to be of non-local manufacture. Resemblances with Boca Chica pottery suggest that these were probably imported from the Greater Antilles.

Vessels tend to be more irregularly shaped than in earlier periods. Most common are bowls with inward-curving or simple straight walls with rounded, flattened or bevelled lips and flat or concave bases. Carinated vessels known from earlier periods are uncommon and necked globular vessels occur in small quantities. Boat-shaped vessels occur occasionally with appliqued head lugs. Cooking-pots seem to have fairly broad bases and low bodies (fig. 11a).

In general, vessels walls tend to be rather thin, between 5 and 8 mm and vessel diameters range from 25 to 35 cm. Not many vessels exceed 40 cm in diameter. The surface of these vessels is finished by simple smoothing or burnishing, with the exception of a few which are polished or covered with an orange-red clay slip.

Figure 9. Decorated pottery of Kelbey's Ridge 2.
a. Potsherd with incision ending in punctations
b. Potsherd with decoration of notched fillets.
c. *Potsherd with incision ending in arches.*
d. Potsherd with deep narrow lined incisions. The serrated edges, which indicate that the clay was still very soft while the incision was executed, are clearly visible.

Griddles which are associated with the baking of flat bitter manioc cakes, known as cassava are usually flat shaped without an outstanding rim (fig. 11b). These belong to the so-called 'pancake type' (Hofman 1993, 71, fig. 16e). The griddles have an average diameter of 45 cm and are approximately 8 mm thick. The baking surfaces are smoothed and the bottoms are crudely finished.

A total of 27 seven perforated discs were recovered. It is generally accepted that these clay discs were used as spindle whorls. Noteworthy are the various stages of fabrication in which they were discarded. These clay discs were often made secondarily from discarded potsherds and have an average diameter of approximately 5 cm and an average thickness of 4 mm. There are a few larger and thicker examples, however, with diameters between 10 and 20 cm and between 8 and 11 cm thick.

The ceramic assemblage on the whole shows characteristics that are the result of firing under rather low temperatures, like the soft fabric and the carbonaceous material in a lot of the sherds. The firing temperatures did not exceed 800°C.

Textural and mineralogical analysis revealed that local volcanic clays were used for the manufacture of most of the pottery. Shell and grog temper are lacking. However, a few specimens have likely been imported from other islands, supposedly the Greater Antilles, as they are made from exotic clays (Hofman 1993, 192). Other studies have also assumed inter-island interaction in this context (Donahue *et al.* 1990, 251; Petersen/Watters 1991, 333, 355).

8. Ceremonial paraphernalia

Ceremonial paraphernalia found around the graves include a snuff-inhaler and three-pointers also known as zemis.

Figure 10. Decorated pottery of Kelbey's Ridge 2.
a. Anthropomorphic head lug representing a Taino deity.
b-c. Zoomorphic head lugs representing bat heads.

The snuff-inhaler is made of manatee bone, it is shaped like a fish with an open mouth (fig. 12a). The eyes contain rests of resin probably used to affix small inlays. The opening in the mouth is connected with two perforations in the gills. This Y-shaped perforation suggests that the object was meant as a inhaler for hallucinogenic snuff.[4] It is most probable that the snuff was inhaled through two hollow bird bones put into holes of the gills. A similar specimen is known from Anguilla, also with the representation of a fish, probably a shark or an other large fish. The gills and mouth of the fish are deeply engraved. Traces of resin remain in the eye and nostril. There is a "Y" shaped perforation leading to two nostril pads on the upper body of the fish. The object has been found at the Sandy Hill site and can probably be dated between 900 and 1400 AD (Douglas 1991, 579).

On Puerto Rico, in the Efrain Irizarry de Lajas collection, a recipient-inhaler made out of manatee bone with the representation of a fish has eyes inlayed with two small green stone beads (Alegría 1981, 38). Anthropomorphic and zoomorphic sculptures made of manatee bone or wood with inlays are a very common cultural manifestation of the Tainos of the Greater Antilles (Hispaniola and Puerto Rico) and also occur on the Virgin Islands (Alegría 1981, 16). The representation of a fish in connection with the inhalation of hallucinogenic snuffs, is uncommon. More frequent are the representations of reptiles and toads.

The small three-pointed objects or zemis which are believed to serve as mediators between the people and 'Yocahu', the spirit of the manioc, are common items in the artefactual inventories of many archaeological sites in the

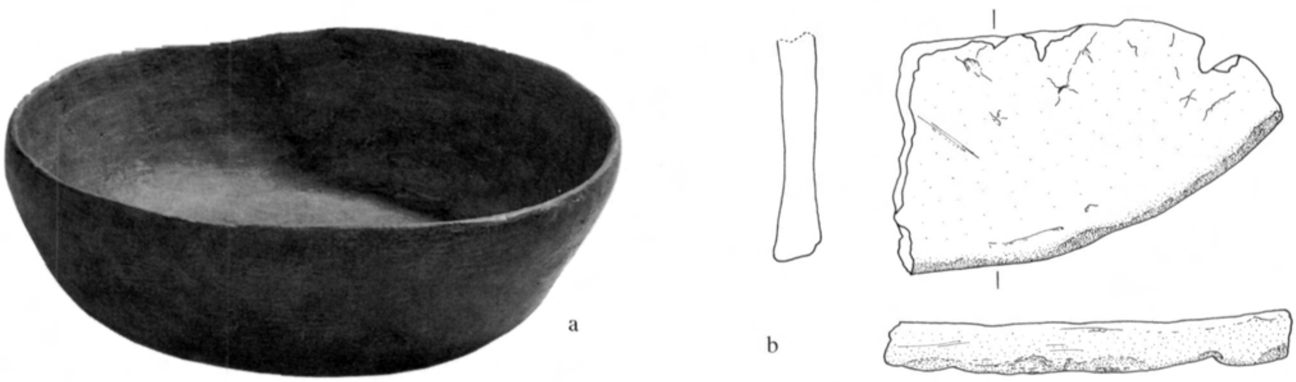

Figure 11. Pottery of Kelbey's Ridge 2.
a. Cooking-pot with broad flat base (restored by Jan Sloos, RMO Leiden). b. Flat or 'pancake-type' griddle.

Caribbean. Particularly, the Taino culture has many large three-pointed objects and sculptures of stone, wood or cotton which they believed would give them water, wind and sun, and also children and other necessities they needed (Bartelomé de Las Casas 1927, Part I, 416). The zemis of Kelbey's Ridge 2 are made from coral, one bearing a weathered decoration of probably a zoomorph representation on one of the ends and the other object is a carved piece of coral representing the head of a deity (figs 12b, c).

9. Synthesis

9.1 Site level

Based on the analysis of the material and the features the following picture emerges as to the structure of the Kelbey's Ridge 2 site and its cultural identification.

The spatial patterning of pottery shows that the high density areas coincide with the locations of the hearths. The occurrence of subsistence debris and the high density of pottery suggest that these locations can be interpreted as special activity areas, *i.e.* as food preparation and cooking areas. Although the observations are limited there also seems to be a zone with a lower pottery density in between the hearths of features 383 and 284 on the one hand, and the hearths of features 503 and 524 on the other. These clusters could represent the domestic areas of the discrete household units.

Based on these observations though restricted to a part of the site, one could imply that the settlement consists of a number of repetitive household units. A unit could have consisted of one or more living quarters, probably a roofed cooking area and an area designated for burials. It seems plausible that the deceased were buried within the huts. Estimates of the life span of the structures can be derived from ethnographic sources of the mainland of South-America, especially the Guyanas, which in some way resembles the climatic conditions on Saba. A life span of about 15 years for a simple hut structure is tentatively assumed (Hugh-Jones 1985).

Based on survey and excavation data the number of household units that could have been situated within the site limits might have been four or five. The radiocarbon dates point to an occupation of the site of 100 years at the most. It is, however, probable that the occupation lasted a much shorter time taking into consideration the number of structures, their life span and the number of burials.

The burial practices encompass more stages and attest to a complex funeral ritual. The differences in treatment of the deceased suggest that the children especially were given preferential attention. It is the graves of the children that contain grave goods, although simple objects, and the composite child-adult burials attest to a special relationship between the first and the third generation. It can be assumed that this relation reflect some kind of kinship relationship and maybe some kind of hereditary principle.

The burial practices documented for the Tainos by archaeological investigations are very similar to the descriptions in the written sources from the early colonial period. Archaeological excavations yield a large number of burials mostly in middens. Direct burial in an excavated grave, with the body in a contracted sitting or lying position is most common, but secondary burials are also recorded. A composite burial occurs in the Playa Blanca 5 site (Rodríguez/Rivera 1991, 555, fig. 7)

The early colonial sources report mostly on the, to European eyes, peculiar burial practices such as the burial of caciques, burials in caves and secondary head burials. Cremations are not mentioned and must not be confused with the desiccation of the body of a cacique over a fire (Lóven 1935). It is a common custom of the Tainos to keep the head

Figure 12. Paraphernalia Kelbey's Ridge 2.
a. Snuff-inhaler from manatee bone. b-c. Three-pointers or zemis from coral.

or a bone of a deceased relative in a basket in the house (Navarrete 1825-1837. vol 1, 223, 363). The bone was kept as an oracle and served as a medium for the relatives to communicate with the dead. The removal of bones and a skull of the Kelbey's Ridge burial could be related to this practice.

Regarding the burial practices there is clearly a connection with the Taino culture of the Greater Antilles. This conclusion is affirmed by the material culture, *i.e.* pottery and ceremonial paraphernalia.

Chican pottery seems to be mostly locally made, although there is evidence of exchange reflected in the presence of exotic clays. The rather poor quality of the pottery and the low percentage of decorated pottery may point to the production of the pottery at household level. The potter's personal qualifications and preferences in combination with specific functional requirements *(i.e.* the use for specific household activities) probably determined the choice of the fabrics, the range of the vessels and the stylistic quality.

The low percentage of decorated pottery can also be regarded as the reflection of a low symbolic value of the pottery within the community itself. It is conceivable that pottery in these households did not draw much attention as medium for decorative displays. The ritual activities could for example have been restricted to ceremonies involving the household level.

The lack of evidence of a ceremonial plaza/ballcourt at Kelbey's Ridge 2 and its associated stone belts, as well as elaborate ritual objects diagnostic for the Taino culture, confirm the peripheral character of the settlement and its probable ceremonial dependency on one of the Greater Antillean chiefdoms for rituals at the community level.

9.2 Regional level

The occurrence of Taino pottery on Saba could imply that for one reason or another a local group had been copying Chican pottery from the Greater Antillean Taino chiefdoms. However, in that case one would expect an imitation rather than one to one copying. In addition, distinctive features of the receiving culture would persist beyond this imitation. Allaire has illustrated that in such a case of unbalanced interaction, it is most likely that ceremonial artefacts associated with the elite are to be assimilated into a local culture (Allaire 1990). The presence of an almost complete set of Tainan elements suggests an extension of the Taino occupation towards the south-east. This expansion could have involved the migration of a small group of Taino colonists to Saba. On a regional level several possible explanations can be attested for this fact:

1. One possibility, which was proposed earlier and which should be regarded as a probable hypothesis, is that of a refugee group, originating from the Virgin Islands or the Greater Antilles fleeing social and/or political instability

in that area, which settled on Saba (Hofman/Hoogland 1991). Recently, migration of Chican groups to, amongst others, the islands of the Lesser Antilles has been suggested to explain the decrease in population estimates on Puerto Rico for the Chican period (Curet 1992b, 289). Since Curet conclusively excludes population pressure as the mechanism behind the migration, there must have been other incentives.

2. Incorporation into the influence sphere of the Tainos for economic or socio-political purposes offer two other options, which in the authors' opinion seem to be the most plausible:
   a. an incorporation for economic purposes could evolve from a need for specific resources, one could think of the exploitation of fishing grounds at the Saba Bank. A similar suggestion was recently made by Lundberg *et al.* (1992) for the Taino expansion on the northern Virgin Islands. They suggested that settlements possibly functioned as resource-extraction sites to exploit the resource potential of the small islands and their shallow waters. The presence of the black durgon (*Melichthys niger*) in the faunal remains and its habitat preference may point to fishing on the Saba Bank (Wing n.d.).
   b. in the case of an incorporation for socio-political reasons Saba could be considered to have had the role of a supportive base to control the route of trade and communication through which exchange of prestige goods took place. This route ran along the Lesser Antillean islands towards the South American mainland.

The production centres of prestige goods for the elite were situated on the South American mainland. Pendants in the shape of a semicircular moon made from a gold, silver and copper alloy, called *guanin*, were made by groups in Columbia and one of the production centres of amulets from green stone was situated on the Lower Amazone. Through exchange with intermediate groups these goods were transported along the rivers to the coast. These exchanges took place through Arawakan and Carib groups. On the coast the prestige goods were probably exchanged with the Tainos through the intermediary of groups living on the southern Lesser Antilles. The exchange of prestige goods was obviously an activity of the political elite of the various groups and was meant to reinforce both the position of the elite within their socio-political unit (chiefdom) and also its prestige within the regional network of peer polities (see Renfrew/Cherry 1986). Interaction was possibly not only expressed by reciprocal relations, but also reflected by the competition between the various groups within the network. Competitive groups could try to strengthen their position through alliances and through executing raids against their rivals.

This point of view emphasises the idea of interaction between groups on the Greater Antilles and the mainland, and is based on the evidence drawn by recent archaeological research and by a critical re-examination of the ethno-historic literature by various authors (Allaire 1990; Boomert 1987; Whitehead 1990).

10. Concluding remarks

The occupation of the northern Lesser Antilles in the pre-colonial period was until now only known from St. Croix. From this island a relationship with the Chican-Ostionoid subseries is apparent. Further to the south-east the site of Kelbey's Ridge 2 on Saba is dated in this period and embraces an extensive set of cultural elements which confirms its tie with the Taino culture. As has been suggested in this paper, this expansion served most probably either economic or socio-political objectives.

On other islands of the northern Lesser Antilles the Taino impact has been scarcely documented by some minor Chican influences on the pottery. The absence of archaeological evidence for late-prehistoric occupation can partly be explained by the scarcity of systematic survey projects on these islands. In the Chican period the settlement pattern changes to more inland locations, and here the quite shallow sites are more susceptible to destruction by agricultural practices and modern development.

notes

1 The research has been funded by the Netherlands Foundation for the Advancement of Tropical Research, WOTRO (W28-279) and the Consultation Organ for Cultural Cooperation in the Netherlands Antilles, OKSNA.

2 From the taphonomy of the skeleton it appears that the burial pit was left open for quite a while. Parts of the skeleton, such as hand- and footbones were found at a deeper level or at the bottom of the pit. This vertical disposition could only have taken place after the ligaments were sufficiently decomposed and the bones could fall apart from their joints.

3 Similar practices are described by 16th century Spanish sources on the Tainos from the Greater Antilles and 17th century French sources on the so-called Island Caribs (Breton 1665, 1666; Navarrete 1825-1837).

4 It is known from the sixteenth century Spanish written sources that the Native Indians used a hallucinogenic snuff known as cohoba, prepared from the seeds of the tree *Anadenanthera peregrina* (Wassen 1979, 242). To strengthen the hallucinogenic effect of the *Anadenanthera* it was necessary to mix it with crushed conch shell. The inhaling of tobacco smoke was a ritual preserved for the cacique and the religious specialist, the *behique*.

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Flint exploitation on Long Island, Antigua, West-Indies

Long Island, an islet off Antigua (West-Indies), forms the major source for flint in the Lesser Antilles. A survey of the islet has indicated the presence of various raw material sources. Test-excavations at the major flintknapping site of Flinty Bay show a very standardized reduction sequence. Apparently, the aim was to obtain high quality cores which could easily be transported.

1. Introduction

For quite some time archaeologists have been aware that good quality flint could be obtained on Long Island, an islet about a mile northeast of Antigua (fig. 1) (Davis 1974; Nicholson 1976b; Olson 1973). However, recently very little systematic research has taken place here. In the early eighties a small hotel was built in the southwestern part of the island; over the years the premises of the hotel were expanded and by 1988 about half the island had been affected (fig. 2). The archaeological sites which were destroyed by the building activities and the lay-out of the gardens have been sampled and described by D.V. Nicholson (Nicholson 1976a, 1976b, pers.comm.). In 1988 the Jumby Bay Resort, owner of Long Island, began selling plots along the coast for the construction of private villas. These new building plans threatened the largest known prehistoric site on the islet, *i.e.* the one along Flinty Bay on the north coast (fig. 2, scatters 1-3).

From March 7 to 26, 1989, a survey was undertaken by the Institute of Prehistory of the University of Leiden intended to document the Flinty Bay site, to locate and characterize the flint sources present, and to investigate the extent and character of the flint extraction sites on Long Island.

2. Inter-insular contact networks

Traditionally, Caribbean archaeologists have been concerned with similarities and differences between archaeological assemblages from different islands, as these could shed light on population movements (Rouse 1964). With a growing interest in archaeology for the socio-economic aspects of prehistoric peoples, this concern has been extended towards attempting to reconstruct inter-island contact-networks. Such relationships had to be maintained, if only to obtain marriage partners.

There are various ways to establish the extent and frequency of contact between islands, such as morphological similarities in artefacts (see also Hofman (1993) for ceramics and Kozlowski (1974) for the preceramic flint of the Greater Antilles), settlement patterns (a.o. Haviser 1990; Watters/Rouse 1989), and the distribution of prestige items (*cf.* Lundberg 1989; Schinkel 1992). A fourth, as yet hardly explored approach involves the analysis of the acquisition and distribution of rare but important raw materials. Due to the different geological character of the various islands, crucial raw materials were not available everywhere and had to be obtained from other islands, either by organizing an expedition, or by exchange or trade. One such material is flint. Both archaeologically and ethnographically, situations have been documented in which search parties were covering large distances to procure essential stones (Gould 1980; Gould/Saggers 1985; Olsen/Alsaker 1984), or very long exchange lines existed (McBryde 1986, 1991a, 1991b). A better understanding of the flint exploitation on Long Island, being a major flint source in the area, would be pivotal for inferences concerning the character of interinsular relationships.

3. Flint sources in the region of the Lesser Antilles

On the Greater Antilles, for example on Puerto Rico (Pike/Pantel 1974) and Hispaniola (Moore 1991; Veloz Maggiolo 1991), flint is commonly available. However, on the Lesser Antilles it is a rare commodity. No flint sources are known from Guadeloupe, Martinique and Dominica (Pinchon 1952), whereas Watters (1980) has not encountered any flint beds on Barbuda and Montserrat, despite of an intensive survey. On St. Kitts small flint pebbles can be collected on the beach (Walker 1979). A deposit of natural flint, not unlike the material employed by prehistoric communities on Saba, is found in the Point Blanche Formation on St. Maarten. A minor pebble occurrence of jaspis and flint on St. Eustatius appears not to have been used by the Indian communities there (Van der Valk 1992).

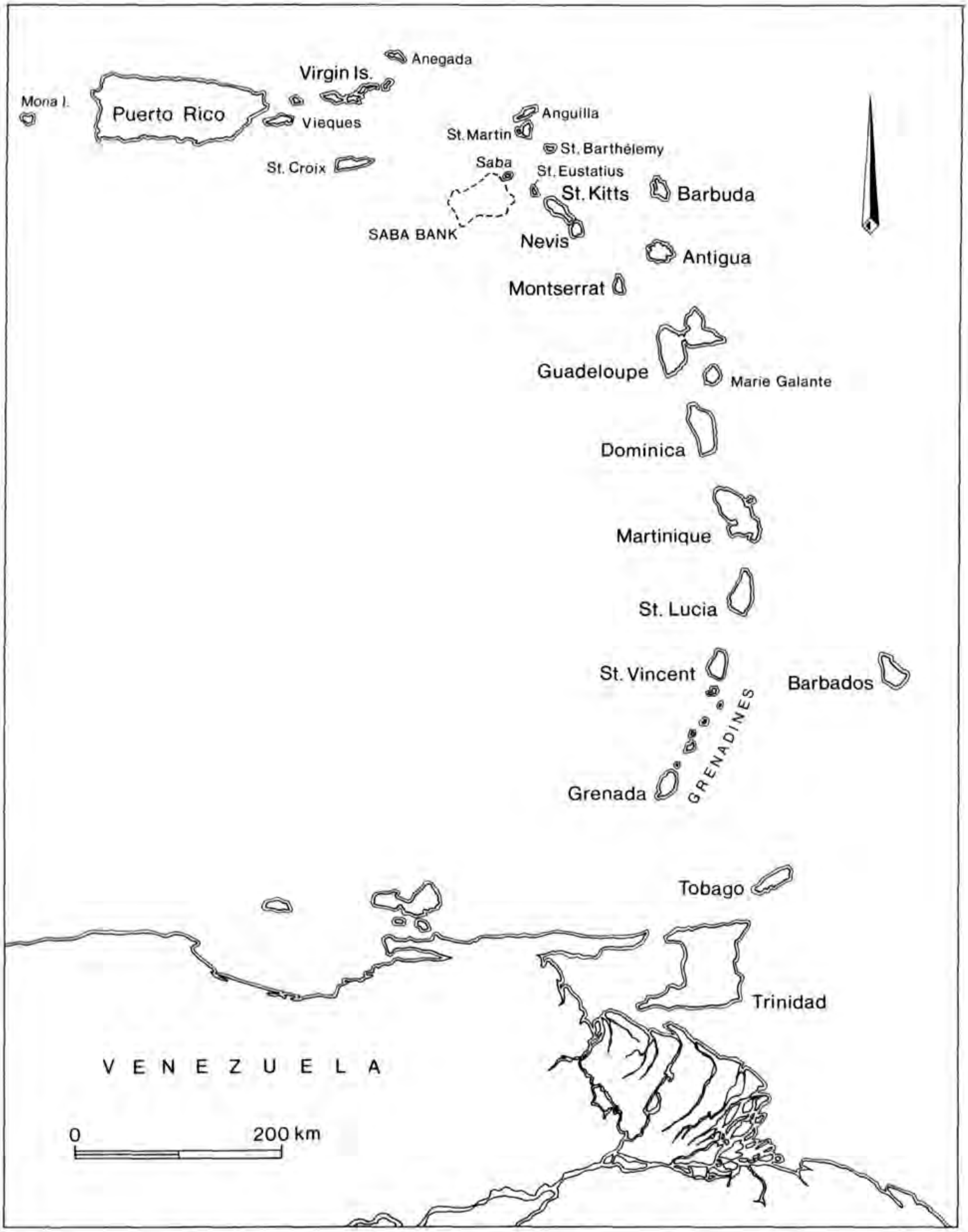

Figure 1. Map of the Lesser Antilles and Puerto Rico.

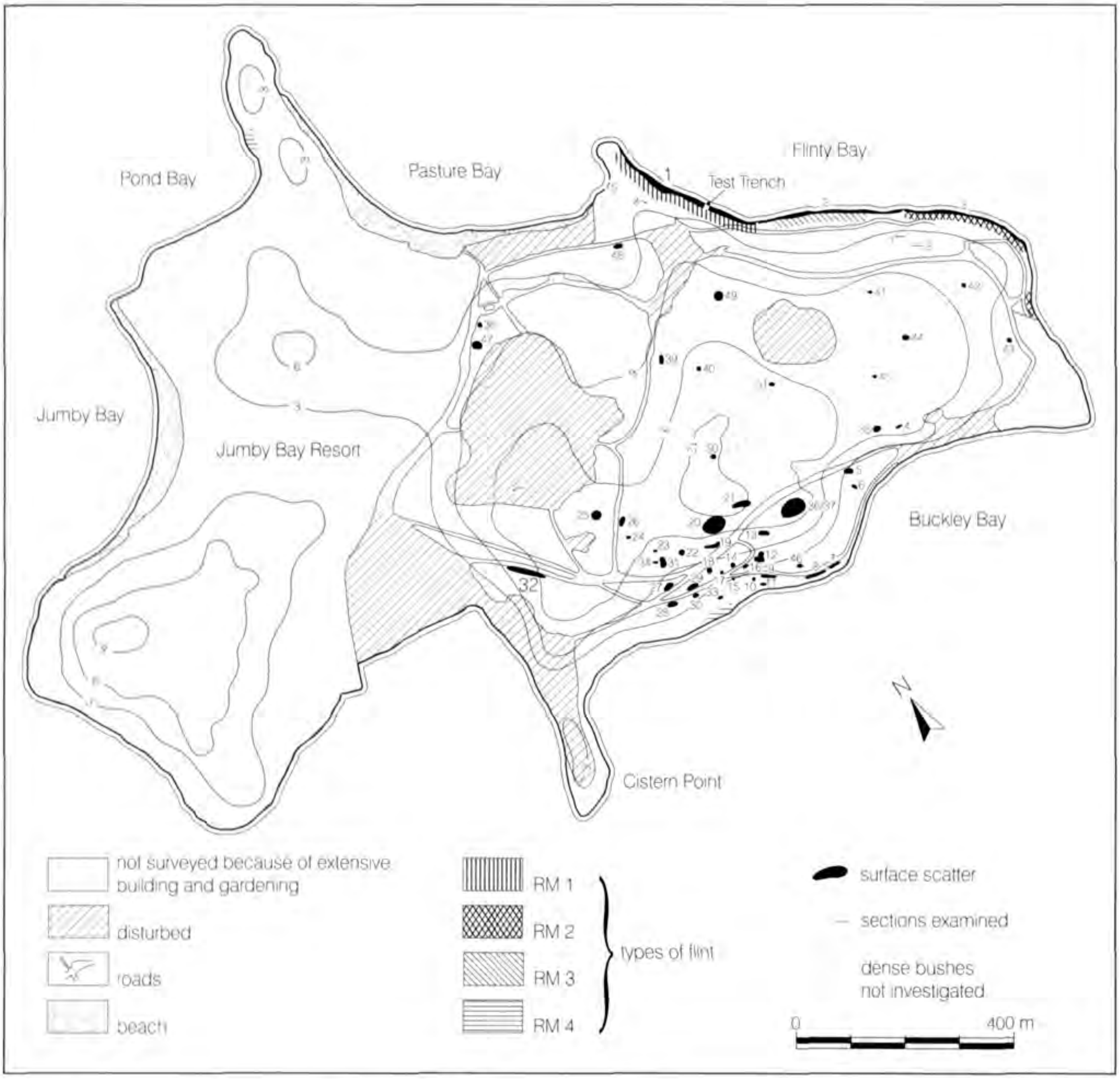

Figure 2. Long Island with the location of the flint sources, find scatters and test trenches.

The major sources of flint on the Lesser Antilles, presently known to us, are located in the northeastern part of Antigua and on adjacent Long Island.

4. Geology and prehistory of Antigua and Long Island

Geologically, Antigua can be divided in three very different zones (fig. 3). The southwestern part consists of volcanic deposits, remnants of the flanks of a large volcano originally located further west but completely eroded by the sea. The central zone is built up of a sequence of volcanic, marine, and fluviatile sediments; this may indicate that the lower flanks of the volcano periodically were below sealevel (Multer *et al.* 1986). The northeast, as well as nearby Long Island, is characterized by limestone strata of the so-called Antigua Formation. Both laterally and

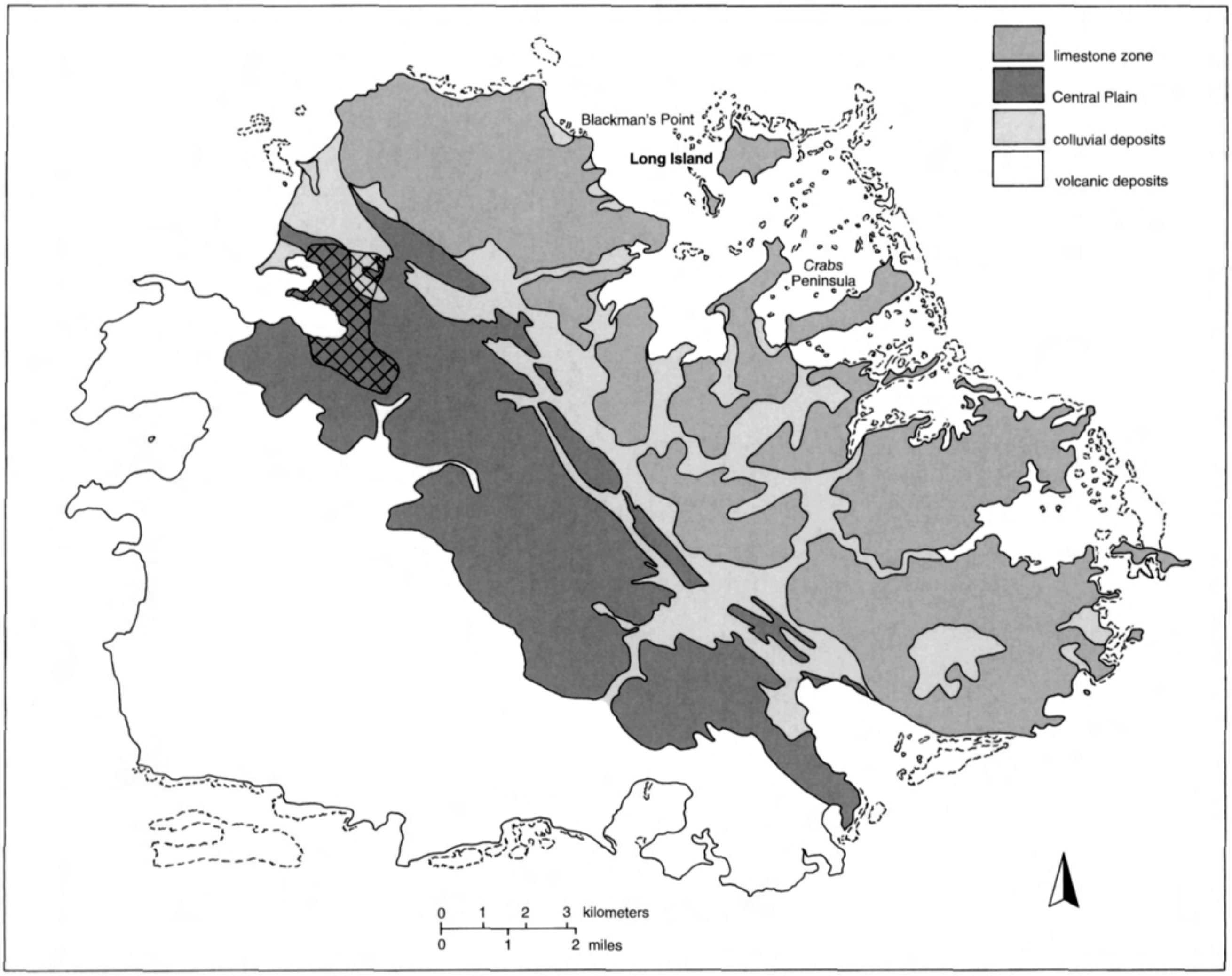

Figure 3. Map of Antigua and adjacent Long Island, with the geological zones differentiated by Multer *et al.* (1986, 2-2).

vertically these strata vary in composition, because they dip up to 15 degrees towards the northeast (fig. 4) (Multer *et al.* 1986). Some of these easily weathering limestone strata contain flint nodules. Northeastern Antigua and Long Island are the only places on the Lesser Antilles where these old sea-bottoms, deposited between 26 and 4 million years ago, come to the surface and, as a consequence, flint is abundant. The variation in limestone strata and the resulting differential weathering may also explain the coastline of northeast Antigua and Long Island: a multitude of bays, islands and peninsula's, with inter-spersed reefs. This landscape was highly attractive for prehistoric man.

Largely due to the tireless efforts of Rouse, the prehistory of Antigua is relatively well-known. Twenty-four sites can be attributed to the preceramic period (also referred to as the Archaic (Rouse 1992), the Meso-Indian stage, and the Ciboney-culture (Kozlowski 1974)) (Rouse 1992). One of the earliest is Jolly Beach, with a C14 date of 3725 ± 90 BP (Davis 1993; Rouse 1992). Virtually all these sites are shell-middens and most of them are located in the northeast. Here the landscape is most suited for the manner in which these prehistoric peoples were presumably living: as hunter/fisher/gatherers (Lundberg 1989). Indian Creek is the best-known site of the ceramic period.

As said above, Long Island is geologically similar to northeast Antigua and may well have been part of it during times when sealevels were lower. The northern shore of Long Island is bordered by an extensive reef-area. It has a

Figure 4. The sequence of limestone layers, dipping in northeasterly direction, is clearly visible at Cistern Point on the south coast of Long Island.

rather rugged shape, and it is exposed to the prevailing northerly winds; apart from the workshop at Flinty Bay (see fig. 2), archaeological sites have not been found in this area. The southern and western shores are more suitable for settlement; here most of the prehistoric sites are located, *i.e.* the preceramic sites of Cistern Point (Davis 1974) and Harbour (Nicholson pers.comm.), the large ceramic site of Jumby Bay, and the sites High Point South, High Point North, Buckley Bay, and Northwest, all four with a probable date in the ceramic period (Nicholson pers. comm.).[1]

Nowadays, the western half of Long Island has been transformed into a park-landscape. The centre of the islet has been destroyed by a large stone quarry. Most of the interior is covered with dense bushes which at places are very difficult to traverse. The coast itself is variable in character: in the south and west sandy beaches are interspersed with mangrove areas, whereas on the exposed northern and eastern shores rocky zones predominate.

5. Survey methods and test excavations

First of all, Long Island was intensively scrutinized for the presence of flint cobbles exposed in the limestone strata. This enterprise was facilitated by the presence of ditches for the wiring of the future villa's. Because a source for the type of flint worked at Flinty Bay could not be established, a 2 m deep trench was dug here to determine whether similar nodules as found at the surface were present in a limestone layer below.

Secondly, the part of the island not yet affected by the building activities of the Jumby Bay Hotel was surveyed. Because of the presence of impenetrable shrubs in the interior, it was impossible to survey systematically. Instead,

Figure 5. Flint nodule in the hard ledges of the northeastern coastline.

we tried to "cover as much ground" as possible; the limited dimensions of the area to be surveyed (half of a 1 × 1.5 km island) made this feasible.

When planning the survey, it was intended to describe every flint scatter encountered, concerning characteristics as distribution, density, size classes, and basic technological categories.[2] However, large parts of the uncultivated interior of Long Island appeared to be covered with flint debris so that one could hardly differentiate individual scatters.[3] It was therefore decided to concentrate on the coast, where distinct concentrations of finds could be distinguished, and sample and describe only a few (arbitrarily defined) scatters in the interior; most of our samples are therefore located along the coast or somewhat inland (fig. 2). Flinty Bay, being a large site (150 × 6 m), was arbitrarily divided in thirteen areas which were individually described and sampled. Altogether, 53 surface scatters were studied and samples were taken from them (fig. 2).

Thirdly, in order to have a better understanding of the Flinty Bay site and hoping to obtain some dating evidence, a sounding of 3 × 1 m was made here. This small excavation also enabled the collection of a "clean" sample of the knapping debris, not influenced by any previous haphazard surface collection. Comparison of the exact counts of the excavated samples and the estimates of the various flint concentrations made in the field, revealed that

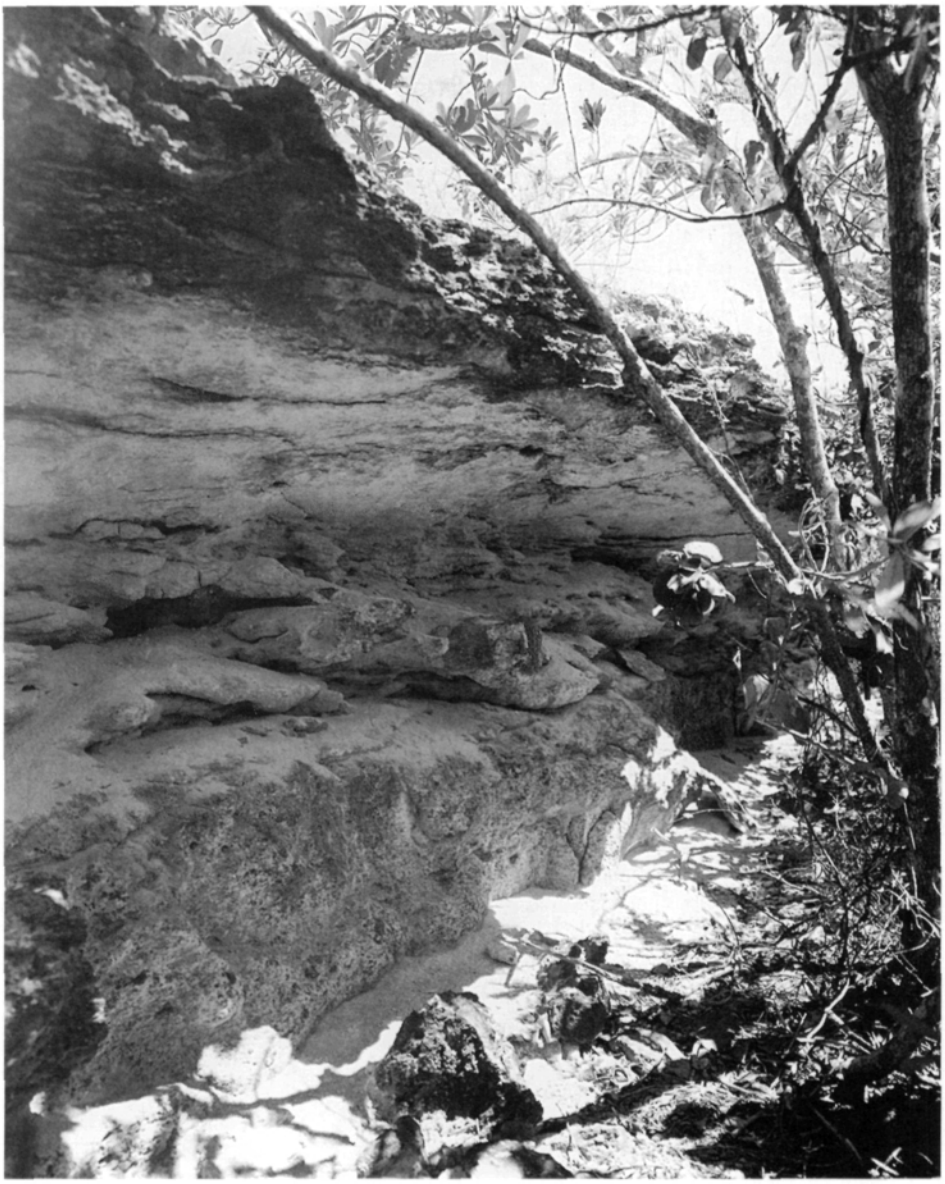

Figure 6. Photo of one of the minor *in situ* occurrences of flint along the southern coast of Long Island.

the number of cores, flakes and blades was overestimated, whereas blocks and splinters had been underestimated. Similarly, the larger size classes were overrepresented as compared to the smaller fraction.

6. The availability of flint sources on Long Island

As stated above, an intensive search was undertaken for *in situ* flint sources. Only at three places could flint be found in its limestone matrix, but it concerned minor exposures and the flint in question seldom turned up in the archaeological flint scatters. The major *in situ* source (hereafter referred to as RM2) was located along the eastern part of Flinty Bay in the hard ledges which had been exposed by the eroding forces of the sea (fig. 5). The flint occurs in clusters and, often, it is almost "stirred" in the limestone. Its colour is brown, the cortex is unweathered and light grey. The nodules display an irregular shape and have very small dimensions. These features, as well as the fact that the flint has numerous inclusions, flaws, and circular breaking planes, make this raw material less suitable for flaking purposes. This type of raw material mainly occurs in the ceramic assemblages. The other two *in situ* sources (RM4) have been located along the cliffs on the

Figure 7. Scatter "32" behind Cistern Point.

south coast, between Cistern Point and Flint House (fig. 6) and along Pond Bay. It concerns very small circular nodules of greyish colour, measuring 5-7 cm in diameter. As these nodules are relatively small and not available in large quantities, they did not appear in the archaeological flint scatters and probably were not exploited by prehistoric man.

The major kind of raw material (referred to as RM1), having the widest distribution, could not be found *in situ*. Most probably, the limestone layers which contained this kind of flint have been eroded long ago, leaving the nodules scattered over much of the northern half of the island. The highest density of this type of flint is found along Flinty Bay where an enormous quantity of flaking debris of this raw material is present (fig. 2). The flint varies in colour from reddish-brown via orange to light-yellow. The cortex has a rusty colour. The nodules mainly have a cylindrical shape, but more circular varieties occur as well; their length ranges from a few cm to a maximum of 30 cm, clustering around 20 cm. The flint displays a fine grainsize and it is very homogeneous with few intrusions, making it highly attractive for flaking.

A last type of raw material (referred to as RM3) was found along the eastern part of Flinty Bay (fig. 2). It concerns pebbles lying on the beach, with a rolled cortex of light-grey colour; the colour of the flint itself can be described as various shades of grey. It was apparently not flaked; all identified hammerstones, however, are made of this type of raw material (Verpoorte 1993).

7. Survey results: variability in the reduction sequences

The majority of the flint scatters was located on the sheltered, southern side of the island. As said, the interior has probably been so disturbed by the sugarcane cultivation in previous centuries, that flint is found everywhere, without apparent concentrations. Most of the flint scatters which were described and sampled in the field proved to be undiagnostic when attempting to reconstruct the reduction sequence. They consisted of a large amount of waste, for the most part displaying natural fractures due to exposure to extreme temperature differences. Two exceptions were apparent, *i.e.* the large flint concentration along Flinty Bay (scatters 1, 2 and 3) and scatter "32" behind Cistern Point[4] (fig. 2); both can be considered real archaeological sites.

7.1 Site "32"

At site "32", two conch shell hand celts were found along with some pottery; this indicates that it probably concerns a mixed site, with both preceramic and ceramic material. The site is located in a rocky matrix and lacks a stratigraphic sequence (fig. 7); it measures 60 × 12 m. It is situated in a very sheltered area of the island, overlooking the mangroves along the southern shore. Because the site was immediately threatened by building activities and as it was one of the remaining two real archaeological sites we

Figure 8. Excavation at Flinty Bay.

know on the island, it was decided to collect all the surface material instead of describing and sampling only a small portion. Scraping of the surface produced altogether 2,850 flint artefacts, next to a small number of sherds and bones, and an enormous amount of shell-debris. The contemporaneity of the various finds is uncertain, because of the shallow depth of the archaeological deposit and the rocky matrix. The sherds postdate 600 AD (det. C. Hofman).

The composition of the flint assemblage is quite different from the one of Flinty Bay. Corecaps and primary and secondary blades are largely lacking, whereas the number of tertiary blades, and especially flakes, is considerable. This would indicate that the primary stages of production took place elsewhere, perhaps at Flinty Bay. Two different technologies could be differentiated: one directed at the production of small flakes and splinters, making use of inferior raw material (RM2), the other comparable to some extent to Flinty Bay in the sense that use was made of the same high quality material RM1 aimed at the production of long blades. The fact that some retouched implements were found, as well as various other find categories, notably shell-debris indicative of shellfish-consumption, would suggest that we are dealing here with a regular settlement area. Whether the location served as settlement during both the preceramic and ceramic periods is impossible to determine at the moment, because we cannot yet accurately differentiate the finds from both periods.

7.2 The flint workshop along Flinty Bay

In contrast, the assemblage from Flinty Bay seemed to be quite homogeneous; because of the large quantities of diagnostic debitage present, it was decided to make a 3 × 1 m sounding at this site (fig. 8). Artefacts were present in the uppermost 20-30 cm of the soil which had formed on the marly limestone. The trench yielded 13,643 artefacts, 8,766 of which were larger than 2 cm (Verpoorte 1993, 32).
Sole use was made of the high quality RM1. Clearly, the reduction sequence was extremely standardized, directed at the production of blade-cores. The percentage of artefacts with cortex was very high. Large numbers of corecaps were encountered (fig. 9), as well as primary and secondary decortication blades and flakes (fig. 10). Exhausted cores and tertiary blades were largely absent, whereas retouched implements were lacking altogether. Virtually all the cores retrieved, mostly precores, showed flaws of some kind, either inclusions in the flint or flaking errors. Most of the cores displayed opposed platforms. Core-preparation was done very carefully and was probably performed by hard-hammer percussion. First, a corecap was removed and the platform was prepared; most platforms are facetted, displaying two or more negatives. Next, the edge of the platform was retouched, either on the platform or on the dorsal face. The creation of a rib on the core-face, to guide the "peeling-off" of the core, was done by means of a crested blade. Dimensions of the removed blades were *c.* 9.5 × 3.0 cm, the average length of the cores retrieved was *c.* 12 cm

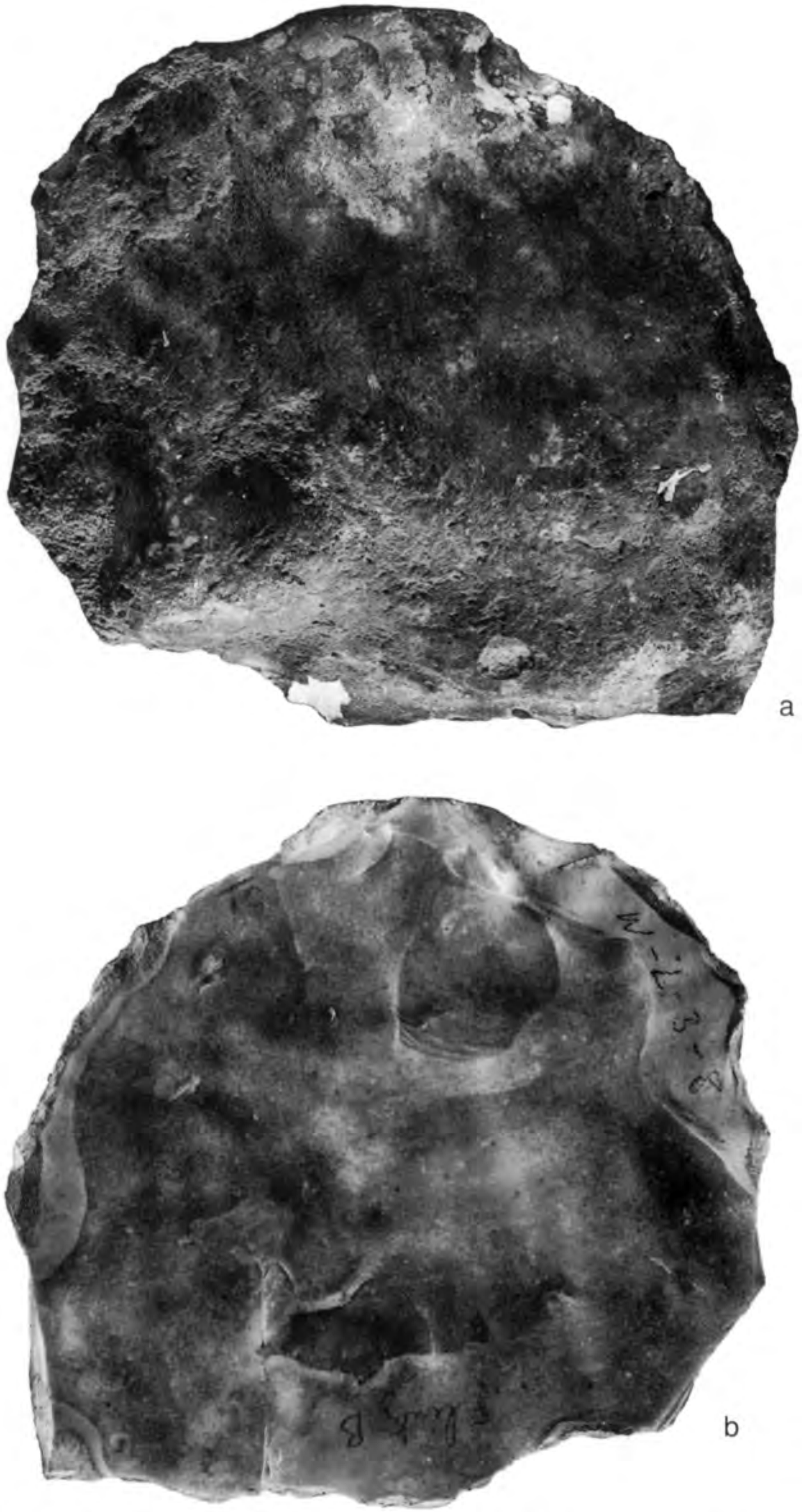

Figure 9. Core cap, a characteristic waste product of the reduction sequence: a) dorsal aspect, b) ventral aspect (scale 1:1).

Figure 10. Secondary blade, characteristic for the preceramic period (dorsal, profile and ventral view, scale 1:1).

(Verpoorte 1993). Incidentally cores were rejuvenated, for example by removing the platform; the resulting flakes are often called tablets and were sometimes found.

It seems that the knapping area[5] along Flinty Bay should be interpreted as a flint collection and primary production site. The reduction sequence was aimed at the production of high quality cores, with primary and secondary decortication flakes and blades as characteristic waste products. It is not sure where the flint source was located. It is unlikely that the flintknappers would have transported the tons of nodules to this place, to flake them here. Flinty Bay is exposed to the prevailing winds; due to the reefs and rocks it would have been difficult to come to shore at this spot.

Most probably, therefore, the cobbles had weathered out of a specific limestone stratum which only came to the surface at this part of the island. It was knapped on the spot.

Whether the flintknappers were actually living on Long Island is not entirely clear. At site "32" a few tertiary blades of the Flinty Bay type of raw material were found. Davis found similar implements at the preceramic site of Cistern Point[6], which he considers to be a settlement because of the presence of food debris (Davis 1974). Additionally, Flinty Bay flint is reported from Antigua itself, from both the preceramic site of Jolly Beach (Rouse 1992) and the ceramic site of Indian Creek (Nicholson 1976b). It was even observed at an early Saladoid site on

Montserrat (Nicholson 1976b). The facts that the reduction strategy was aimed at removing all superfluous waste material and that only perfect cores were taken from the site suggests that the knappers intended to cut down on the weight to be transported. This indicates that the majority of the knappers did not live on Long Island, but on "mainland" Antigua or other nearby islands. Further reduction must have taken place at the settlement sites there, because evidence for such activities is lacking on Long Island. Obviously, this does not exclude the possibility that some of the flintknappers did live on the islet: the presence of two preceramic sites with food debris can be considered proof of this. The predomination of tertiary blades on site "32" provides additional evidence for the existence of a (temporary) settlement site.

A serious drawback is that it has proven impossible to date the Flinty Bay site. Pottery was not present, nor carbonized wood or bone. Most researchers assume that the site dates from the preceramic (Davis 1974; Nicholson 1976b; Rouse 1992). One argument in favour of a preceramic date is the sophisticated flint technology displayed here, something which is generally not associated with the ceramic period (Nicholson 1976a, 259). What little we know of the flint technology during the ceramic period points to a somewhat haphazard reduction strategy, to the manufacture of tools based on small flakes. Nevertheless, we should seriously consider the possibility that the site reflects ceramic exploitation. Geologists postulate a sealevel rise around 200 BC, in which case a preceramic flint exploitation site at Flinty Bay would have been washed into sea. Yet another possibility may be that we are dealing with remnants of gunflint production. The sheer size of the flaking area and the systematic reduction sequence would argue in favour of such an hypothesis (*cf.* Gould 1981). However, gunflint production always took place with a steel hammer (a.o. Gould 1981; Knowles/Barnes 1937) and the platforms on the cores and flakes of Flinty Bay do not display evidence for the shattering which is characteristic of steel hammer percussion. I would suggest that this latter argument prevails and that, until proven otherwise, the Flinty Bay area be considered a prehistoric knapping site. An attribution to either preceramic or ceramic will have to wait until reliable samples of flint implements from datable settlement sites become available.

8. Concluding remarks

The archaeological survey of Long Island has shed more light on the most important flint extraction site known on the Lesser Antilles. Various types of raw material could be identified. The major production site is located along Flinty Bay, where enormous quantities of debitage were found: corecaps, primary and secondary blades and flakes and discarded cores displaying flaws of various sorts. Exhausted cores, tertiary flakes and blades, and retouched implements were entirely lacking. Clearly, the aim of the production was to manufacture high quality cores, which were transported from the site to be "peeled" elsewhere, most likely to Antigua or other nearby islands. Although the basic reduction sequence was uniform, differences in platform preparation were noted: some cores displayed retouching on the platform itself, some on the dorsal face. Such variation may indicate that various groups of people were visiting the site to obtain the necessary raw material. More extensive excavations could illucidate this further.

Future research should be directed at a detailed analysis of raw material used and technological features displayed by the flint implements deriving from other islands, most importantly "mainland" Antigua. The specific island context of the region allows a very fruitful application of a regional approach towards flint technology. Technological features on the flint artefacts found on different islands and the nature of the discard products present may indicate the stage of production during which the flint was transported there. Such information can illucidate whether the Long Island flint was exploited by one group of people and then transported further (*cf.* McBryde 1986, 1991a, 1991b; Torrence 1986), or the extraction location was directly accessible to different island communities (*cf.* Gould 1980).

Acknowledgements

Foremost I would like to thank the Jumby Bay Resort, in particular Don and Karen Tate, for their support and interest. Not only did they encourage the research, they also provided us with room and board. Desmond Nicholson, director of the Museum of Antigua and Barbuda, was a constant source of inspiration. He allowed us access to all the material he had collected on Long Island over the years and he showed us flint sources and archaeological sites on "mainland" Antigua. I am very grateful to the staff who did a formidable amount of work in the short period the campaign could last; members included John Hagen, Corinne Hofman, Menno Hoogland, Jan Pauptit and Alexander Verpoorte. This research was partially funded by WOTRO (W28-248 (86)). I thank Corinne Hofman and Peter Akkermans for commenting on an earlier draft of this paper.

notes

1 Nicholson, director of the Museum of Antigua and Barbuda in St. John's, Antigua, has documented all the Long Island sites and has collected numerous artefacts.

2 The survey description form included the following variables:
1. date, name of the surveyor, surface of the scatter in meters.
2. density (on the form indicated by drawings of possible distributions).
3. technology (% of nodules, flake- and blade-cores, primary, secondary and tertiary flakes, blades, crested blades, blocks, splinters, hammerstones).
4. description of the retouched tools.
5. presence of cortex (in %), burning (in %), and patination (in %) and colour of the flint.
6. size classes (<1 cm, 1-5 cm, 6-10 cm, >10 cm) in %.
7. presence of other find material (pottery, bone, shell, coral, stone, and carbon) and an interpretation of the character of the site (settlement or workshop).
8. interpretation and estimate of the homogeneity.
9. on the form a grid was present to make a plan of the scatter, and notes could be made as to the contents of the samples taken.

3 Several authors had noted the presence of circular scatters of flint, which some interpreted as knapping floors. Historical information, however, reveals that from 1750 until *c.* 1850 the island was used for the cultivation of sugarcane; later, freed slaves grew various crops on the island. The fields were cleared of the larger stones which were collected on piles. Through time these piles slumped down to circular concentrations. Three 1 × 1 m squares were dug into two of such circular concentrations (scatter nrs 28 and 31, see fig. 2). Counts of the various size classes confirmed that these "flaking floors" only contained the larger fraction and lacked the characteristic small flaking debris.

4 This is probably the same site as Harbour, reported by Nicholson as being a preceramic settlement.

5 At Flinty Bay Olson (1973) noted the presence of several flint knapping floors, circular in shape with large stones which he interpreted as seats for the knappers. We found no traces of such stones, nor of discrete, circular flaking floors. The site consists of a long stretch of almost solid flaking debris.

6 We attempted to locate this site but without success. The area displays lots of bulldozer tracks and most likely this site was destroyed.

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Use-wear analysis on preceramic Colombian artefacts of the Abriense toolclass

The application of micro-wear analysis to the artefacts of a series of pre-ceramic sites in Colombia is expected to amplify the interpretative possibilities of chert implements of a typo-morphologically undiagnostic character. As a pilot-study for this research project, a selection of artefacts from the site Galindo was analyzed. The results of the analysis indicate that the traditional typology used to classify these tools is not always relevant for a functional interpretation.

1. Introduction

The most characteristic artefacts produced by preceramic groups of hunters and gatherers in Colombia, are flakes and core tools made of chunks of tabular chert or water-worn chert nodules. The technology by which the main part of these tools was manufactured is sometimes referred to as the "edge-trimmed tool tradition" (a.o. Hurt 1977). It is characterized by the use of direct percussion; in most cases the working edges have no retouch at all, occasionally there are artefacts with unifacial retouch. No bifacials are found among these tools. This expedient technology is not limited to Colombia but is typical for the whole Northwest of South America (a.o. Cardich 1991; Hurt 1977; Stothert 1985). From the early pre-ceramic up to the colonial period these artefacts were manufactured without significant morphological or technological changes. In Colombia, this tool class is usually called "Abriense", after the type-site El Abra.

In the past two decades Colombian archaeologists have developed an extensive classification system to catalogue these tools on the basis of morphological and, to a lesser extent, technological criteria. The largest number of artefacts though, is inevitably classified as "atypical flakes" (Correal Urrego 1977, 1979, 1990; Correal Urrego/ Pinto Nolla 1983; López 1991 a.o.) or "amorphous multifunctional tools" (Ardila 1984). However useful this classification system may be for typological purposes, when it comes to a functional attribution there is only one certainty: interpretation as (used) tools is always doubtful.

As microscopical analysis of use-wear traces on flint implements has been developed into a mature analytical tool and has proven to be essential for the interpretation of tool functions, a research project was started to apply this method to the Colombian artefacts in order to extend the interpretative possibilities of this undiagnostic toolclass.

First, experiments were conducted to determine whether the use-wear traces on tools of the different chert types of which the Abriense artefacts are usually made, are comparable to those known to develop on flint tools. Several contact-materials (wood, hide, bone, meat, fish, siliceous plants) were worked on, using tools made of tabular blocks of coarse chert from the Sabana de Bogotá and finely grained chert pebbles from the Magdalena valley (fig. 1). It was confirmed that wear-trace formation on these cherts is comparable to the formation on flint, but traces are usually less developed on the coarser types.

Although it has been established that micro-retouch displays comparable characteristics on different lithic materials (a.o. Shea 1988), this analysis concentrated on the presence of use-polish, edge-rounding and striations, and not on use-retouch. The analysis of the formation of edge-removals and of the indicative value of these removals on this specific tool-class and material is part of the research project, but has not been investigated thoroughly enough yet.

2. The sample

A selection of *c.* 200 implements from Galindo, a preceramic open-field site, was chosen for a pilot study. The site is located on a colluvial terrace on the Sabana de Bogotá, an intermontane plain at a height of 2,600 m above sea level in the eastern Andes-chain in central Colombia (fig. 1). The terrace is part of a 25 m high hill, deposited during the late cretaceous (Guadalupe Superior). One of the characteristic sediments of this formation consists of tabular chert blocks, found on the top of the hill and on the slopes.

Thousands of stone fragments were excavated on the terrace, as well as a remarkably low amount of animal bones, some fireplaces and one male burial. The material was found in four occupational levels, the oldest three dating from the 9th millennium BP and the youngest level dating from the ceramic period. The site was excavated in 1986 and 1987 and the artefacts seemed well preserved for a microscopical analysis.

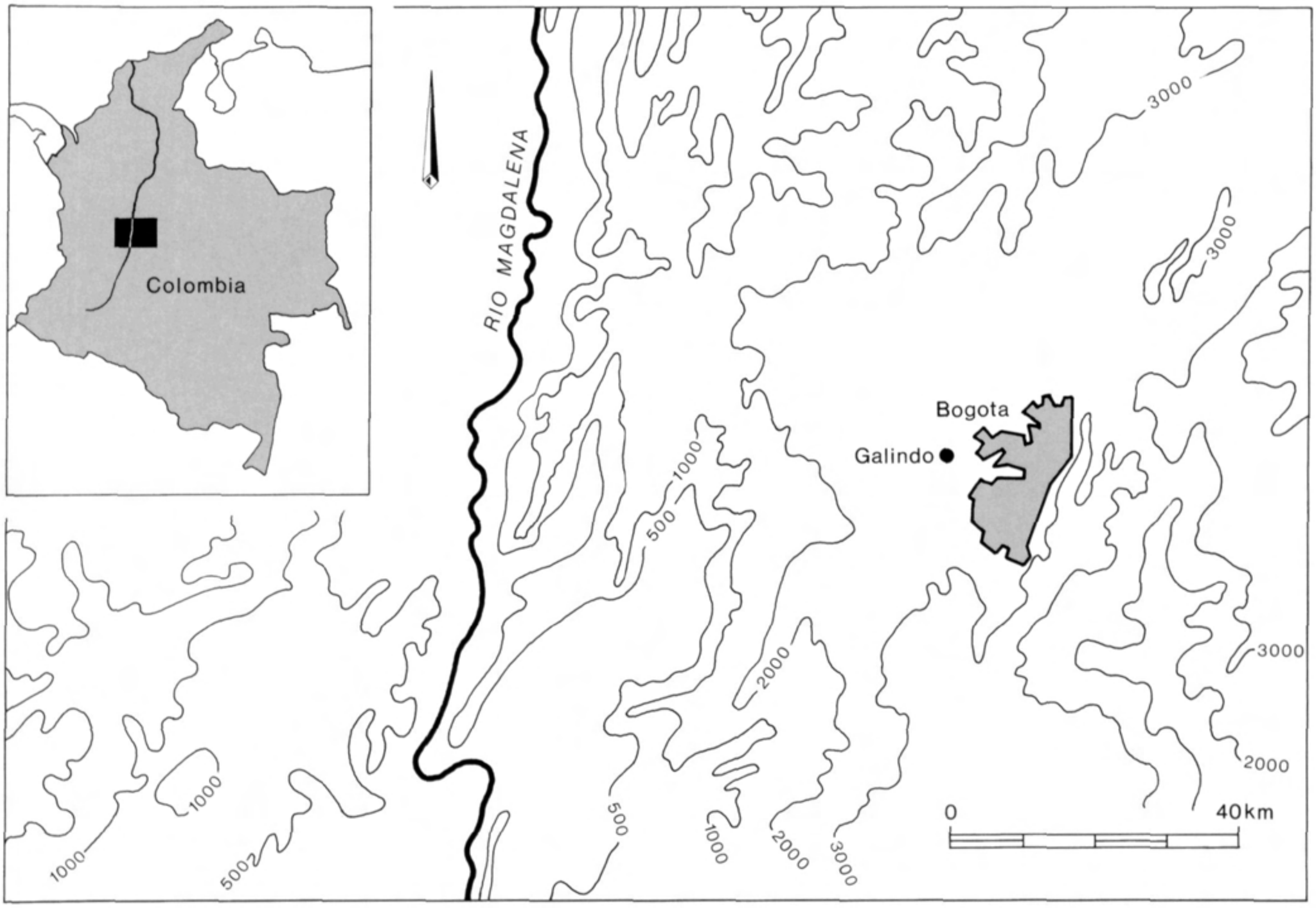

Figure 1. Research area. Location of the site Galindo on the Sabana de Bogotá.

The sample was selected by the excavator[1] from all four occupational levels and contains tools of most of the Abriense categories that are usually distinguished. Guided by the aforementioned morphological and technological criteria, she made a selection of artefacts that in her opinion were most likely to have been used as tools. Although the percentages of selected artefacts (listed in tab. 1) are too small to be statistically significant and are not systematically spread over the various tooltypes, the sample was useful for this pilot study, meant to enhance knowledge of the characteristics of use-wear traces on the Abriense class chert tools. Following the results of this study, a larger and more representative sample of the artefacts from this site and other preceramic sites will be analyzed.

Practically all the artefacts are made from local chert, found on the hill itself. A number of tools are made of finely grained chert which was extracted from the Magdalena valley, at least 60 km to the west of the site (Pinto Nolla 1991).

3. The analysis

On a total of 211 artefacts, 300 possible working edges were distinguished and analyzed with a high power microscope, using magnifications between 100× and 300×. All artefacts were cleaned with a 10% HCL solution in an ultrasonic tank for five minutes, then immersed in a 10% KOH solution for another five minutes and thoroughly rinsed with water; the implements were cleaned with alcohol during microscopical examination. The use-wear traces were classified and coded with an adapted and simplified version of the system developed by Van Gijn (1990).

The 300 possible working edges were selected on the basis of edge morphology and other phenomena which could be observed without microscope: (intentional) retouch, a straight cross section of the edge, polish or protruding points.

Of these 300 edges, 75 appeared to be actually used. Of the remaining edges, 38 were coded as "probably used", 56

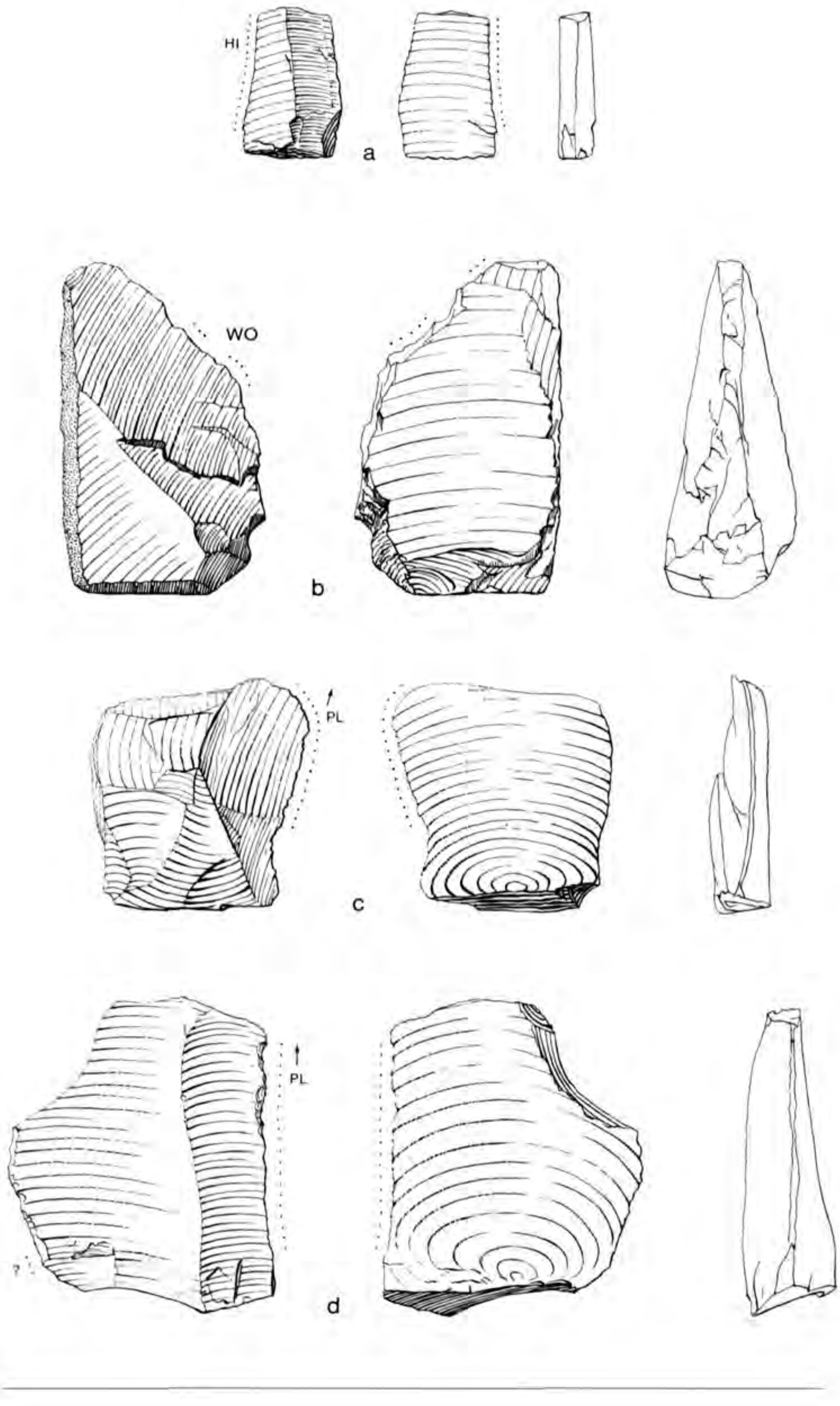

Figure 2a. Tool nr. 909. Prismatic flake with hide-working traces.
Figure 2b. Tool nr. 855. Lateral scraper with wood-working traces.
Figure 2c. Tool nr. 762-25. Concoidal flake used for plant-working.
Figure 2d. Tool nr. 768-26. Classified as "a-typical flake", used for plant-working.

Table 1. Number and percentage of analysed artefacts of Galindo
rect.= rectangular, not interpretable (burned, patina)

type	total	analyzed (%)	contact material interpreted (%)	probably used	unsure	no traces	not interpretable	hafting traces
triangular flake	268	30 (11)	17 (57)	4	2	3	3	3
prismatic flake	253	25 (10)	4 (16)	3	2	11	5	1
concoidal flake	155	21 (14)	11 (52)	4	3	2	1	0
rect.lateral flake	75	12 (16)	7 (58)	4	0	0	0	1
tronconical flake	19	5 (26)	0	1	2	2	0	0
rect.end flake	76	3 (4)	0	0	2	1	0	0
atypical flake	676	15 (2)	4 (27)	2	3	6	0	1
scrapers	74	14 (19)	2 (14)	0	2	6	4	0
lateral scraper	243	8 (3)	2 (25)	1	2	2	1	0
end-scraper	235	6 (3)	2 (33)	1	3	0	0	0
discoidal scraper	12	5 (33)	1 (20)	0	2	2	0	0
multiple scraper	46	7 (15)	0	2	1	1	3	0
perforators	65	60 (92)	14 (23)	8	12	23	1	2
total	2197	211 (10)	64 (30)	30	39	59	18	8

Table 2. Contact materials.
observed phenomena: 0= no observed phenomena; 1= retouch larger than or equal to 1 mm; 2= retouch smaller than 1 mm; 3= polish; 4= straight edge; 5= ground surface; 6= protruding point
tooltypes: 3= perforators; 11= triangular flake; 12= prismatic flake; 13= concoidal flake; 14= rectangular lateral flake; 15= tronconical flake; 16= rectangular end flake; 17= atypical flake; 21= lateral scraper; 22= end scraper, 23= discoidal scraper; 24= multiple scraper

contact material	total	tooltypes	observed phenomena
bone	2	11	4
soft plant	3	13	1 3 4
wood	9	3 11 13 14 20 21	1 4 6
siliceous plant	3	11 17 22	1 3 4
hide	12	3 12 13 14 17 22	1 2 4 6
hard material	3	3 11 23	4 6
soft material	3	11 14 17	1 2 4
soft animal material	3	13	4
hard animal material	1	11	4
bone/wood	3	11 21	1 4
unknown	3	12 13	1 2 4
greasy lustre	3	3 12 14	1 2
wood/bone/antler	10	3 11 14 17	1 4 6
meat/bone	6	11 20	2 4 6

as "unsure", 101 displayed no traces at all, and 30 could not be interpreted because they were either burned or had colour patina on the surface. In most cases only one of the registered edges was actually used; when different possible working edges on one single tool were interpreted as used, this was mostly on the same contact material.

The different tooltypes and observed (and not observed) traces are presented in table 1, where the number of tools is counted, not the number of possible working edges. Hafting traces are found once in combination with contact material (butchering) and seven times on tools registered as "probably used".

The contact-materials the 64 tools are thought to be used on, are listed in table 2. Most frequent are the tools used for hide-and woodworking (resp. 12 and 9 implements; figs 2a, b, 3a, b), and for a mixed category wood/bone/antler. Other polishes were interpreted as being the result

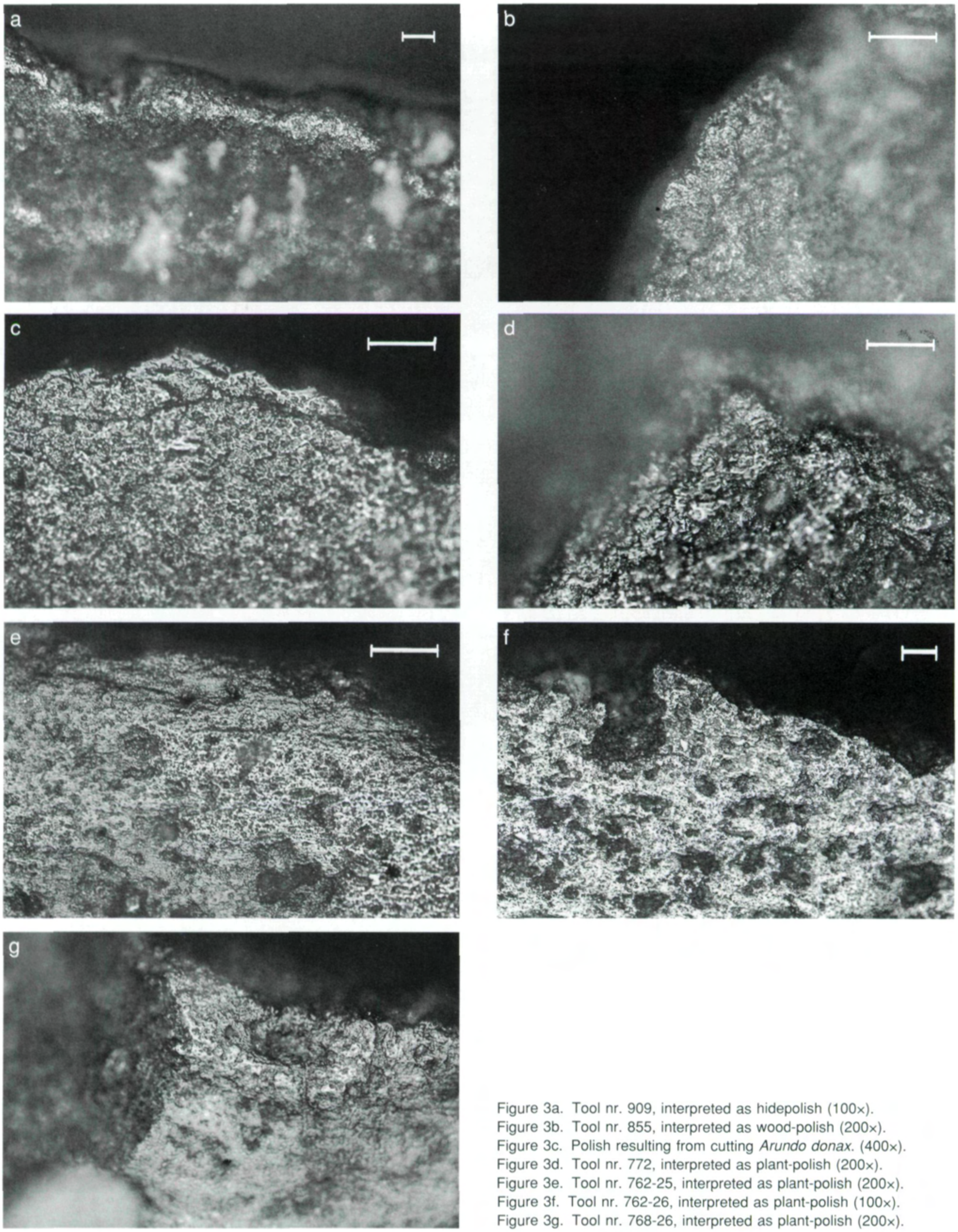

Figure 3a. Tool nr. 909, interpreted as hidepolish (100×).
Figure 3b. Tool nr. 855, interpreted as wood-polish (200×).
Figure 3c. Polish resulting from cutting *Arundo donax*. (400×).
Figure 3d. Tool nr. 772, interpreted as plant-polish (200×).
Figure 3e. Tool nr. 762-25, interpreted as plant-polish (200×).
Figure 3f. Tool nr. 762-26, interpreted as plant-polish (100×).
Figure 3g. Tool nr. 768-26, interpreted as plant-polish (200×).

Table 3. Working edges and the presence or absence of wear traces.
* should not have been registered as possible tool
** all perforators and one atypical flake

observed phenomena	total	contact material interpreted (%)	possibly used	unused	no traces	not interpretable	hafting traces
no phenomena observed*	1	0	0	0	1	0	0
retouch ≥ 1mm	55	14 (25)	11	11	9	10	0
retouch < 1mm	25	7 (28)	6	6	6	0	7
polish	2	2 (100)	0	0	0	0	0
straight edge	149	27 (18)	15	22	61	18	7
ground surface	1	0	0	1	0	0	0
protruding point**	67	14 (21)	8	16	28	2	0

from contact with bone, different plants and soft and hard (animal) material (sometimes, when found on one tool, interpreted as "butchering"). On six tools traces of unknown contact materials were registered, one of which is described as a "greasy lustre". In 32 cases a probable motion could be established, mostly in combination with a specific contact material. Although flakes were normally used in a longitudinal motion, four flakes (two with a straight edge and two with retouch) were employed as scrapers on hide and on wood/bone/antler.

Six tools were used for plant processing, four of which are made of a non-local, finely grained chert (figs 2c, d, 3e, f, g). One of these tools derives from the ceramic level, the others were found in the pre-ceramic levels. The plant-polish on one of these pre-ceramic tools is very similar to the polish that resulted from experiments conducted on "cañabrava de Castilla" (*Arundo donax* L.; figs 3c, d).[2]

One triangular and one atypical flake were interpreted as possible arrowheads. Among the Abriense artefacts no projectile-points are distinguished, due to the absence of certain technological characteristics like bifacial retouch. From a morphological point of view, however, it should not be excluded that triangular flakes with sharp edges could have been used for this purpose (comp. Odell 1988). The two possible arrowheads were interpreted as such because they showed micro-linear impact traces; one of them seems to have hafting traces at the proximal end whereas the other one has a broken tip and traces of contact with hard material (bone/wood).[3]

4. Conclusions

As was expected, not all artefacts classified as tools display interpretable wear-traces: even in a sample of "most probable tools", only one fourth of the artefacts was interpreted as used implement. This can be caused by (a combination) of the following factors:

1. Only few artefacts were actually used; many of the artefacts classified as tools may be debris.
2. Most of the tools are made of coarse grained chert, on which the formation of wear-traces is slower than on fine grained flints. Due to this fact and the expedient character of this tool-class, it is fairly safe to state that most of the implements were probably used for a time too limited to produce recognizable wear-traces.
3. Wear-traces of soft contact materials have disappeared due to post-depositional processes and treatment during and after excavation.
4. The author did not recognize traces on the other artefacts.

It is not yet clear which of these factors is the main cause of the low number of tools among the selected artefacts. Analysis of a larger number of implements from this site and other contemporary sites on the Bogotá plain and in the Magdalena valley is expected to shed more light on this matter.

As far as the size and the choice of this sample allows any interpretations concerning a correlation between typology and function of the tools, it can be stated that there seems to be no correlation at all. All tooltypes were used on different contact materials, and all these materials were worked on with different tooltypes (tab. 2). Analyzing this specific toolclass, there appears to be more correlation between the morphological aspects of the edges and other "observed phenomena", and the presence or absence of wear-traces (tab. 3). Retouch seems to be a relatively good indication for use. Of the artefacts displaying retouch smaller than 1 mm, 28% was interpreted as being used; when retouch was equal to or larger than 1 mm, 25.5% of the analyzed artefacts were registered as used. A straight cross section could be associated with use in 18.1%, which would mean that this phenomenon is slightly less indicative. In this sample, polish visible without microscope always indicates use (two artefacts, figs 2c, d.) One of these tools also has retouch on the used edge. A separate cluster are the artefacts with protruding points, as observed on all the perforators, and on a few other tooltypes. On 14 of these tools, contact material could be established (20.9%), and on 28 (41.8%) no traces were registered. None of these percentages is high (or low) enough to lead to detailed conclusions, but it is expected that this will be possible at a more advanced stage of this project.

The fact that there are artefacts displaying interpretable wear-traces stimulates further research. The results prove that use-wear analysis supports the interpretation of certain artefacts as tools, which were traditionally only classified as such on typo-morphological grounds. However, without devaluating the traditional typology, in view of the absolute absence of technological predetermination it seems to be better to focus on edge-morphology than on the typological categories for a functional analysis of this tool-class.

notes

1 Mrs. Maria Pinto, Universidad Nacional de Colombia, Bogotá. An extensive report of this analysis will be published as an appendix to her doctorate thesis.

2 This specific reed did not exist in precolonial times, but according to different sources (a.o. Simon 1627, T III, 185), in colonial times comparable species were widely used, on the Bogotá plain *e.g.* for construction. An archaeological reference for the use of reed-like plants for constructions can be found at the Aguazuque site on the same Bogotá plain, dated between 5025 and 2725 BP. All occupational levels of this site revealed circular series of postholes, one of which contains remains of a *Bambusea*. Besides, all levels contain graminea-pollen (Correal Urrego 1990). Wear-traces on the stone artefacts from this site will also be analyzed in the near future.

3 Analyzing the material from the preceramic site Tequendama, also located on the Sabana de Bogotá, the author found triangular flakes with the same characteristics: strongly developed micro-linear impact traces, broken tips and hafting traces.

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Le "Projet Toguèrè" dans le Delta intérieur du Niger, Mali

De 1989 à 1991 un groupe de chercheurs maliens et néerlandais a dressé l'inventaire d'une importante catégorie de sites archéologiques dans la partie Sud du Delta intérieur, du Niger au Mali. Cette recherche, intitulée 'Projet Toguèrè' a été effectuée dans le cadre d'une coopération sur le plan socio-culturel entre les Pays-Bas et le Mali. Les chercheurs espèrent que cette étude approfondira leur connaissance de l'histoire du peuplement du Delta intérieur du Niger. Trois campagnes de prospection ont permis de visiter et de décrire entre 800 à 1000 sites. Ainsi se termine la première phase de la recherche du 'Projet Toguèrè'.

1. Région des recherches

La partie Sud du Delta intérieur du Niger couvre une surface d'environ 25.000 km^2 et s'étend de Ké-Macina et de San jusqu'à Tombouctou. Sujettes à des inondations annuelles, de vastes zones de cette région sont très fertiles et propices à l'agriculture et à l'élevage. Les eaux sont poissonneuses. Bordé par la région sèche du Sahel, le Delta intérieur est un oasis économique et écologique dont la population actuelle forme une mosaïque de plusieurs groupes ethniques, chacun possédant sa propre langue, son identité et son régime alimentaire. Les quatre groupes principaux sont: les Bamana et les Marka, agriculteurs qui cultivent le mil et le riz; les Bozo, pêcheurs spécialisés et maçons, et les Fulani, éleveurs. Liés les uns aux autres par l'échange de leurs produits, ces groupes ethniques exploitent tous une 'niche écologique' spécifique. Dans les plus grandes villes, comme à Djenné, ils cohabitent souvent ensemble, chaque groupe dans son propre quartier (Gallais 1967, 1981).

Le grand nombre de sites archéologiques dans le Delta intérieur permet de conclure que cette région du Mali a toujours été un lieu privilégié, aujourd'hui comme par le passé. Les sites archéologiques les plus remarquables sont les togué (pluriel de toguèrè): buttes anthropiques dont le caractère et la fonction sont comparables aux 'terpen' néerlandais. Le prototype d'un toguèrè consiste en une élévation circulaire aplatie au sommet, dont les flancs sont assez raides. Plusieurs togué sont entourés d'une dépression circulaire (Dembélé *et al.* 1993, 224). L'ensemble des togué forme un système d'établissements fossiles.

A côté de ces vestiges archéologiques on trouve aussi des sources littéraires arabiques et des manuscrits locaux, les 'tarikhs', qui témoignent de la grande importance du Delta intérieur du Niger après la naissance et le développement des grands états de l'Ouest africain, le Ghana, le Mali et le Songhia (McIntosh/ McIntosch 1981, 1/2). Les voies commerciales du Sud montagneux et du Mahgreb dans le Nord se rejoignaient dans le Delta intérieur, les villes de Djenné et de Tombouctou jouant un rôle important comme centre commercial des biens apportés.

2. Le Projet Toguèrè

Un des buts du 'Projet Toguèrè' est d'examiner dans quelle mesure il existe une continuité entre la population actuelle de cette région et les occupants antérieurs. À partir d'une prospection systématique de grande ampleur on tente d'inventorier un nombre exhaustif de togué dans le Delta intérieur dans la perspective d'approfondir la connaissance des populations qui ont occupé les togué.

Le 'Projet Toguèrè' est placé sous la responsabilité de l'Institut maliens des Sciences Humaines (ISH) à Bamako. Le projet est mené en collaboration avec des chercheurs néerlandais (Universités de Groningue, d'Utrecht et de Leyde) et est financé par le Ministère des Affaires Étrangères néerlandais. L'équipe de recherche se compose d'étudiants en archéologie, géographie physique et sociologie, sous la direction du Dr. M. Dembélé, associé à l'Institut des Sciences Humaines, et du Prof. Dr. J.D. van der Waals, co-fondateur du projet (Van der Waals 1989, 1). Le 'Projet Toguèrè' n'est pas la première tentative de recherche sur les togué dans la partie Sud du Delta intérieur du Niger. Les travaux de R.M.A. Bedaux *et al.*, une équipe mixte des université d'Utrecht et de Groningue et l'ISH, sur togué Doupwil et Galia (Bedaux *et al.* 1978), et des McIntosh sur toguèrè Jenné-Jeno l'ont précédée (McIntosh/McIntosch 1980). Toutefois, l'échelle de la zone d'étude du 'Projet Toguèrè' est nouvelle.

Préalablement aux trois campagnes de prospection sur le terrain, 150 photographies aériennes (échelle 1/50.000e,

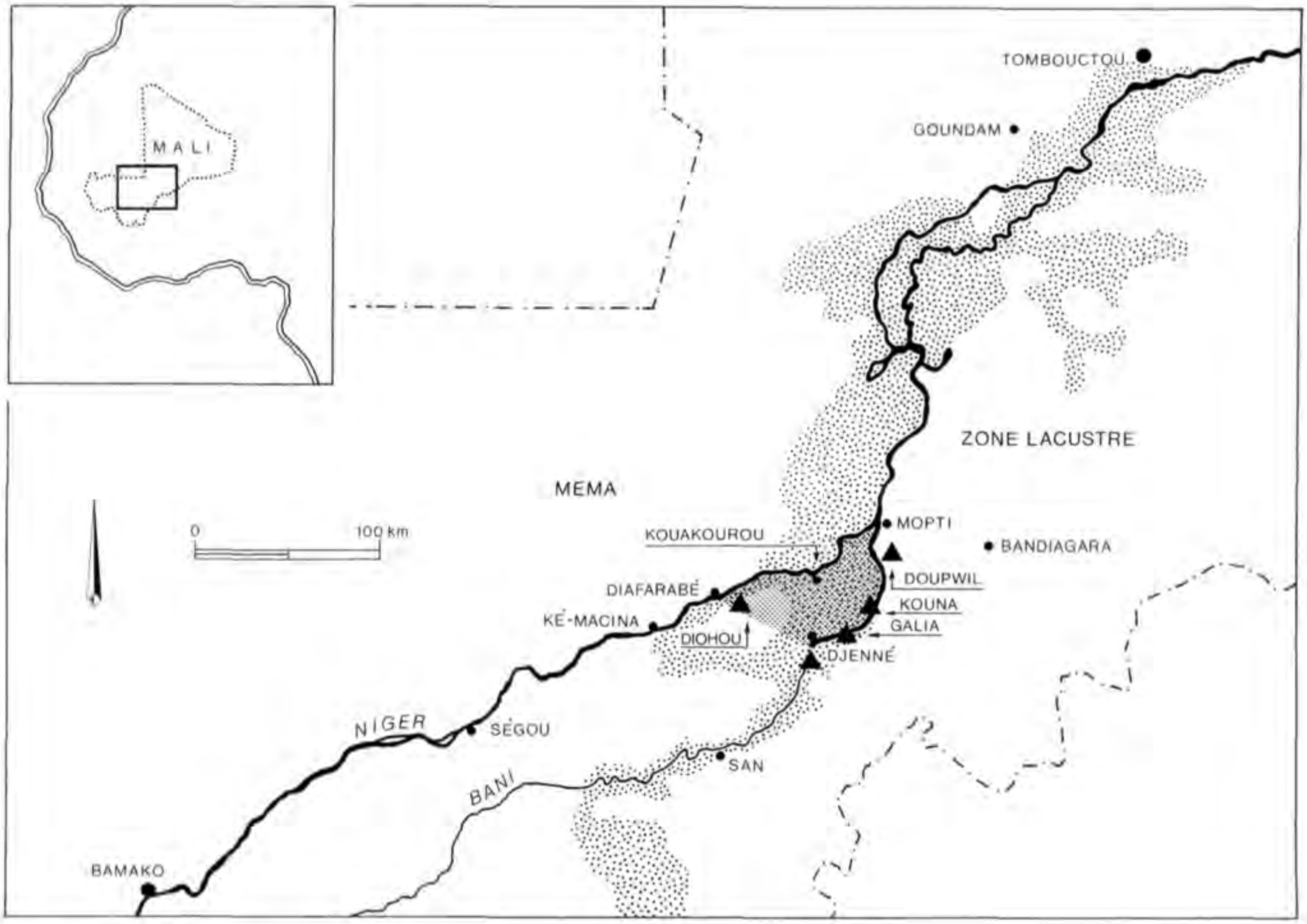

Figure 1. Carte de Mali.

série de l'IGN 1971-1979) du Delta intérieur du Niger avaient été étudiées au stéréoscope. Ensuite les buttes susceptibles de contenir des vestiges archéologiques avaient été reportées sur les photographies aériennes. Tous ces togué ont été repérés sur le terrain à l'aide de la photo-interprétation. Ils se localisent surtout dans les cuvettes et sur les légères éminences bordant les marigots. Les togué situés dans les dunes sont plus difficiles à repérer sur les photographies aériennes, le pourcentage de levées de terre naturelles étant beaucoup plus élevé ici. Sur les photographies aériennes se présentaient parfois des buttes semblables aux togué, mais qui, sur le terrain, se trouvaient être des collines naturelles. Cependant il n'est pas arrivé que l'on découvre sur le terrain des togué qui n'avaient pas été observés sur les clichés. Quelques togué ont probablement disparu suite à l'érosion fluviatile ou parce qu'ils sont couverts de sable. Néanmoins, tout porte à croire que le nombre de togué ainsi disparu est faible. L'analyse des photographies aériennes permet donc de découvrir presque tous les togué repérables.

Le 'Projet Toguèrè' est subdivisé en deux phases. La première phase impliquait un inventaire de grande envergure des togué dans la partie Sud du Delta intérieur du Niger. L'aire de recherche est limitée par le plateau de Bandiagara dans le Sud et le Niger dans le Nord, entre les villes Djenné, Mopti et Kouakourou. Le choix de cette aire, une surface de 2000 km^2, a été déterminé par la découverte d'une grande concentration des togué. La recherche de terrain consistait en trois campagnes de prospection d'une durée de deux mois, effectuées de 1989 à 1981 entre janvier et mars. La base centrale était installée dans la ville de Djenné et des bases secondaires étaient fixés à Say, Kouakourou, Soye, Sofara, Soufroulaye, Mopti et Diafarabé. Le but de cette phase de la recherche était d'approfondir la connaissance sur la localisation des buttes anthropiques, l'ensemble des matériaux trouvés à la surface et l'état de conservation des buttes. Cette phase a été achevée en 1991. Dans la deuxième phase de la recherche, des fouilles ont été effectuées sur quelques-uns des togué les plus élevés, répartis sur la zone d'étude. Les fouilles visaient à augmenter et à compléter les recherches de céramique conduites auparavant. Des informations spécifiques concernant certaines régions et certaines périodes pourraient perfectionner la typochronologie pour la céramique de la partie Sud du Delta intérieur du Niger. L'analyse de la céramique est d'une grande importance pour la datation des sites. La première fouille de cette série a été réalisée à la fin de 1991 à Diohou, un toguèrè du côté sud du Niger en face de Diafarabé. Une deuxième fouille aura lieu sur un toguèrè à Kouna en 1994.

3. Situation des sites

La géomorphologie de la partie Sud du Delta intérieur se caractérise par un grand système de ramifications de cours d'eau et de lacs permanents et intermittents. Il y a des buttes naturelles en bordure des rivières, des cuvettes et des dunes. La plupart des sites se trouvent sur les langues de terre a côté des rivières (Schmidt 1992, 55). Ceci ne surprend pas, puisque ces buttes offrent plusieurs avantages pratiques. Tout d'abord, elles dominent le paysage, ce qui limite le risque d'inondations. Deuxièmement, il y a de l'eau en permanence a proximité immédiate du village, et troisièmement, elles constituent les parties les plus fertiles du Delta. Cette localisation est optimale pour les agriculteurs, les pêcheurs et les éleveurs. Il est difficile de déterminer quels ont été les facteurs prépondérants pour les habitants des villages. Outre les avantages indiqués ci-dessus, des facteurs démographiques et politiques peuvent, eux-aussi, avoir joué un rôle. Ceux-ci ne peuvent guère être déduits du choix de la localisation ou des vestiges archéologiques.

4. La datation

Il est probable que les togué datent du temps où des groupes de gens, originaires du Sahara qui se désertifiaient de plus en plus, sont arrivés dans le Delta intérieur (McIntosh/McIntosch 1980, 440). Sur les togué ou des recherches ont été effectuées on n'a jamais trouvé de vestiges néolithiques. Dans les couches culturelles les plus anciennes de Jenné-Jeno, un toguèrè, de grande importance par ses dimensions spectaculaires (33 hectares), et sa longue durée d'occupation (il atteint une hauteur de 8 mètres), on a trouvé des scories. Sur la base de ces données on pense que les togué sont un phénomène de l'âge de fer (McIntosh/McIntosch 1980, 434). Les résultats des fouilles effectuées sur les togué de Jenné-Jeno, Doupwil et Gallia pourraient former une indication sur la durée du peuplement togué de la partie Sud du Delta intérieur du Niger, de la période de 250 ans A. D. (McIntosh/ McIntosch 1980, 75) jusqu'au 16ᵉ et 17ᵉ siècle (Bedaux *et al.* 1978, 189).

A l'aide de recherches géographiques entreprises pour le «Projet Toguèrè» on a tenté de dater les togué isolés en proposant une reconstruction paléogéographique de la dynamique hydrographique. L'âge d'un cours d'eau limitrophe pourrait servir de datation relative pour un toguèrè. Cependant, les recherches physico-géographiques s'accordent pour conclure que le système de drainage actuel est représentatif de toute la période qui importe du point de vue archéologique, de 500 av. J.-C. jusqu'à maintenant. A cause de la transition d'un climat humide vers un climat aride qui s'est produite pendant cette période, et de la diminution de l'érosion fluviatile, il est peu probable que le système hydrographique ait changé profondément ces 2500 dernières années (Terlien/Makaske 1990, 47).

La seule possibilité de dater les sites est offerte par l'analyse de la céramique, des fusaïoles et des pipes. C'est pourquoi une chronotypologie détaillée de la céramique est de grande importance.

5. Quelques résultats

Pendant la prospection des 800 à 1000 togué furent enregistrés à l'aide d'une fiche de site sur laquelle sont mentionnées les dimensions des buttes anthropiques, telles que la longueur, la largeur et la hauteur, de même que la présence ou l'absence de traces funéraires, de traces d'activités métallurgiques et d'autres matériaux. Des échantillons de céramique ont été collectés pour réaliser une étude complémentaire, par exemple pour déterminer la phase finale de l'occupation.

En général les togué sont de forme circulaire. La longueur varie de 25 m à 758 m, la largeur de 11 à 453 m et la hauteur de 0.4 m à 8 m (Schmidt 1992, 34). Quelques togué ont atteint cette hauteur par l'entassement successif des débris d'occupation. Il est possible que, dans les régions où le danger de crue était grand, les lieux aient été artificiellement surélevés, au préalable, pour prévenir les inondations. Dans ces régions ce n'est probablement pas l'entassement des débris seul qui est responsable de la hauteur des togué.

L'ensemble des matériaux trouvés à la surface des togué présente des constantes. Les occupants du togué enterraient leurs morts dans des jarres funéraires. Sur les buttes anthropiques on a rencontré quatre types d'habitations: des bâtiments ronds en briques cylindriques (djeney ferey), des bâtiments ronds en briques rectangulaires, des bâtiments rectangulaires en briques cylindriques (djeney ferey) et des bâtiments rectangulaires en briques rectangulaires. Sur beaucoup de togué ont été trouvées des scories et aussi des vestiges d'activités métallurgiques, tels que de hauts fourneaux, des creusets et des tuyères. Il y a des matériaux significatifs de pratiques agricoles, tels que des meules, ainsi que des artefacts qui se rapportent à la pêche: des poids de filets.

La présence de matières primaires qui ne sont pas originaires du Delta intérieur, telles que le fer, l'or, le bronze, le cuivre, le grès, le verre et les cauris, révèle l'existence des contacts commerciaux.

Un des résultats les plus alarmants de la prospection est l'ampleur du phénomène des togué touchés par le pillage. Ces dernières années un nombre croissant de sculptures de terre cuite de grande valeur artistique a surgi dans le commerce de l'art de l'Occident. Pour les musées et les collectionneurs ces sculptures sont des objets recherchés, pour lesquels on débourse des sommes astronomiques. Toutefois, il n'est presque pas possible d'en déterminer l'origine et le contexte archéologiques, étant donné qu'elles proviennent de fouilles illégales entre autres du Delta intérieur du Niger. A côté des paysans qui individuellement, pendant la saison sèche, essayent de se constituer quelques revenus supplémentaires en déterrant des objets sur les togué, on trouve toujours plus de groupes organisés qui fouillent les buttes systématiquement jusqu'à une profondeur de 1 à 1,5 mètres, détruisant sur leur passage tout ce qu'ils ne peuvent pas utiliser (Dembélé/Van der Waals 1991, 905). Quand le toguèrè est enfin abandonné, les couches supérieures n'ont plus aucune valeur pour les recherches archéologiques. Ainsi 19% des togué est déjà détruit. Si on y ajoute les actions des paysans, il s'avère qu'en 1991 environ 45% des 834 togué ont été touchés par le pillage (Schmidt 1992, 89). A supposé que le pillage illégal continue de cette façon, les archives du sol seront tellement perturbées que, dans dix ans, des recherches archéologiques ne seront plus guère possibles. Ainsi une catégorie importante des sources de l'histoire malienne se perdra pour toujours.

Reconnaissance

J'aimerais remercier le Dr. M. Dembélé et le Professeur, dr. J.D. van der Waals d'avoir bien voulu prêtre leurs données à ma disposition.

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Pollen from coprolites and recent droppings: useful for reconstructing vegetations and determining the season of consumption?

An attempt has been made to infer the season of consumption and to reconstruct the former vegetation from the results of the analysis of the pollen contained in coprolites. A comparative analysis of recent droppings of foxes showed that it is not possible to infer the season of consumption from such results, except possibly in some special cases. The same analyses showed that it is possible to reconstruct the vegetation to a certain extent: all the species encountered in the droppings were present in the local vegetation, the species that were found to be dominant in most samples were also dominant in the vegetation and all of the species with high frequencies in the droppings were frequently occurring species in the vegetation.

Most of the coprolites were found to contain pollen of cultivated species; although this does not necessarily mean that those species were grown on the site itself, it does imply their presence there.

1. Introduction

Conditions for the preservation of pollen and (uncarbonised) seeds are often far from perfect at archaeological sites. Particularly on dry, sandy soils pollen is often absent. The consequence of this is that it is often very difficult to reconstruct the former vegetation of such sites. One of the alternative sources of information that have been considered in this context is coprolites. Coprolites are excrements which have been petrified due to particular local conditions (a dry matrix, the presence of large amounts of phosphate and chalk, the presence of a cover layer of drift sand). They are found in excavations relatively frequently. Coprolites often contain several zoological and botanical macro-remains. They also contain large amounts of pollen. To obtain pollen coprolites are scraped well to avoid the risk of contamination with pollen from the outer surface. They are then dissolved in phosphoric acid (85% for 3 to 4 hours), after which the resultant solution is separated with the aid of bromoform/ alcohol (s.g. 2). Finally an acetolysis is carried out (Erdtman 1969).

In our case it was hoped that the pollen from coprolites would provide answers to two questions. The first of these concerned the environment. As already mentioned above, it was hoped that the information obtained from the coprolites would help us to reconstruct the former vegetation. The second question was whether some Neolithic sites in the western part of the Netherlands had been occupied on a seasonal basis. It has often been assumed that pollen contained in coprolites can be used to determine the season in which it was consumed (see Paap 1976).

Pollen can make its way into the intestinal system in two ways: via inhalation (Wilson *et al.* 1973) and via food and drink (Kowalski *et al.* 1976). The behaviour of the donor is an important factor in this respect. In our sites the donors of the coprolites were probably dogs.[1] In order to determine what information the pollen from the coprolites could provide about the vegetation or the season, comparative research was carried out using the droppings of foxes from the dunes west of Vogelenzang (Amsterdamse Waterleiding-duinen, fig. 1). Foxes were chosen because prehistoric dogs are probably more comparable with present-day foxes than with present-day dogs. Moreover, the vegetation of the territories of the foxes was well known. A practical reason was that we were able to collect the droppings there. Fresh droppings were collected in part of the area once or twice a month for two consecutive years. They were analyzed for pollen and macroremains using the usual laboratory procedures, with the difference that a tablet containing *Lycopodium* spores was added.

2. The analysis of the fox droppings

The collected droppings were described and prepared for pollen analysis. An example is shown in figure 2. The excrements yielded macro-remains besides pollen[2]. After the droppings had been prepared the pollen was counted. The taxa present, their numbers and the preservation of the pollen varied considerably. In some exceptional cases the foxes in question had eaten butterflies. The scales of the wings were found and enormous amounts of pollen from plants that are visited by butterflies, such as *Anchusa*, *Echium vulgare* and *Solanum dulcamara* (fig. 3).

The presence of large numbers of small black particles (probably bacteria) often made it difficult to count the

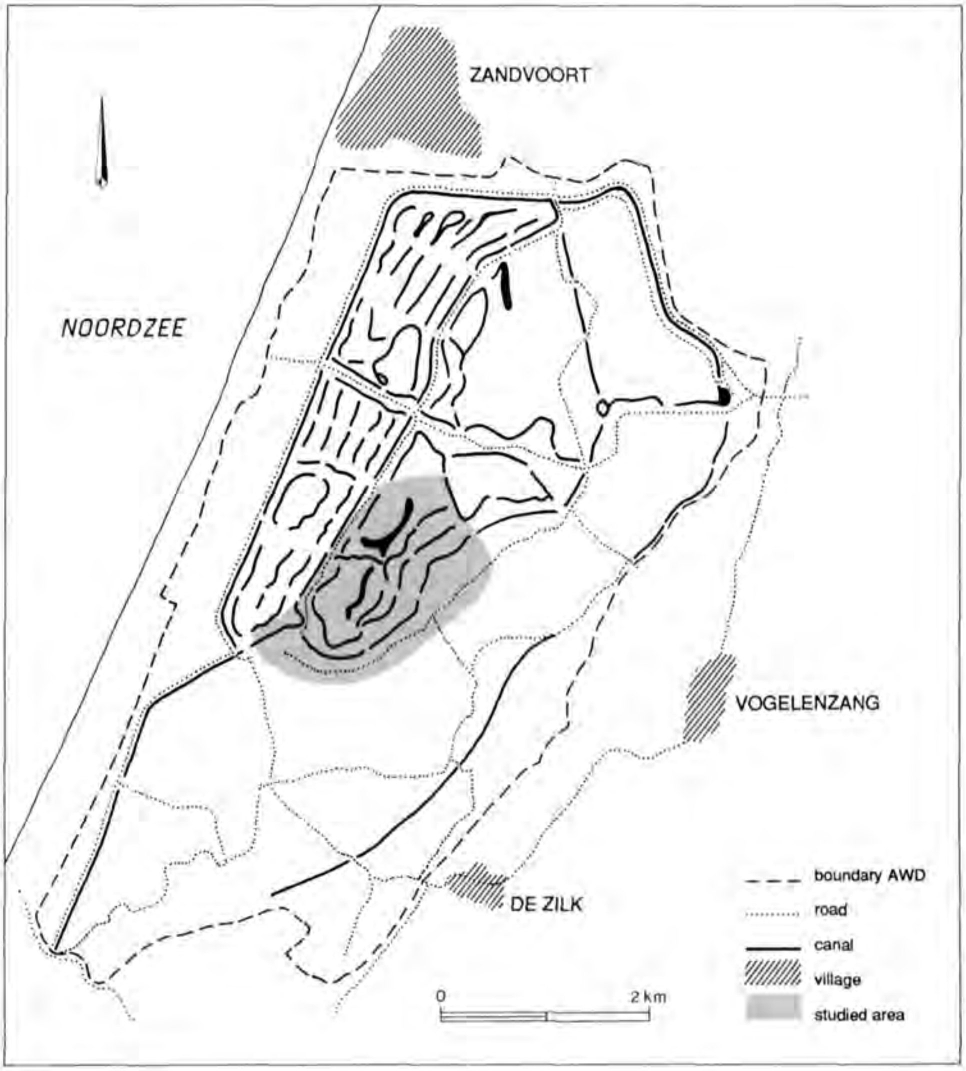

Figure 1. Position of the investigated area in the Netherlands.

pollen. In some cases they covered the pollen completely. A sieving experiment was carried out using a sieve with meshes of 9 μm to see whether the particles could be removed[3]. The sieving of the samples of fox droppings did not lead to a spectacular reduction in the number of bacteria. It was therefore decided to stop sieving and to make the most of the black slides. The result is shown in figure 4.

3. Vegetation reconstruction on the basis of the fox droppings

The composition of the local vegetation (fig. 5) was determined via observations in the area and from maps by Doing (1988). The vegetation resulting from the data obtained for the fox excrements was compared with the actual vegetation. A vegetation can be reconstructed in two ways: qualitatively and quantitatively. The qualitative reconstruction was found to be quite reliable in the sense that all of the species encountered in the fox excrements indeed occurred in the dune area. However, it was not possible to reconstruct the entire vegetation from the data obtained because the donor had not ingested pollen from all the species present (for instance because some species produce only little pollen).

The quantitative reconstruction was reliable to a certain extent only. A distinction was made between dominant and frequently occurring species. There were two dominant taxa in the vegetation: *Hippophae rhamnoides* and Gramineae. In the excrements the first species was regularly found to dominate, followed by Gramineae. In the case of some samples, however, other species dominated, for example *Prunus serotina*, *Alnus*, *Betula*, *Pinus*, *Crataegus*.

Figure 2. Example of a fox dropping. 1:1. Amsterdamse Waterleidingduinen.

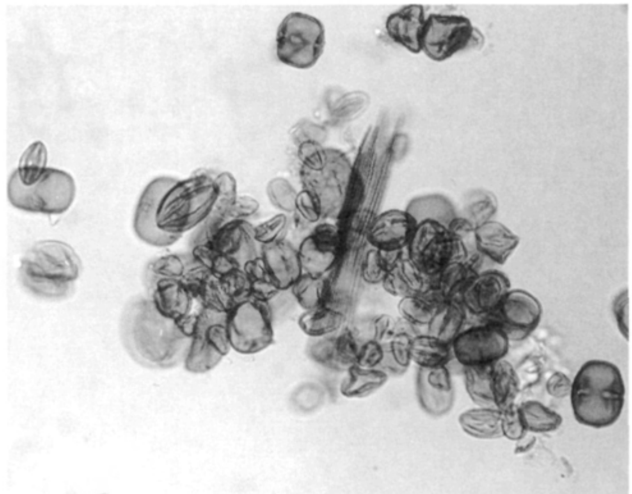

Figure 3. Pollen and wing scale of a butterfly. Amsterdamse Waterleidingduinen. 1:200.

Compositae and the species visited by butterflies. These species were present in the vegetation, but not as dominant elements.

The species frequently encountered in the droppings were all frequently occurring species in the vegetation. The opposite, however, did not apply: there were certain species in the vegetation which, for various reasons, were hardly, if ever, encountered in the droppings.

The overall conclusion is that it proved possible to reconstruct the vegetation to a certain extent: all the species that were encountered in the fox excrements actually grew in the dune area, the species that were found to be dominant in many samples were also dominant elements in the vegetation and all the frequent species in the excrements were frequently occurring species in the surroundings.

4. Season of consumption as reflected in the recent fox droppings

The absolute numbers were plotted on a logarithmic scale (see fig. 5) to enable comparison of the results with Spieksma's pollen calendar (Driessen *et al.* 1988, 105).[4] At first sight there seemed to be no connection between the two. It appeared to be impossible to infer the season of consumption from the data obtained for the excrements. However, this changed when the species were divided into two groups, one of species of which pollen were to be found in the area for part of the year only and one of the species of which pollen were present on the plants throughout the year. In the case of the last group some correspondence with the calendar was observed for the flowering period (in particular in the case of the samples of the 'butterfly foxes' of August 1987 and August 1988) and in some cases for the fruiting season (species that were eaten as fruit, such as *Prunus serotina*, in October 1987, and *Rubus fruticosus*, in August 1988).[5]

With the possible exclusion of the exceptional samples, such as those of the 'butterfly foxes' and those containing the remains of Rosaceae fruit, which provided indications of the flowering and fruiting season, respectively, the samples did not provide any information on the season of consumption.[6]

5. Results of the analysis of the coprolites

Over the past few years several coprolites have been analyzed (fig. 6). The macroremains usually encountered are bones, including those of fish, sand, small pieces of charcoal, the odd seed (*Juncus*, *Poa* and *Phragmites*) and pollen, usually well preserved (tab. 1).

The dominant species in two Neolithic coprolites from Hekelingen (western Netherlands) was *Alnus*. Species with high frequencies were *Hedera helix* and *Corylus avellana*. Together with the other species encountered they were indicative of a dry place bordered by an alder carr, which was in excellent agreement with the other botanical evidence from this site.[7] The question concerning seasonal occupation raised in the introduction, could not be answered, as will have become clear from the results of the fox-dropping research.

The dominant species in the twelve coprolites dating from the Roman period that were found in The Hague (western Netherlands) were *Myrica gale* (1×) and Gramineae (11×). On the basis of the results obtained in our fox research they would indicate a vegetation dominated by grasses. This is in accordance with other evidence obtained for this region.[8] The large amount of *Myrica gale* pollen can be understood by assuming that the dog drank water from a dune lake at the time when the shrubs surrounding it were in flower. Enormous amounts of pollen would then have floated on the surface of the water.

Species with high frequencies in the samples from The Hague were *Corylus avellana*, *Plantago lanceolata*, *Myrica gale*, *Filipendula*, *Alnus*, *Rumex*, Cyperaceae, Ericaceae, Cruciferae, Compositae liguliflorae, Monoletae and Cerealia. These and the less frequent species grow in small

Table 1. Pollen from coprolites.

site	Hekelingen		Villeneuve St. Germain			Uitgeest	The Hague												The Hague				
sample number	12C-291	12D-288	F4.C.19B	142	249	20-3-53	301	323	345	356	522	688	698	1100	1103	2258	4367	4382	98	283	303	417	3
period	Neolithic		late Iron Age			Roman	Roman												Middle Ages				
Cerealia	4	1	114	4	53	18	-	3	15	10	3	13	5	4	2	7	19	-	84	52	71	17	10
Juglans regia	-	-	-	-	-	-	-	-	-	-	-	1	4	1	-	1	-	-	-	-	-	-	-
Pisum sativum	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-
trees and shrubs:																							
Alnus spec.	672	91	13	-	22	18	-	1	6	15	8	6	10	17	2	6	2	9	7	38	11	9	8
Betula spec.	6	-	1	-	2	7	-	-	2	3	2	1	2	7	2	-	1	1	1	3	3	2	1
Corylus avellana	76	22	1	-	11	3	-	20	10	64	18	5	13	10	5	7	2	3	-	33	6	8	4
Hedera helix	108	4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	7	-
Hippophae rhamnoides	-	-	-	-	-	-	-	2	1	5	-	1	1	3	1	-	-	1	-	-	-	-	-
Juniperus communis	-	-	-	-	-	-	-	-	1	-	1	24	3	7	1	1	-	1	-	-	-	-	-
Myrica gale	5	-	-	-	-	-	500	2	8	14	3	1	3	1	17	3	-	2	-	3	-	2	1
Pinus spec.	2	3	1	1	1	4	-	-	1	1	1	1	2	1	-	1	-	-	-	-	2	-	1
Quercus spec.	24	5	1	-	4	4	-	1	2	6	-	2	1	4	1	3	2	2	1	4	1	4	2
Salix spec.	8	-	-	-	-	-	-	-	2	3	10	2	2	1	2	-	1	1	6	27	2	4	-
Ulmus spec.	34	4	-	1	-	-	-	-	1	2	-	-	-	1	-	-	-	-	-	-	-	-	1
other taxa	16	8	1	-	-	-	-	-	1	1	-	-	-	-	-	-	1	1	1	18	-	-	2
herbs:																							
Artemisia spec.	-	-	2	2	1	-	1	3	7	19	6	1	5	4	2	6	6	4	1	-	6	4	-
Caryophyllaceae	-	-	1	1	2	1	-	2	-	14	6	4	4	4	3	4	2	5	3	4	1	-	-
Centaurea jac./prat. type	-	-	1	1	-	-	-	-	-	-	-	-	-	2	6	2	-	2	-	-	-	-	-
Chenopodiaceae	4	2	3	1	2	8	-	2	4	24	5	-	8	3	1	7	4	2	2	6	4	6	1
Compositae lig. type	1	-	9	11	5	2	1	10	12	42	22	55	22	30	15	27	13	5	8	58	18	12	4
Compositae tub. type	2	1	14	6	10	7	-	6	1	21	12	7	13	7	3	3	5	2	4	47	24	6	1
Cruciferae	-	-	-	5	-	11	-	1	-	-	4	112	1	2	-	-	-2	-	28	5	2	-	
Cyperaceae	5	6	1	2	-	26	-	4	13	32	21	34	15	6	17	15	6	3	3	32	2	-	8
Ericales	3	-	-	-	-	1	1	8	15	45	9	9	13	9	5	10	4	2	2	26	-	10	11
Filipendula spec.	3	6	1	1	-	3	-	2	1	60	6	6	3	2	2	1	-	3	-	1	3	30	-
Gramineae	42	1	80	21	151	160	1	91	145	516	235	244	371	105	185	132	72	74	218	187	86	208	35
Lotus uliginosus	-	-	-	-	-	1	-	-	-	1	3	-	-	3	1	1	-	1	-	-	-	-	-
Mentha type	-	-	-	-	-	-	1	1	1	1	-	-	-	1	-	-	-	-	-	-	-	-	1
Monoletae psilatae	36	18	-	1	-	1	-	2	2	18	4	1	106	7	5	3	5	9	9	23	11	20	12
Papilionaceae	-	-	-	-	-	-	-	1	1	6	3	16	7	14	3	4	-	4	3	-	-	-	-
Plantago lanceolata	-	2	9	2	13	1	-	13	6	87	20	23	20	22	19	13	11	11	7	10	8	6	-
Plantago major/media	-	-	-	-	-	-	-	3	-	1	1	-	1	1	-	-	-	-	-	-	1	1	6
Polygonum aviculare	-	-	1	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	3	2	-	-
Polypodium	2	-	-	-	-	-	-	1	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-
Ranunculus spec.	-	-	-	3	-	4	1	3	2	30	5	9	13	4	6	3	2	4	6	8	1	13	2
Rubiaceae	1	-	1	-	-	-	-	4	10	11	-	5	4	6	3	5	1	3	6	4	3	6	-
Rumex acetosa type	-	-	2	-	7	7	-	11	5	20	16	9	32	6	4	4	5	10	2	9	1	12	-
Sanguisorba minor	-	-	-	-	-	-	-	3	-	1	-	4	-	-	2	2	-	3	1	-	-	-	-
Sphagnum spec.	1	-	1	-	-	4	1	3	3	7	1	1	2	5	3	1	2	1	-	16	2	1	3
Triletae psilatae	1	2	4	2	3	-	-	-	1	-	4	1	1	-	-	-	-	-	-	-	1	-	-
Umbelliferae	-	1	12	10	10	7	-	3	3	11	11	7	2	4	3	2	1	-	2	6	2	-	-
Urtica spec	2	1	2	-	2	1	-	6	1	4	-	1	2	-	-	-	-	-	6	1	1	-	-
other taxa	5	57	28	6	26	72	-	11	7	109	7	21	12	8	1	3	5	7	11	16	9	11	17

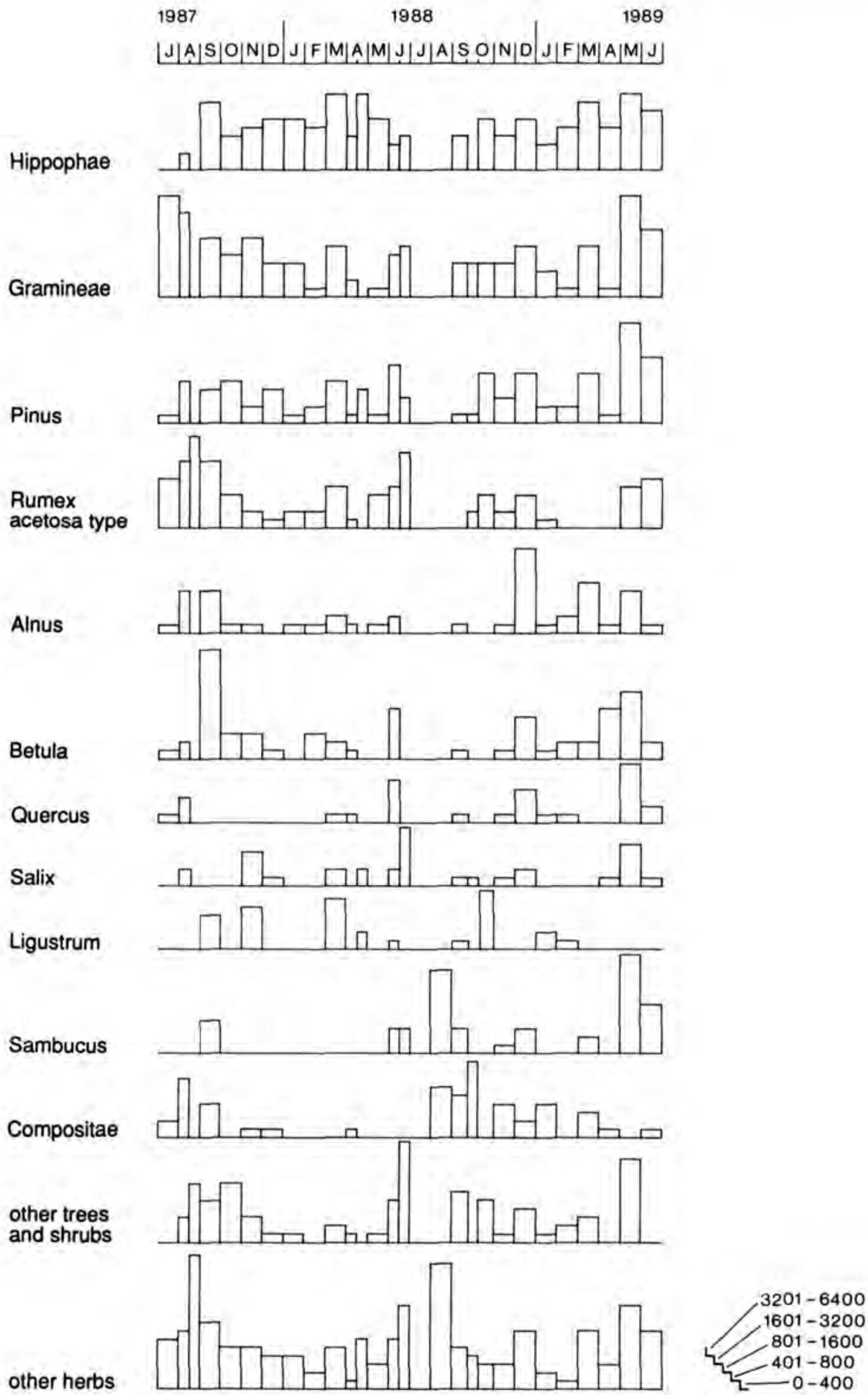

Figure 4. Absolute numbers of pollen from fox excrements (log. scale).

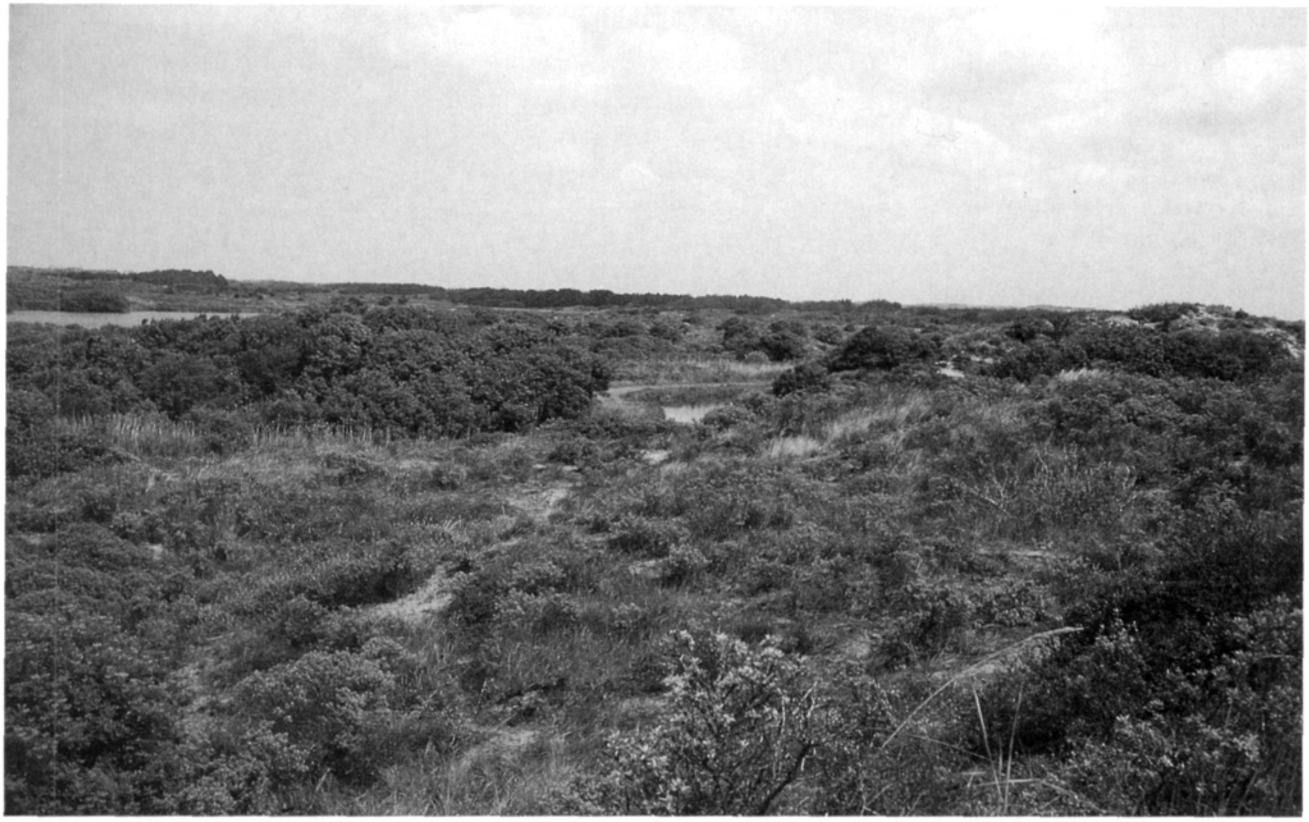

Figure 5. Vegetation of the studied area. Amsterdamse Waterleidingduinen.

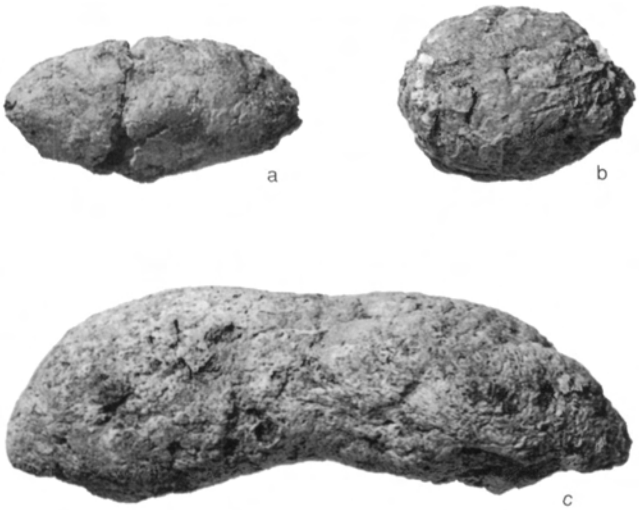

Figure 6. Coprolites from: a - Hekelingen (Neolithic), b - Villeneuve Saint Germain (Late Iron Age), c - Uitgeest (Roman Period). 1:1.

woods and brushwood, grasslands of varying moisture contents and in aquatic and ruderal environments. The cereals are a special case. Although they were frequently encountered in the excrements they were not necessarily common species in the former vegetation. They may have been leftovers that were fed to the dogs. The cereal pollen included pollen of oat (*Avena*), barley (*Hordeum*) and wheat (*Triticum*). Other pollen of cultivated species encountered besides that of cereals was pollen of walnut (*Juglans regia*) and pea (*Pisum sativum*). Such pollen of cultivated species provides information on the food consumed by the occupants of the site. It cannot prove that the species in question were grown on the site itself, but it does imply that those species were present there, for instance as supplies.[9]

Coprolites from (around) the same period from Uitgeest (western Netherlands, 1×) and from the Late Iron Age site Villeneuve Saint Germain (northern France, 3×) yielded roughly the same results. Gramineae regularly dominated and the other species represented an open landscape closely resembling that inferred from the results of the analysis of the coprolites from The Hague. Cereals were frequently found.

Gramineae also dominated in some medieval coprolites (5×) from The Hague.[10] Rye (*Secale cerale*) was a frequent species in these coprolites.

Acknowledgements

We would like to thank F. Spieksma for explaining the various ways in which pollen can enter the intestinal system, J. Mulder for sending us information about foxes and their behaviour, G. Baeyens and her colleagues for granting us access to the AWD area, J. Goudzwaard and C. Bakels for collecting the droppings, O. Brinkkemper for his critical remarks and, finally, the foxes for providing us with enough basic material for the comparative study.

notes

1 We did not identify the donor on the basis of the colour, odour and distribution of the coprolites on the site as has been done in some other studies. We believe that the shape (oval/cylindrical with long thin ends, as with all carnivores) and the dimensions are important criteria. In our case this left us with two possibilities: human beings or dogs. This had to be solved by inspecting the contents. The presence of sand, charcoal and bones pointed to dogs.

2 regularly encountered:
sand, fragments of leaves, moss, seeds (*Urtica dioica, Prunus serotina, Polygonum, Sambucus nigra, Betula, Rubus fruticosus, Rubus caesius, Rumex acetosella, Hippophae rhamnoides, Senecio, Viola, Carex, Moehringia trinervia, Lycopus europaeus, Typha, Sagina, Veronica, Poa, Crataegus monogyna, Gramineae*), stellate hairs of *Hippophae rhamnoides*, hairs of rabbits, fragments of bones, remains of insects, different species of larvae and caterpillars.
occasionally encountered:
fragments of flowers, fragments of twigs, spores of fungi, spiders, puparia of flies, fragments of feathers and nails of birds, eggs of water fleas, fleas, fragments of shells, lice, ticks, scales of butterfly wings, eggs of Bryozoa, fragments of birds' eggs.

3 The sieving experiment comprised two samples of the fox droppings and two samples from a peat layer not connected with the study presented here. The results obtained for the samples from the peat appeared promising at first: the small mineral parts had been removed almost completely. However, closer inspection showed that the pollen content had changed. The disappearance of pollen of small species like *Urtica* and *Solanum* seemed acceptable in view of the improved and more reliable countability of the slides. However, large amounts of pollen from larger species like *Alnus*, *Salix*, *Corylus*, Gramineae, Rubiaceae, Chenopodiaceae, Umbelliferae and Monoletae had also disappeared, which was more serious.

4 Absolute numbers were obtained by the addition of *Lycopodium* tablets. The pollen calendar provides the pollen content of the air in the Netherlands.

5 Pollen is known to adhere to fruits. Moreover, Mulder (1988) discovered that several of the foxes he studied buried food and left it in the ground for a short time, which makes it still more difficult to ascribe the pollen to a specific season.

6 It is possible that more positive results would be obtained if more data were to be collected (more droppings per month over a period of several years) and compared with the results of a similar study in another area (with a different vegetation). A study of the droppings of herbivores would involve other problems, such as the possibility of cattle having been fed summer hay in the winter time.

7 Pollen and seeds were studied (Bakels 1988).

8 Evidence obtained in archaeobotanical research of remains from the Scheveningse weg (Vermeeren, unpublished) and pollen research (Jelgersma *et al.* 1970; De Jong/Zagwijn 1983).

9 It is always very difficult to ascertain whether or not a cultivated species was grown on the site itself. It has long been believed that the presence of pollen of a species constitutes evidence that that species was grown on the site but we do not agree. With the exception of the pollen of rye, virtually all cereal pollen is released from the chaff in threshing. The assumption that cereals were traded and stored in the chaff is gradually winning ground; that would mean that small amounts of cereal pollen discovered at a site would not constitute evidence for the cultivation of the species on the spot, but would simply indicate its presence there. We initially thought that we would be able to prove whether or not peas had been cultivated at a site. Peas were stored after they had been removed from their pods. We assumed that any pollen that may have been present on the outside of the pods would have disappeared by the time they were stored. If that were true, the discovery of pea pollen at a site would mean that peas were grown on the site itself. Unfortunately, however, recent peas that were shelled and prepared for pollen analysis were found to contain pollen.

10 Four of these have already been published in Magendans and Waasdorp 1989.

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Traces of Ancient Vessel Use: Investigating Prehistoric Usage of four Pot Types by Organic Residue Analysis using Pyrolysis Mass Spectrometry

In this study, Curie-point Pyrolysis Mass Spectrometry (CuPyMS) was used for the characterisation of solid organic residues situated on vessels of different shapes and sizes, found in an indigenous settlement from the Roman period at Uitgeest-Groot Dorregeest. The analysis of very small samples produced 'fingerprints' which reflect the chemical composition of the residues. Soil samples of the surrounding sediment were analyzed to check for contamination, but no indications could be found for severe post-depositional degradation or contamination of residues with soil components. The chemical composition of the residues was correlated to the size and form of the vessels using Discriminant Analysis in combination with Complete Link Cluster Analysis. This correlation reflects a distinction in original use between vessels of different forms and sizes. The presence of 'marker' compounds for fatty acids, proteins, smoke condensates and charred polysaccharides detected in the residues, gives information about the possible original use of the various types of vessels.

1. Introduction

1.1 Functional classification of pottery, the use-alteration perspective

Pottery is a find-category frequently studied by archaeologists in search of information about different aspects of past societies, such as, social organisation, the organisation of trade and exchange, demography and subsistence. In spite of the long-standing tradition of ceramic studies in archaeology, it has always remained difficult to assign functions to ancient vessels. The understanding of how pottery was used is however essential to all studies that deduce information from pottery assemblages. The archaeological information stored in any assemblage of artefacts can only be interpreted fully if the actual use of the objects is known (Skibo 1992, 4).

Archaeological methods to identify vessel function are either directed to the function intended by the potter, or to the actual use of a vessel. The study of intended vessel functions is based on the assumption that the form, size and composition of pottery and, to a certain extent, its decoration, are constrained by the intended context and conditions of use (Braun 1973). The main difficulty of this approach is the interpretation of observed morphological and technological variation in terms of function (Rice 1987, 207-232). The relationships between form, function and production technology are complex and variable. The study of intended vessel functions is therefore limited in detail and resolving power and will usually result in a general framework of possible functions (Rice 1990).

Studies directed to the actual use of vessels, on the other hand, can give independent information about the utilitarian role of a vessel. The traditional archaeological approach, the study of recovery context, is usually limited in resolution and open to multiple interpretations. The most direct and detailed way to analyze vessel use is through traces found in and on the ceramics. Hally (1983) was the first to use the term 'use-alterations' for modifications to the ceramic caused by use of the vessel. More recently, other researchers (Henrickson 1990; Skibo 1992, 42-49) have described various types of modifications including: the effects of firing such as, soot deposition and discoloration due to differences in oxidative state (*i.e.* oxygen discoloration); attrition or 'use-wear' of ceramic vessels (*e.g.* scratches, dents, chipping); and organic residues present in the vessels. Although each of these types of alterations can give information about vessel use, it must be kept in mind, that none will give information about the complete range of possible vessel uses within a society, but rather, on vessels of a selective range of daily applications.

1.2 Organic residue analysis to study vessel use

Studies of organic residues found in association with ancient pottery have mainly been directed to the identification of extractable compounds such as lipids and resinous materials (see bibliographies in Evershed *et al.* 1992; Heron/Evershed 1993; Rottländer/Schlichterle 1980). Both visible surface residues and compounds absorbed in the ceramic of the vessel wall are potentially useful sample material for systematic research of vessel use within ceramic complexes. In the literature some disagreement exists concerning the suitability of the different materials. Absorbed residues are probably more universally present

(Evershed 1993) and are claimed to be more protected against degradation and contamination with soil compounds (Rottländer 1990). Their analysis is, however, limited to specific classes of extractable compounds, such as lipids or resinous materials, and the results are harder to interpret because the compounds are probably accumulated in the ceramic over a longer period of vessel use. Surface residues, on the other hand, are less common but have recently been shown (Oudemans *et al.* in press) to contain a better preserved complex lipids profile. In addition, surface residues are probably the result of the last, or one of the last, phases of vessel use. In theory, this increases the likelihood of identification of the original vessel contents. Finally, solid surface residues can be studied for many classes of non-extractable compounds such as proteins and polysaccharides. Since the chemical composition of the total residues is unknown prior to analysis, solvent extracts, as obtained in the study of absorbed residues, may not be considered representative for this composition without further study.

The knowledge of complex solid biomaterials is, however, constantly increasing due to the application of new analytical techniques, such as analytical pyrolysis mass spectrometry (Boon 1992). Curie-point Pyrolysis Mass Spectrometry (CuPyMS) has been shown to be a suitable analytical technique for the study of charred natural products (Pastorova *et al.* 1993a, 1993b) and for the study of archaeological surface residues (Oudemans/Boon 1991). The advantage of this technique is the capacity to analyze a complex mixture of compounds in one single analysis. Mixtures of soluble compounds and solid materials can be analyzed.

In this paper, a series of solid organic residues from an indigenous settlement from the Roman period at Uitgeest-Groot Dorregeest was analyzed with CuPyMS to characterise their chemical composition. The mass spectra were compared using multivariate analytical techniques, resulting in clusters of chemically similar residues. The clusters were subsequently correlated to the size and form of the vessel. The hypothesis is tested (Abbink 1985, in prep), that variation in form and size of vessels represents a variation in intended use of the pottery.

2. Experimental

2.1 Samples and sample treatment

The pottery studied was recovered from an indigenous settlement from the Roman period (*c.* 0-300 AD) at Uitgeest-Groot Dorregeest in the Netherlands (Woltering 1982, 1983). The settlement was situated on the remains of a coastal barrier and a sandy Dunkirk I creek deposit. During the Roman period, the settlement was bordered on SE and SW by a low lying, eutrophic peat deposit and cut off on NW and NE by a fresh water gully running in an old course of the salt water creek. In the settlement a number of incomplete three-isled houseplans and about twenty filled-up water wells, dated to the Roman period, could be detected (Abbink 1985).

The choice of the sample material for CuPyMS analysis was based on three criteria: burial context, vessel morphology and presence of different types of surface residues (Abbink in prep). The pottery was found in three different types of burial contexts: in sandy creek deposits, in highly organic clay deposits *(i.e.* filled-up prehistoric wells or ditch fills) and in peat deposits (tab. 1). Different morphological vessel types were distinguished in the studied ceramic complex based on several size and form characteristics (Abbink in prep). Four types of vessels were selected for this study (fig. 1) of which type II represents the largest number in terms of quantity of recovered sherds. Vessel types I, III and IV were much less abundant. The sample set used in this study, contained various different types of surface residues. Most of the residues were dark brown, carbonized thick (> 1 mm) crusts situated on the interior of vessels. Although these chars occurred in all four different vessel types, they were very rare in vessels from type IV. A few cream coloured, flaky, crusts of medium thickness (*c.* 1 mm), occurred on the inside of vessels. These residues were most frequently found on vessels of type IV.

Very rarely, smooth red brown, thin (< 1 mm) residues were discovered all over the interior of vessels or situated as streaks or dripping traces on the exterior of vessels. The patterns on the exterior of vessel 8-1 were probably the result of purposeful decoration with a thick liquid. A fourth kind of residues, of pitch black colour and smooth, thin (< 1 mm) appearance could be found on the exterior of several vessels. These black residues were most frequently found on vessels of type I. The selected sample set consist of 17 sherds from complete vessels of all four types, and 10 sherds which were too small to allow identification of the original vessel type. These sherds were included because they contained well preserved residues.

All sherds had previously been washed with tap water. The residue samples were scraped from the ceramic surface with a scalpel (cleaned with Dichloromethane), after removal of the outermost 0.5 mm of the residue. In addition to the residue samples, two samples of the most organic sediments present in the site (P_1 and P_2) were analyzed in order to check for exchange of compounds from the sediment. About 100 µg of each sample was ground with a small glass mortar and pestle. Subsequently a suspension was made by addition of about 50 µl ultra pure water (Millipore Q-grade).

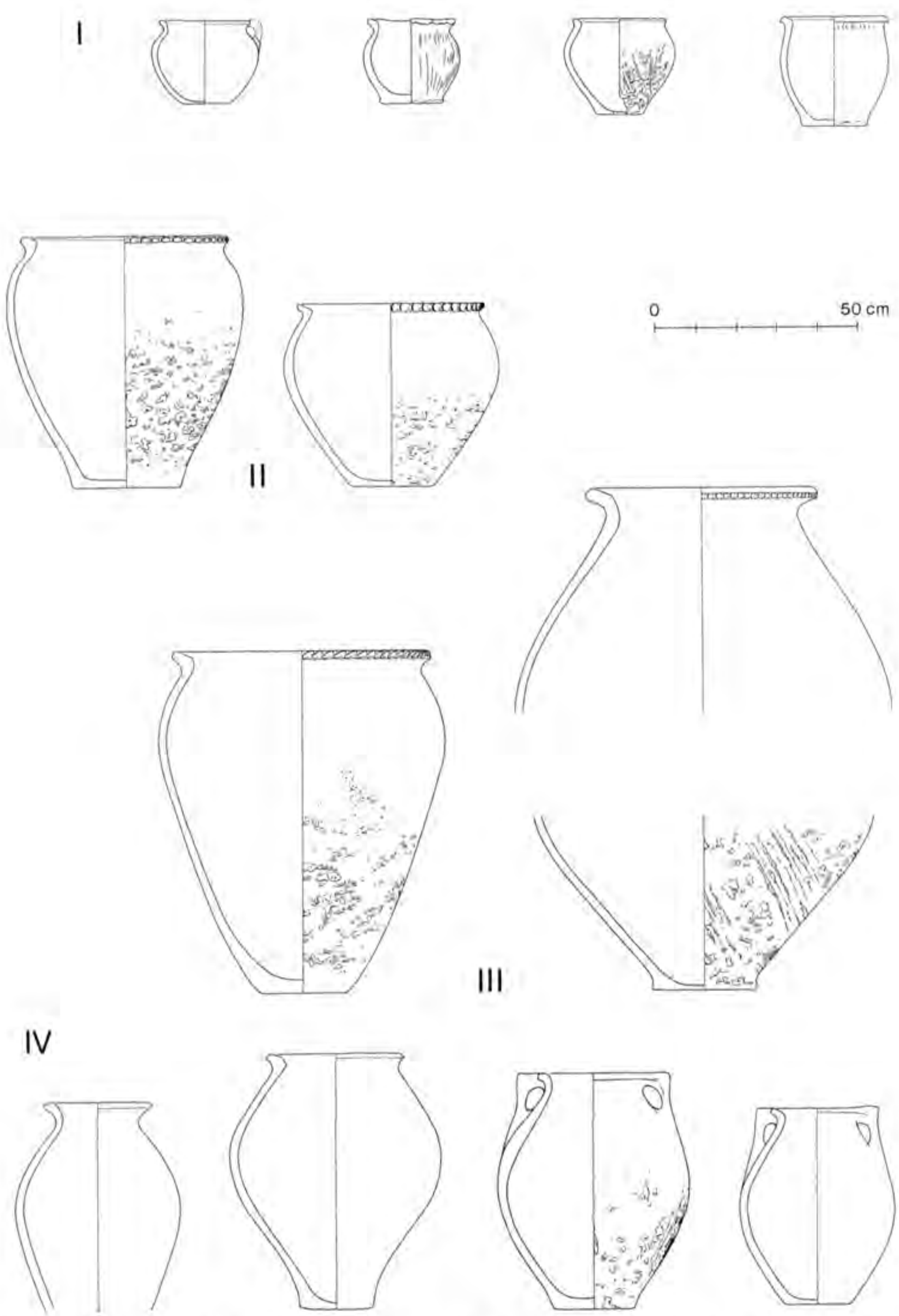

Figure 1. Morphological vessel types from Uitgeest-Groot Dorregeest (Abbink, in prep). The typology is based on form and size variables such as Greatest Diameter (GD), Rim Diameter (RD), and Distance from Rim to Greatest Diameter (DRG). Type I: small, three partite, wide mouthed vessels (GD/RD < 1.5, GD < 170 mm and GD/DRG > 2.4); Type II: medium sized, three partite, wide mouthed vessels (GD/RD < 1.5, GD ≥ 180 mm, GD < 340 mm and GD/DRG > 2.4); Type III: large, three partite, wide mouthed vessels (GD/RD < 1.5, GD > 350 mm and GD/DRG > 2.9); Type IV: Jar-like, three partite, narrow mouthed vessels (GD/RD ≥ 1.5 but GD/RD < 2.1 and GD/DRG < 2.4). Drawings by J. Hulst, State Service for Archaeological Investigations in the Netherlands (ROB).

Table 1. Residue samples and soil samples
[a] Find number: the first number indicates the number of the excavation pit, the letters indicate multiple samples from one vessel.
[b] Residue appearance: Brown, dark brown, thick (> 1 mm), charred crust on interior of the vessel; Black, smooth, thin (< 1 mm) black residue on exterior of the vessel; Red brown, smooth, thin (< 1 mm), red brown residue situated on interior (smooth layer) or exterior (often in streaks or dripping traces) of vessel; Cream coloured: white yellow, brittle crust of medium thickness (ca. 1 mm) on interior of vessel.
[c] Position of the residue on the vessel: In, Interior; Ex, Exterior of the vessel.
[d] Vessel Type: the morphological vessel type (Abbink in prep).
[e] Sediment: the soil type in which the vessel was found.
[f] P_1 and P_2 are peat samples from the excavation found in respectively pit 16 and pit 34.

number	find number[a]	residue[b]	position[c]	vessel type[d]	sediment[e]
1	7-7	brown	In	II	organic clay
2	8-1	red brown	Ex	III	organic clay
3	8-2	brown	In	III	organic clay
4	8-5	cream coloured	In	I	organic clay
5	14-6-4.2	brown	In	-	sandy
6	14-6-4.3a	brown	In	I	sandy
7	14-6-4.3b	black	Ex	I	sandy
8	14-6-4.4	brown	In	-	sandy
9	14-6-4.5	brown	In	-	sandy
10	18-3-3.2a	brown	In	I	organic clay
11	18-3-3.2b	black	Ex	I	organic clay
12	18.7	brown	In	II	organic clay
13	19.7-90.2a	brown	In	II	organic clay
14	19.7-90.2b	brown	In	II	organic clay
15	20-4	brown	In	II	sandy
16	20-4-157	brown	In	-	sandy
17	20-4-12-3	brown	In	II	organic clay
18	31-4a	brown	In	I	organic clay
19	31-4b	black	Ex	I	organic clay
20	32-6-18	brown	In	-	peat
21	33-5-2a	brown	In	-	peat
22	33-5-2b	brown	In	-	peat
23	33-8-2a	brown	In	-	peat
24	33-8-2b	brown	In	-	peat
25	34-0-12	brown	In	-	organic clay
26	34-0-30(=34-12)	brown	In	II	organic clay
27	34-7-62	red brown	In	II	organic clay
28	34-7-95.b	black	Ex	I	organic clay
29	34-11-3	brown	In	II	organic clay
30	35-5-120	brown	In	II	sandy
31	35-7-28	cream coloured	In	-	sandy
32	35-20	cream coloured	In	IV	sandy
33	35-21	brown	In	II	sandy
34	$peat_1$[f]	peat			pit 16
35	$peat_2$[f]	peat			pit 34

2.2 Instrumental

The analyses were performed in triplicate on a fully automated Curie-point pyrolysis mass spectrometer, the FOM-autoPYMS, built at AMOLF in the mid seventies and described in its latest version by Boon *et al.* (1984). Pyrolysis is a thermal fragmentation of large, non-volatile molecules in an inert atmosphere. The smaller, more volatile fragments formed during this rapid heating process are representative of the original (macro) molecules. Curie-point pyrolysis is accomplished by inductive heating of a ferromagnetic wire coated with the sample material. The thermal energy thus transferred to the sample is used for desorption or pyrolysis of the molecules. The desorbed molecules and pyrolysis fragments are subsequently ionised and transported to the mass spectrometer where they are separated according to mass. The instrumental conditions were: heating for 0.1 s at a rate of 5000 °C/s up to a Curie-point temperature of 610 °C, the total heating time was 1.0 s. The pyrolysis chamber was set at 180 °C, the ionisation current was 16 eV and the total mass range measured was *m/z* 20-240 at a scan speed of 10 scans/s with a total number of averaged spectra of 200. The results are visualised in a Mass Spectrum in which the intensity of each mass is plotted on a scale of 1 to 100% relative to the most abundant mass. Mass Spectra (fig. 2) can therefore be seen as a chemical 'fingerprints' of the total organic chemical composition of the sample.

2.3 Multivariate Analysis

In order to facilitate the comparison of mass spectra, a data reduction technique called Discriminant Analysis (DA) was applied. The statistical package used was a modified version of the ARTHUR multivariate analysis package (Hoogerbrugge *et al.* 1983). A number of Discriminant Functions (DFs) were calculated, which express the main similarities and dissimilarities between groups of samples. The DFs are linear recombinations of highly correlated masses. The number of DFs needed to explain the total variance in a set of samples depends on the diversity of the samples and the complexity of the material studied. The total variance in a set of samples can be seen as a summation of variance introduced by systematic changes in sampling or analytical procedure (I_W = within group variance), and variance between the groups of replicate analyses of samples (I_B = between group variance). The Fisher ratio (F) of a given DF, defined as $F = I_B/I_W$, expresses the amount of variance relevant to group separation explained by that DF. The characteristic variance of a sample set is here defined as the sum of the Fisher ratios of all the DFs. Using these Fisher ratio's, a selection of DFs can be made that are most relevant to group separation. Two-dimensional representations of the discriminant space (discriminant maps of two relevant DFs) can be made (figs 3, 4), showing the samples plotted around an origin, which represents the calculated 'average spectrum'. The relative difference in chemical composition between two samples is expressed by the Euclidean distance between two sample points in the map (*e.g.* samples close together are more similar to one another then samples further apart).

In order to outline groups of chemically similar samples, Complete Link Cluster Analysis (CLCA) was employed. Since not all DFs have the same explanatory power, each dimension is weighted prior to cluster analysis. The weighting factor k_i is defined as the percentage of the characteristic variance explained by the given DF_i. The weighted Euclidean distance D between sample points x_1 and x_2 is defined as:

$$D^2_{(x_1,x_2)} = \sum_{i=1}^{n} k_i.(x_{1i}-x_{2i})^2 \tag{1}$$

in which i symbolises the dimension or DF and k_i is a weighting factor for dimension i and x_{1i} and x_{2i} are the values for x_1 and x_2 in the dimension i. CLCA was applied to the weighted Euclidean distance between the samples in the discriminant dimensions considered relevant to group separation. The similarity value S between object x_1 and object x_2 is defined as:

$$S_{(x_1,x_2)} = 1 - \frac{D_{(x_1,x_2)}}{\max D_{(x_m,x_n)}} \tag{2}$$

in which max D s(,(x_m,x_n))represents the maximal weighted Euclidean distance between two points within the set of sample points. Clusters of samples with high similarity values can thus be formulated.

In order to explain the chemical differences between the clusters in terms of molecular composition, the sets of correlated masses which define the dimensions of the discriminant space are subsequently chemically interpreted in terms of classes of bio-organic compounds (figs 3, 4).

3. Results and Discussion

3.1 Soil samples versus archaeological residues

In order to compare the archaeological residues to the surrounding soil in which they were buried for many centuries, the CuPyMS mass spectra of residues and soil samples were included in a DA of the total sample set. A discriminant map of the discriminant functions DF_1 and DF_2, respectively expressing 41.9% and 28.6% of the characteristic variance (fig. 3), visualises a clear distinction between these two groups of samples. The soil samples are primarily characterised by mass peaks in the DF_1^- spectrum, whereas most of the organic residues on the vessels are characterised by the DF_1^+. The residue samples are further characterised and divided by masses in the DF_2 dimension (not shown in fig. 3).

The spectrum representing the DF_1^- space contains markers for the bio-organic compound classes lignins, polysaccharides and fatty acids (see tab. 2: Soil). These chemical characteristics are quite typical for pyrolysates of peat samples and are consistent with data presented by others (Boon *et al.* 1986; Bracewell *et al.* 1980). The absence of lignin and intact polysaccharide markers in pyrolysates of archaeological residues on pottery has already been shown before in Pyrolysis GC/MS studies

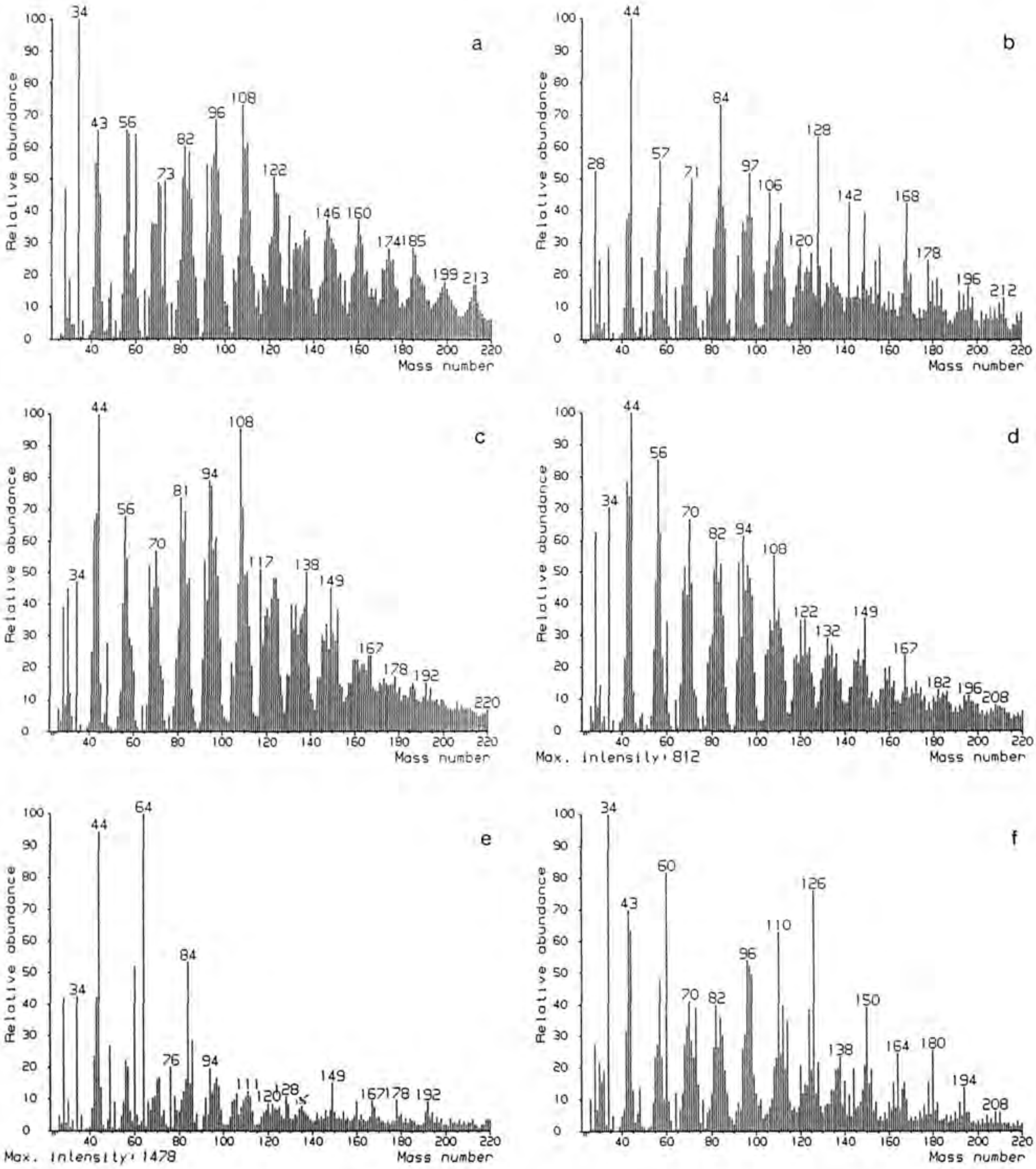

Figure 2. Mass Spectra of five archaeological residues and a peat sample. The intensity of each mass is plotted relative to the most abundant mass. Letters A through E indicate clusters of chemically similar residues (see Results and Discussion). A: sample 12 (18-70), a typical dark brown char from vessel type II; B: sample 11 (18-3-2.b), a black soot from the exterior of a vessel of type I; C: sample 31 (35-7-28), a cream coloured residue; D: sample 18 (31-4.a), a typical char from vessel type I; E: sample 28 (34-7-95.b), a black soot contaminated with Elementary Sulphur; and F: sample 34 (P_1), a peat sample from pit 16.

(Oudemans/ Boon 1991). Although polysaccharides have probably been an important component of prehistoric foods, intact polysaccharides have obviously not survived the extreme conditions during cooking or burial in the ground. Lignins originate from the 'woody' parts of plants, and are not likely to be a significant constituent of foods. Fatty acids are a different matter altogether, because they are at all times an important component of human foods. The quantity of fatty acids in the peats must, however, be much larger so they appear in the DF_1^- side of the spectrum. The archaeological residues are distinctly different in chemical composition (figs 2, 3) and are primarily typified by fragments indicative of proteins, charred polysaccharides and elementary sulphur (see also tab. 2).

Exchange of any significant quantity of compounds between archaeological residues and organic soils, such as P_1 and P_2, has obviously not taken place, which is in agreement with a study on the exchange of soil lipids by Heron *et al.* (1991). It is therefore not likely that remains of soil, stuck to the surface of ceramics, will ever be mistaken for residues of the original vessel contents. In addition, no correlation could be found between the chemical composition of residues and the type of sediment in which they were preserved. In Figure 3 samples recovered from different sediment types were situated in various quadrants of the map. In conclusion, it can be stated that the chemical classification of the residues based on CuPyMS data is, therefore, a reflection of the original vessel contents and not an artefact of post-depositional changes in chemical composition of residues during burial.

3.2 Chemical composition of archaeological residues

After removal of the soil samples from the data set, a second discriminant analysis was performed to 'zoom in' on the chemical characteristics of the various residue samples (fig. 4). Although nineteen DFs were defined to explain the total variance in the data set, only the first three (explaining respectively 44.0%, 16.8% and 13.3% of the characteristic variance) were considered representative of the chemical composition of the residue material. The additional DFs represented minor variations in chemical composition due to fluctuations in analytical circumstances or presence of inorganic components. The second DF was not considered suitable for mapping, because it represents merely the presence or absence of contaminating phthalate esters (indicated by fragments *m/z* 149 and 167), that could be identified as originating from plasticisers. These contaminations probably take place in contact with plastic bags in which ceramics are often stored after excavation. The DF_2 is therefore not relevant to the chemical composition of the original residue.

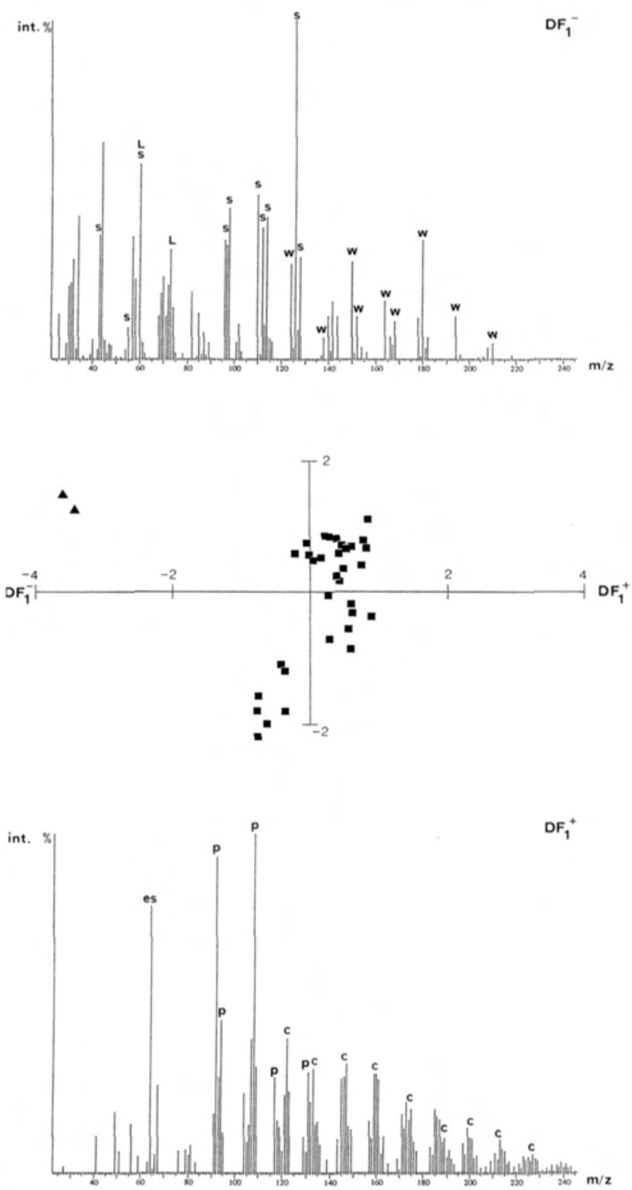

Figure 3. Discriminant map comparing Residues and Soil samples. Residues (black squares) and soil samples (black triangles) are plotted according to their similarities and dissimilarities in chemical composition. Triplicates are plotted as one average point. Markers for lignin's (W), polysaccharides (S), fatty acids (L), Proteins (P), Charred Polysaccharides (C) and Elementary Sulphur (ES) are indicated in the Spectra for the DF_1^+ and DF_1^- directions.

The weighted CLCA of the distances in the first three dimensions, indicated the existence of 5 clusters A through E (fig. 4). Clusters B and D are situated in the same direction on the map (fig. 4), and are characterised by the same masses in the given dimensions DF_1 and DF_3. The

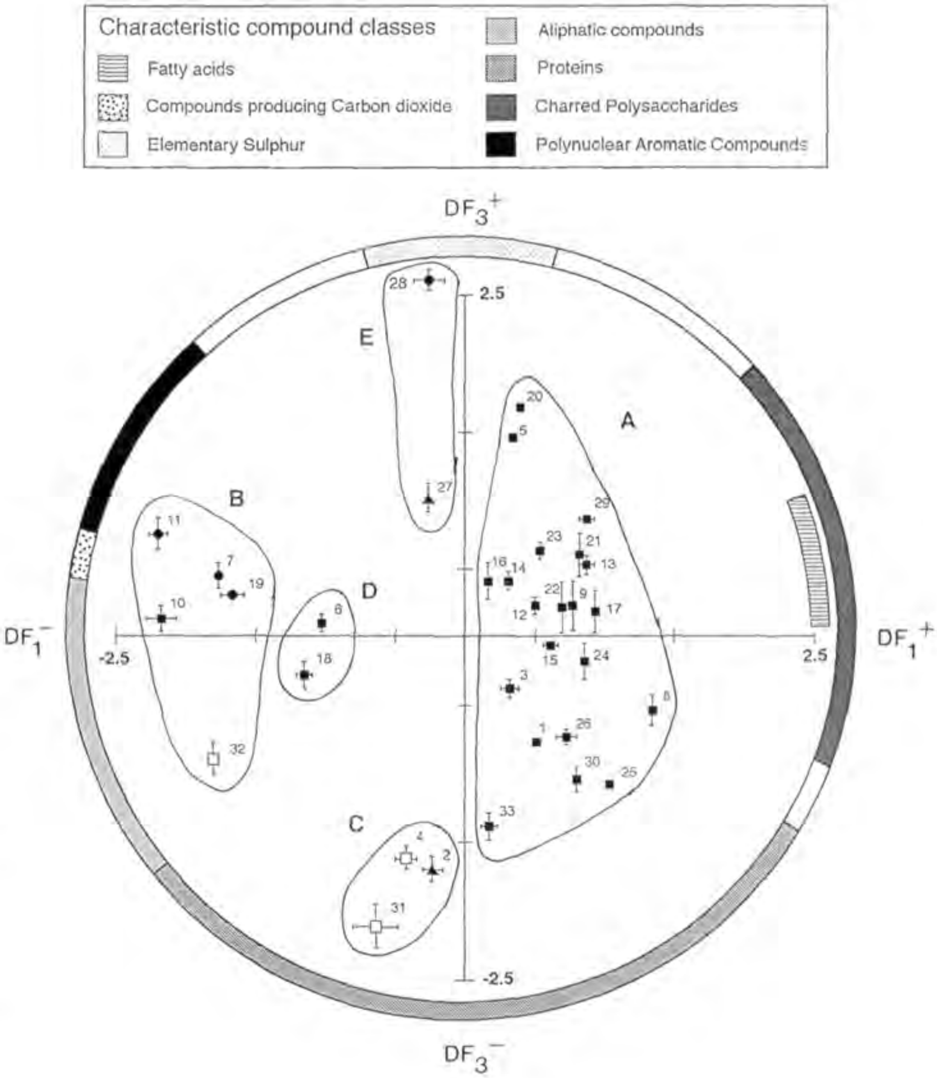

Figure 4. Discriminant map with clusters of residues (A through E) and their chemical characteristics. Triplicate measurements are indicated by standard deviation error bars. The relative difference in chemical composition is expressed by the distance between two sample points. Indicated are: brown chars (black squares); black soot residues on exterior of vessels (black dots); red brown residues (black triangles); and cream coloured residues (white squares). The shadings in the circle indicate the compound classes indicative for various directions in the discriminant map.

calculated relative similarity values give a measure for the relative chemical similarity between samples in the clusters (tab. 2). The typical chemical characteristics of the clusters can be interpreted as indicators or markers for certain compound classes (tab. 2). Features that appear in all samples will, however, not be shown as typical characteristics for either of the clusters. For the absolute chemical composition of the residues, the original mass spectra must be considered as well (fig. 2).

Cluster A consists of chars containing charred polysaccharides. The combination of markers *m/z* 110, 146, 147, 160, 161, 162, 174, 175, 188 and 189, is typical for polysaccharides heated under inert circumstances at temperatures over 250°C (Pastorova *et al.* 1993a, 1993b). The experiments described by Pastorova and co-workers were designed to resemble charring processes in ceramic vessels. During the cooking of a thick liquid, high temperatures caused by restricted circulation could cause burning and eventually charring against the heated wall and bottom of the vessel. Some of the residues in cluster A contain additional characteristics, such as a strong protein influence (*i.e.* samples 1, 3, 25, 26, 30, 33) or the presence of fatty acids in relatively large quantities (*i.e.* samples 9, 13, 17, 22).

Clusters B and D consist of residues containing aliphatic compounds and/or Polynuclear Aromatic Compounds (PACs) and their methyl and ethyl derivatives. The black samples on the exterior of vessels (samples 11, 7, 9) are characterised by the presence of PACs and compounds which release CO_2. A detailed identification of these compounds by Pyrolysis Gas Chromatography Mass Spectrometry (PyGCMS) has led to the interpretation of the

Table 2. Clusters of residues and their typical composites.
[a] cluster: the cluster A through E. Soil samples are also indicated as a separate unit.
[b] Sample numbers: number as indicated in Table 1.
[c] Markers: typical pyrolysis markers for certain compound classes expressed in m/z.
[d] Relative Similarity Values: similarity in chemical compositions of the samples within a cluster relative to the maximal variation between the two most different samples (see formula 2).
[e] Compound Classes: chemical compound classes represented by the typical markers. References: 1: Pastorova *et al.* (1993 a); 2: Waller (1972); 3: Meuzelaar *et al.* (1982), 109; Munson/Fetterolf (1987); 4: Medalia et al. (1983); 5: Meuzelaar *et al.* (1982), 6-18, 115-149; 6: Boon *et al.* (1986); Van der Heiden *et al.* (1990).

C[a]	Sample[b]	Markers[c]	S[d]	Compound classes[e]
A	1, 3, 5, 8, 9, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 26, 29, 30, 33	146, 147, 160, 161, 174, 175, 188, 189.	0.62	charred polysaccharides (1)
		60, 73, 101, 115, 129.		fatty acids (2)
		92, 94, 117, 131, 154.		proteins (3)
		32, 34, 60, 64, 96, 128, 160, 192, 224, 226, 256, 258		elementary sulphur
B/D	6, 7, 10, 11, 18, 19, 32	78, 91, 92, 105.	0.78	phenols
		128, 142, 156, 170, 178, 192	0.93	PAC's (4)
		44		CO_2
		55, 56, 57, 69, 70, 83, 84, 85, 97, 98, 99		aliphatic compounds
C	2, 4, 31	92, 94, 117, 131, 154	0.81	proteins
E	27, 28	32, 34, 60, 64, 96, 128, 160, 192, 224, 226, 256, 258	0.76	elementary sulphur
Soil	P_1, P_2	43, 55, 60, 72, 96, 98, 110, 112 114, 126, 128		polysaccharides (5)
		124, 138, 150, 152, 164, 168, 210, 180, 184, 194		lignin's (6)
		60, 73, 101, 115, 129		fatty acids

residues as smoke condensates or 'soot' from cooking over wood fires (Oudemans/Boon 1991). In addition, we find several chars and a white residue in the clusters B and D. These residues belong to this cluster due to the presence of markers for aliphatic compounds (not due to the presence of any PACs). The aliphatic compounds are most likely pyrolysis products of some kind of aliphatic polymeric structure formed from lipids under high temperatures. This is shown to be possible by the presence of similar aliphatic markers in pyrolysates of experimentally obtained chars of recent food stuffs (Oudemans/Boon 1991). This aliphatic product may be formed by heating of oils in the vessel in order to make it more water proof. However, the obvious absence of any intact fatty acids is, in this context, rather strange. One would expect to find remainders of free fatty acids in the residues as well. Sample 32 is different in appearance as well as in chemical composition: it contains some protein markers in addition to the aliphatic compounds mentioned earlier. The origin of this residue may be found in a combination of water proofing and the use of the vessel for storage or processing of proteinaceous materials.

Cluster C contains protein rich residues of different appearance. Although these different samples seem difficult to compare, their clustering indicates similarity in chemical composition. The mass spectra (fig. 2) show a clear pattern of protein fragments and even include some markers for intact dipeptides such as *m/z* 154 (Munson/Fetterolf 1987). It is not clear, whether these three residues are of a similar origin. The absence of fatty acids and charred polysaccharides from the mass spectra, does however suggest a vessel contents of primarily proteinaceous material. These residues show a relatively well preserved protein pattern, which suggests a lack of heating. The cream coloured residues 4 and 31 are situated on the interior of vessels may have been formed during storage or processing of protein-rich materials. Dairy products seem to be excluded because no significant quantities of fatty acids are present. The red

Table 3. Summary of possible origins of residues per type vessel.
[a] Vessel Type as indicated in figure 1.
[b] Residue appearance: as indicated in table 1.
[c] Number: indicates the number of samples.
[d] Clusters as indicated in table 2 and figure 4.

Vessel[a]	Residue[b]	n[c]	C[d]	Origin	Possible vessel use
Type I	Char, interior	3	B/D	heated lipids	water proofing?
	Black, exterior	3	B/D	soot	cooking on wood fires
	Black, exterior	1	E	contamination	cooking on wood fires
	Cream coloured, interior	1	C	protein	proteinaceous material?
Type II	Char, interior	10	A	starch	starch-rich food
	Red brown, interior	1	E	contamination	proteinaceous material?
Type III	Red brown, exterior	1	C	protein	proteinaceous material?
Type IV	Cream coloured, interior	1	D	protein	proteinaceous material?

brown sample 2 is situated on the exterior of a vessel and may be a protein mixed with an inorganic pigment used for decorative purposes. The presence of a similar redbrown residue (though contaminated with elementary sulphur) sample 27 on the inside of a vessel, suggests that this material may be prepared in a ceramic vessel, causing a smooth residue all over the interior of the vessel.

Cluster E is a cluster with sulphur containing residues. The markers m/z 32, 34, 64, 128, 160, 192 and 256 indicate the presence of elementary sulphur (S_8). Elementary sulphur is quite rare in nature and the origin of the material is not clear. It is possible that the clay used for the production of these specific vessels contained S_8. Since the two samples (27 and 28) involved were both very thin, clay particles could have been scraped from the surface of the vessel and mixed with the sample. Elementary sulphur may also be produced by bacteria during degradation of biological compounds.

Additional results concerning the exact nature of these solid residues and their possible origin will be published in a Temperature resolved Pyrolysis Mass Spectrometric study of these materials (Oudemans/ Boon in prep).

3.3 Correlation with Pot Type

When the morphological pot types are plotted in this map (fig. 5), it becomes obvious that there is a correlation between the chemical composition of the residue and the original size and form of the vessel on which the residue was found (tab. 3). Vessels of different size and form were therefore obviously used for different daily uses.

Although there is no complete overlap between vessel type and chemical properties of the residues, careful interpretations can be made about possible vessel usage of different vessel types.

Vessel Type II:

The majority of the residues on these vessels are found in cluster A. The origin of these residues can probably be found in the preparation of grains or porridge or other starch-rich stews. In some cases protein-rich material such as meat, fish or pulses may have been added, while in other instances fats may have enriched the mixture. Samples 27 belongs to cluster E because it contains markers for elementary sulphur. This sample is of quite a different nature and may be the result of the preparation or storage of a protein rich material (see for explanation above).

Vessel Type I:

The origin of the charred residues in this type of vessels is not completely clear. The CuPyMS data indicate that they are evidently quite different in composition from those in vessels of type II. The absence of charred polysaccharides, protein markers or fatty acids as typical features, is significant. These residues may have been formed during activities other than food preparation. A possible origin may be found in a post-firing water proofing of the vessels by heating of oil in the vessels. The high temperatures may cause cross linking of the lipids. Interesting in this case is also the frequent presence of soot on the outside of these vessels. One residue (sample 4) is clearly different and belongs to cluster C, which suggests occasional variation in use.

Vessel Type III and IV:

Due to the absence of multiple samples of these vessel types, no conclusions can be drawn on the usage of these vessel types as a whole. The MS data of the two samples that were analyzed did, however, present interesting evidence explained earlier.

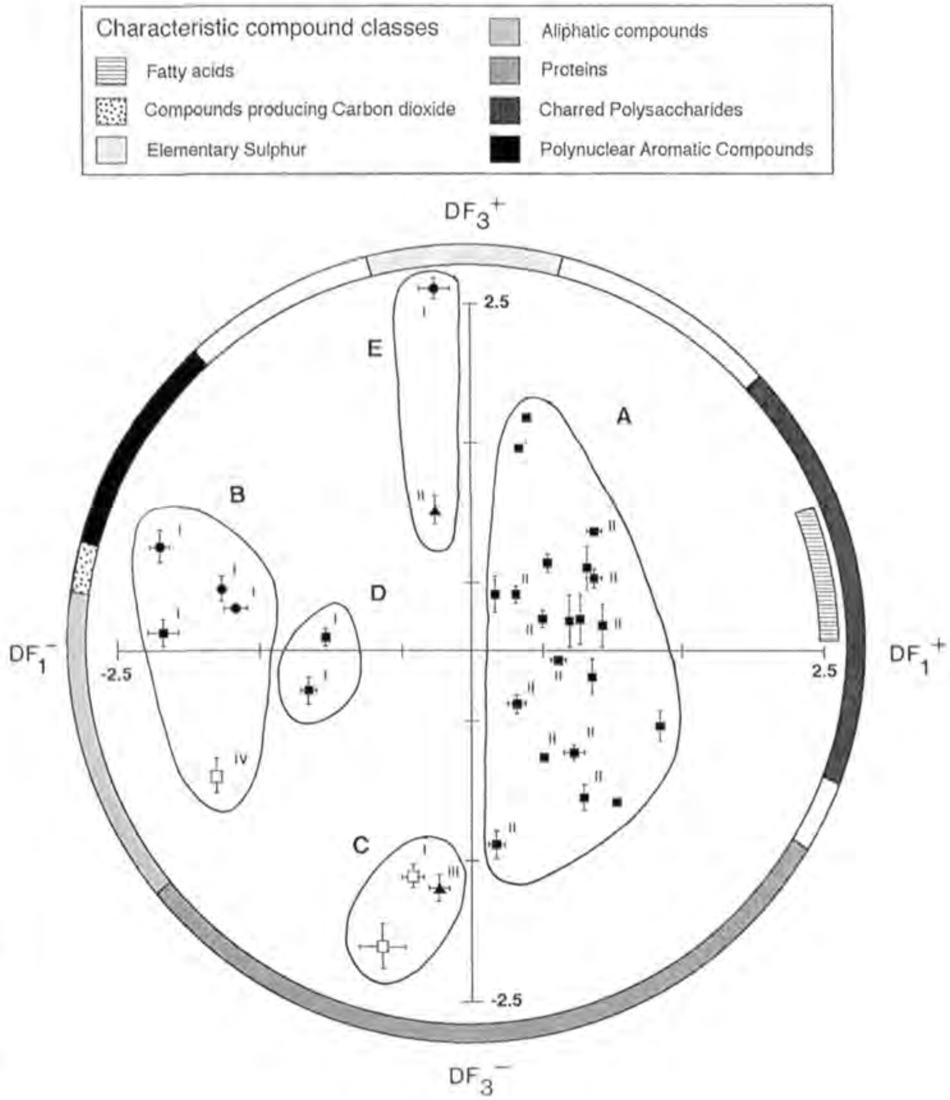

Figure 5. Correlation between vessel types and chemical composition of the residues. The vessel types are indicated I through IV. Sherds of which the vessel type could not be identified are indicated without type number. Clusters of residues (A through E) were derived from the chemical characteristics as expressed in the CuPyMS spectra (see fig. 4).

More work should be done on larger numbers of complete vessels, in order to confirm the vessel uses here suggested and check their statistical significance. However, even when the origin of samples cannot be understood completely, it can still be concluded that vessels from type I and II were used in a different way. This supports the original hypothesis that the variation in pot morphology had an utilitarian meaning in the indigenous settlement in Uitgeest-Groot Dorregeest.

4. Conclusions

This paper presents the first systematic study to correlate the chemical composition of solid organic surface residues to the form and size of vessels in which they were preserved. It has been shown that CuPyMS, in combination with multivariate analytical techniques, is a useful method to systematically and rapidly analyze and categorise solid organic residues found on ancient vessels. The chosen analytical strategy presents not only a measure for similarity or dissimilarity in chemical composition of the samples, facilitating as such an objective classification of the residues, but also highlights the chemical components typical for the various clusters. The chemical classification was shown to be a reflection of the original vessel use, and not an artefact of post-depositional changes in chemical composition of the residues.

Results form the CuPyMS studies give clear evidence to conclude that a correlation does indeed exist between the chemical composition of the surface residues studied and the morphological vessel type of the vessel in which they were found. Vessels of different sizes and forms were, therefore, used for a different daily use within the indigenous settlement from the Roman period at Uitgeest-Groot Dorregeest. These results support the usefulness of a morphological vessel classification as a basis for functional studies within this ceramic complex.

The significance of organic residue analysis within archaeological ceramic studies is, however, not limited to testing existing theories concerning the relation between form and function of pottery, but also lies in the detailed information about daily use of vessels that cannot be obtained by any other method.

Acknowledgements

This work is part of the research program of the Institute of Prehistory Leiden (IPL) and the Foundation for Fundamental Research on Matter (FOM) and was made possible by financial support from the Netherlands Organization for Scientific Research (NWO). We gratefully acknowledge both IPL and FOM for the financial support of one of the authors (T.F.M. Oudemans). In addition, we would like to thank B. Brandt-de Boer, G.B. Eykel and A.S. Noguerola for their assistance with sample analysis and statistical data handling and C.C. Bakels and A.A. Abbink for critical reading of the manuscripts and supplying the samples and all additional information on the ceramics studied.

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Artificially intelligent archaeologists: fundamentals, facts and fictions

Artificial computing techniques can be very useful tools for archaeological research and education, but they are not much being applied yet. In this paper the abilities of two of these techniques, i.e. expert systems and neural networks, are described and compared. With both techniques an application has been built for the analysis of use-wear traces on flint implements.

1. Introduction

Computers started to be used by archaeologists in the early 1960s. At first they were only used as facilities for the storage and statistical analysis of large data sets (*e.g.* Kendall 1963). In the 1970s the 'New Archaeology' clearly affected the way in which mathematics and computers were used. Gradually their use became more differentiated. They evolved from data-describing aids to process-modelling, hypothesis-generation and data-explaining aids (Doran/ Hodson 1975). With this shift of attention came a need for more advanced problem-solving techniques that could utilize specialist knowledge, *i.e.* artificial intelligence techniques. Doran even expected knowledge utilization to become fundamental in archaeological data analysis (Doran 1974, 70). However, it was not until the 1980s that artificial intelligence technology reached a sufficiently high level to enable the first archaeologists to build their own expert system applications. This development was part of a process in which computing techniques were integrated in all kinds of archaeological research — a process which was made possible by the introduction of the personal computer and the subsequent explosive growth of the amount of software available. The archaeological world swiftly adopted many of the new computing techniques, for instance geographical information systems, but the same does not hold for artificial intelligence techniques. Despite the facts that several successful expert systems have been developed (*cf.* Bishop/Thomas 1984; Brough/Parfitt 1984; Francfort 1991; Grace 1989; Lagrange/Vitali 1992; Patel/Stutt 1989) and that several researchers have pointed out their potential value for archaeological research (*cf.* Baker 1987; Doran 1987, 1988, 1990; Voorrips 1990; Wilcock 1986), they have been neither readily accepted nor developed and applied on a large scale. Their usefulness is still being discussed.

This lack of popularity of expert systems in archaeology is a rather strange phenomenon. Expert systems offer means for modelling and formalising subjective and heuristic expert knowledge and for making that knowledge accessible to and usable for non-experts. As most of our knowledge is subjective, there are certainly abundant potential applications in archaeology. The lack of popularity in archaeology is also strange in view of the great amount of attention that is being paid to this technology in many other scientific research disciplines, and also commercially; numerous applications are operational in all kinds of fields.

According to Gibson this lack of popularity is 'due perhaps to the limited potential of expert systems in host disciplines' (1992, 263). But, in my opinion, their lack of popularity is due mainly to their supposed limited potential rather than to their actual limited potential. When archaeologists are asked about their opinion on these techniques, they are very interested. Ignorance and threshold fear, however, keep them from exploring their abilities. They either do not think of these techniques as potential aids for their research because they simply don't know the abilities of these techniques, or they hesitate to use them because of some fictions they have heard or because of prejudice. In other words, as long as they are not repeatedly confronted with useful applications and good results they will not start using or developing them.

The aim of this paper therefore is to show how these techniques can be useful for, for instance, educational and research purposes. Only expert systems and neural networks will be discussed below, because they are the two artificial intelligence techniques that simulate human reasoning for the purpose of problem solving. First, some fundamentals of both techniques will be given to demonstrate their specific abilities. Secondly, the functionalities of these techniques will be compared by means of two applications that have been developed for the analysis of use-wear traces on flint artefacts. The results of a test-case in which both applications were involved will be presented. Finally, an attempt will be made to separate some facts from fictions regarding these techniques and artificial intelligence in general.

2. Artificial intelligence applications

Expert systems and neural networks were developed by the research discipline called Artificial Intelligence. This discipline is concerned with the development of computer techniques that enable the simulation of human intelligence. The artificial intelligence research has yielded several techniques, each specialised in imitating aspects of human behaviour, speech or reasoning. Examples of these are robotics, (visual) pattern recognition, natural language processing, speech recognition, expert systems and neural networks.

Both expert systems and neural networks are computer programs that simulate human reasoning processes. If they are provided with human knowledge and problem-solving methods, they can solve highly specialised problems or execute complex reasoning tasks.[1] The aim of these techniques is to offer an opportunity to organise human expert knowledge into a form in which it can be used by non-experts.

Apart from their background and aim, expert systems and neural networks have nothing in common. They have different architectures and use specific knowledge storing and processing methods. Furthermore, they work with different data formats. Expert systems can process non-numerical (symbolic) knowledge, whereas neural networks are based on numerical data. The most important difference, however, concerns the type of knowledge they can handle. Whereas expert systems require explicit knowledge (*e.g.* decision rules), neural networks can work with examples which contain knowledge implicitly. Those differences imply that the two techniques should be used for different purposes. Expert systems are successful in simulating heuristic methods and techniques. Neural networks, on the other hand, are capable of detecting (hidden) relationships between the properties that describe patterns within large and complex data sets. They can therefore be employed in analyzing problems of which the relations between the variables are unknown.

2.1 Expert system fundamentals

An expert system consists of three components, *i.e.* a knowledge base, an inference mechanism and a user interface (fig. 1). In a way, a knowledge base can be compared with a data base in that both are storage facilities. A knowledge base, however, consists of knowledge instead of raw data. The inference mechanism can be seen as the central nervous system. It applies the knowledge and controls the reasoning process. The latter means that it makes sure that the appropriate knowledge is applied at the appropriate moment. The communication between the system and its users is handled by the user interface. It serves as an intermediate between the two sides by receiving and translating their respective messages.

For an expert system to be able to simulate expert reasoning it must be provided with specific expert knowledge. Usually, this is heuristic knowledge, which has been extracted from the expert himself. Such knowledge is based on formal facts and theories (gained through education) and on subjective rules-of-thumb and intuition (gained through experience). Before the extracted knowledge can be stored in a computer, it must be modelled, formalised and translated. The extraction, formalising and modelling of knowledge is called the acquisition phase. It is the most delicate phase of the expert system development process. Due to the subjective nature of the knowledge involved, it is for instance difficult to retrieve the expert's underlying reasoning processes. Moreover, it may be hard to have this kind of knowledge represented by means of explicit representation methods such as (IF-THEN) decision rules.[2] Eventually, the acquisition yields a formal knowledge model that consists of all the knowledge and procedures necessary for solving a specific problem. The knowledge model can be translated by means of a computer language and subsequently implemented into a computer. Nowadays, the actual development of the expert system can be facilitated by using an expert system shell. A shell is a program which provides all the facilities of an operational expert system but leaves the knowledge base empty.

An expert system uses its knowledge either to interpret information or to validate hypotheses. Such systems are called data-oriented (forward-reasoning) and goal-oriented (backward-reasoning), respectively. A data-oriented system 'reasons' in a forward direction, which means that it has no predefined goal. Instead, the reasoning process reacts to information that the system receives from the external world.[3] The system will try to interpret this information by searching in its knowledge base for conclusions that can be drawn from it. For instance, if a user indicates that his data are 'red, round, and small', and the system has a rule saying 'IF red and round and small THEN it is a cherry', the system will conclude that the data represent 'a cherry'.

A goal-oriented system does the opposite, it 'reasons' in a backward direction in order to confirm a predefined goal. This means that such a system tries to retrieve the information that is required to confirm that goal. For instance, if a user indicates that his hypothesis is that 'it is a cherry', and the system has a rule saying 'IF it is a cherry THEN (it must be) red and round and small', the system will ask whether the characteristics 'red and round and small' are indeed present. Such a goal-oriented system cannot only retrieve the required information by questioning its user but also by consulting its knowledge base or another external data source, such as a data base.

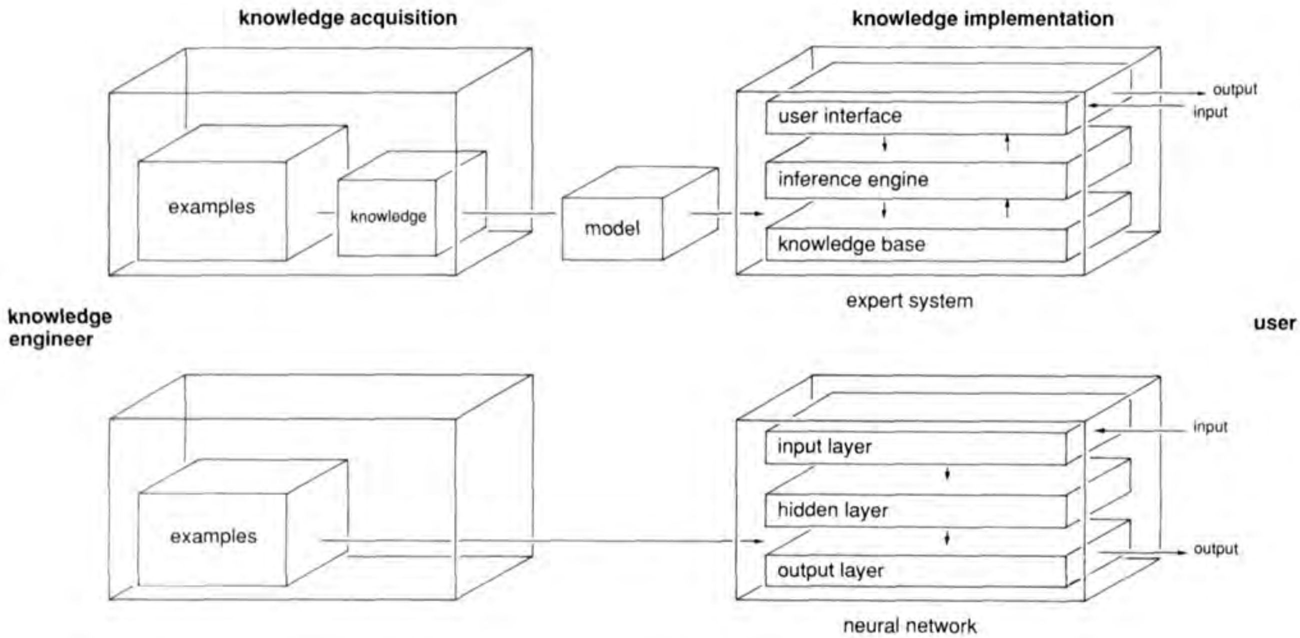

Figure 1. An expert system versus a neural network regarding their architecture and the composition of their knowledge.

As data-oriented systems can be used to interpret data or to react to (changes in) incoming information, they are most suitable for applications with analytical and educational purposes, especially for those that require an immediate reaction of a 'master'. A goal-oriented system can be applied to situations in which a user wants his hypothesis verified or wants to obtain a second opinion due to uncertainties.

Used in either of these two ways, an expert system can only be applied to tasks that can be clearly defined and that are of a restricted extent and complexity. As far as the complexity is concerned, a directive may be that a human expert must be able to solve a particular task or problem within a couple of hours. Of even greater importance is that the required knowledge can be represented by means of explicit methods. However, some expert knowledge can hardly be formalised because of its subjective character; experts may have difficulties in describing their knowledge explicitly and in explaining the underlying reasoning processes which they apply (Kidd 1987, 3). Moreover, some problems are so complex that it is not possible to determine the relations between their variables. This means that such tasks cannot be simulated by means of the expert system technique. For those cases a neural network application may be a suitable alternative approach.

2.2 Neural network fundamentals

The architecture of a neural network is deduced from the biological structure of the human brain. The brain is a very complex organ that is made up of ten to one-hundred billion cells, called neurons. Neurons are special cells that are capable of receiving, storing and sending information. Each neuron is connected to approximately ten thousand other neurons and together they form a complex network.

Via the connections (dendrites) they send electrical and chemical signals through which they communicate with each other. Since these signals can be transferred simultaneously, thousands of impulses can pass the neurons per second (Carling 1992). That way the network structure enables a massive neuron activity. This implies that the brain can process enormous amounts of information and, thus, adequately respond to the situations it is confronted with.

An artificial neural network is a computer program that tries to simulate the principle of a biological neural network by means of a mathematical model. Like the human brain, an artificial network consists of neurons, *i.e.* small processing elements that can receive, process and send signals. These neurons are arranged in at least three layers: an input layer, one (or several) hidden layer(s), and an output layer. The neurons of the input layer represent the variables describing a problem. The output neurons represent the solution that is associated with it. The neurons of the hidden layer act as an intermediate between the input neurons and the output neurons. They are invisible to both the application developer and the user for they have no direct connection to the outside world.

As with the human brain, the neurons of a neural network are connected to one another, although not physically. They can pass information to one another through programmed instructions. Each neuron in one layer is connected to those of another layer (fig. 2). A network's knowledge is distributed among these connections. It is not stored within the neurons.

The principle of a neural network is that it can be instructed with examples of a problem to enable it to solve similar problems. It searches for relationships between the variables of a reference data set in order to apply these to similar data. The network translates these relationships as connections between the neurons. Each connection has a specific weight, a numeric value. The collection of weights is stored as a data matrix.

The configuration of the connections is based on the results of calculations and has been established through a process of repetition of examples. Creating the right weights is a complex and time-consuming process, which can take a long period of training. Training means that a network is provided with a large set of examples which consist of input and output patterns, which the network tries to simulate in order to construct the connections and their weights between the various input and output neurons. For instance, the input for a network that has to recognise fruit would be 'red, round, small' and the output 'cherry' or 'yellow, round, large' and 'melon'. Both the connections between the input and output and the weights are entirely programmed by the network software. They are constructed by means of predefined mathematical functions and the network developer has hardly any influence on this process. The network starts its training by giving an arbitrary output to a specific input of an example. It compares this output with the expected output of the example. The arbitrary outputs are of course predominantly wrong. However, the network evaluates these mistakes and subsequently adjusts the connections or the weights of the connections until the network is able to generate all the outputs correctly. In other words, it 'learns' by experience.

Once this training is finished, the application building is finished. The network can then be employed for the interpretation of 'new' situations or problems that resemble those it has learned. With a neural network this means that a user only has to select the input variables that represent the properties of the problem. With reference to the prior example, the neurons 'yellow', 'round', and 'small' could for instance be selected. These activated neurons subsequently send a signal to the hidden layer. As each hidden neuron is connected to each input neuron, it will always receive several signals. These incoming signals are of various weights, because they come from various connections. The hidden neuron calculates its activation strength by summing up the incoming signals. Only if a certain activation level is reached, does a hidden neuron pass a signal on to the neurons of the output layer. Again, the strength of these signals and the weight of the connections are responsible for the degree in which the neurons of the output layer are activated. Finally, the combination of the activated output neurons represents the network's interpretation of the information that was presented by the user (Lawrence 1991).

From a developer's point of view, the development of a neural network is far less time-consuming than that of an expert system. Although it probably seems quite complicated, building a neural network is fairly simple. The connections and the weights matrix are programmed by the network software on the basis of predefined mathematical functions.[4] The knowledge acquisition phase consists only of selecting the input and output variables and collecting sufficient examples (fig. 1). As for the implementation, the developer's task is twofold. First, he makes the network structure, *i.e.* he defines the input and output neurons and the number of hidden layers. Then he provides this network with a large set of examples. So, unlike with an expert system, the knowledge does not have to be made explicit before it can be implemented into a network. The developer has to build decision rules (IF-THEN) for an expert system, whereas the neural network deduces the relations from the examples and builds the decision 'rules' itself. The only requirement is that the examples must be representative descriptions of the various situations (and the associated solutions) that have been experienced within the problem domain; they must cover the range of variability exhibited by the real world.

3. Two applications[5]

In 1990, a project was launched at the Institute for Prehistory of Leiden University to develop an expert system application for the analysis of use-wear traces on flint artefacts. This application was intended to support both students and experienced use-wear analysts in the analysis of use-wear traces and in the evaluation of interpretations, respectively.

The reason for launching this project was the desire to study the possibility of formalising use-wear analysis for the purpose of computer-assisted instruction. Since the use-wear expert at Leiden University[6] spends much time on the training of students, it was decided to develop an expert system that would be able to provide support in this task;

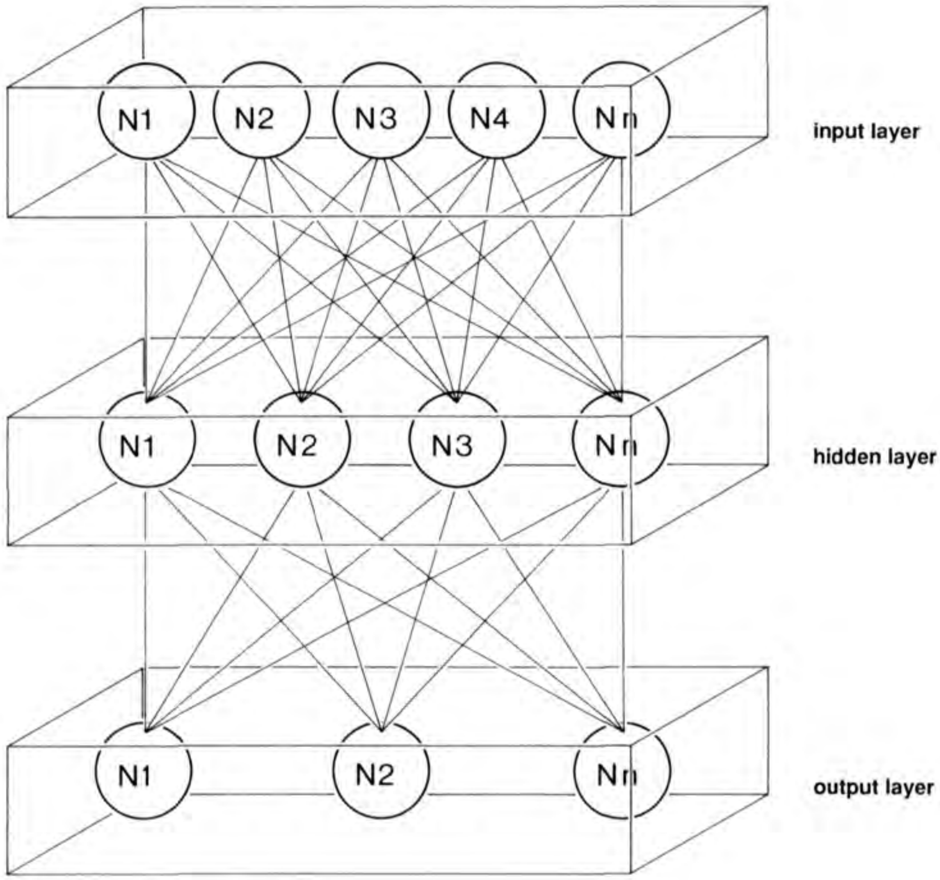

Figure 2. Neuron and layer structure of a neural network. Each neuron (N) in one layer is connected to each neuron of another layer.

if parts of the expert's task were to be taken over by an educational system, the expert would be able to spend more time on research. Moreover, unlike a human expert such an artificial expert is available at any moment and is easily duplicated. That means that both the research and the educational capacity of the human expert can be increased. Using an expert system can be advantageous for students as well. They can control the pace and the direction of their learning and they have the opportunity to work with advanced computing technology.

Another advantage of developing an expert system was that it would offer an opportunity to formalise and standardise the method of analysis. Formalising a method improves its scientific acceptance while standardised procedures yield less subjective results. Moreover, once the knowledge is in a formalised format, it can be evaluated in order to trace deficiencies.

The project has resulted in a system called WAVES.[7] At present this system is partly operational. The working parts have been tested and one of these tests will be discussed in the next section. While this application was being developed, the neural network technology was introduced into the archaeological world. Neural networks were launched as 'a superior alternative' (Gibson 1992, 263) to expert systems, whose major functional disabilities they overcame. In order to verify these statements and to make a comparison with the achievements of the expert system, it was decided to develop such a system for use-wear analysis as well. A neural network application[8] could be realized with relatively little effort by using the knowledge source used for the expert system. Moreover, if both systems were to be based on the same knowledge source, it would be possible to compare their analyzing qualities.

3.1 THE EXPERT SYSTEM APPLICATION

As WAVES is meant to be used by two different groups of users, it consists of two independent parts. One part executes the analysis method as a step-by-step process. In this way students can be trained to execute the required procedures. While supervising the process of analysis, the program also tries to arrive at an interpretation. This means that it reacts to the information given by the user. It is data-oriented.

The other part evaluates interpretations in order to support the experienced analyst who is already familiar with the procedures but not very confident of his or her interpretations. This part is goal-oriented; it tries to confirm the interpretation by questioning the user. The following description and test-case refer to the analyzing part only.

As the analyzing part of the WAVES application not only steers the direction of the process of analysis, but also interprets the observed wear traces, it needs detailed information on the characteristics of the wear. This is obtained via a question-and-answer game. It means that the system will ask the user for a description of the analyzed implement and of the observed wear traces. In order to make sure that the system receives the appropriate information, the answers to the questions are of multiple-choice format. This means that for each answer (variable) a lists of possible answers (values) is given (fig. 3). The user chooses a value that corresponds best to the traces observed. Whenever the user is uncertain about his answer, he can ask for background information on the meaning of certain questions or of variables and values. This information consists of descriptions, photos or schematic drawings that explain the differences between the values.

The system's method of analysis resembles that of the expert. It starts by verifying whether an implement is analyzable and whether the observed wear traces can be ascribed to use.[9] This is followed by the actual analysis of the use-wear traces. The analysis is divided into two parts: one for the interpretation of use retouch and the other for polish, edge rounding and striations. These parts work independently of one another and can be employed separately. The reason for this division is that the various wear categories are either not always simultaneously present or not equally diagnostic. In such cases it should be possible to arrive at an interpretation that is based on either one of the categories. An advantageous side-effect of the division is that two independent interpretations can be obtained if all wear categories are present. The system's final questions relate to the morphological aspects of the implement. This information can be used to verify whether the result of the analysis is in accordance with the implement's morphology.

On the basis of the received information, the system subsequently attempts to identify the nature of the materials and the motions that may have caused the observed traces. As different contact materials may sometimes have caused similar wear attributes and as similar materials may have resulted in different wear patterns (*e.g.* Unrath *et al.* 1986), it is often difficult to identify the exact contact material and motion. Moreover, a tool may have been used on several materials. Hence, it would be wrong to focus on the identification of one contact material only. Therefore, the result of the system's interpretation consists of a list of all the materials and motions that may have caused the wear and the probabilities of those materials and motions actually being responsible for the observed traces (fig. 4). These probabilities are expressed by means of scores, which are the results of the calculation of the indications suggesting a specific contact material.[10] They also give an indication of the value of the interpretation; traces that are not diagnostic, such as a generic weak polish, will not yield interpretations with high scores. If, on the other hand, the wear characteristics are indicative of only one contact material then this material will have a higher score than the others. Furthermore, the system's interpretation is accompanied by pictures showing the wear traces that the system associates with the result of the analysis. With the aid of these pictures, the user can verify whether the system's interpretation corresponds to his observations.

The knowledge on which WAVES is based was derived from the results of an experimental programme consisting of 301 experiments with replicated flint artefacts (Van Gijn 1989, 168-174). It was believed that these results could serve as a reference collection from which knowledge rules could be deduced. A detailed analysis of these data revealed what combinations of the wear attributes are diagnostic of specific contact materials and motions (Van den Dries/Van Gijn in press).

The main reason for using a reference collection as the basic knowledge source was that it is very difficult to build a knowledge model with knowledge extracted from human experts directly and from research reports (Van den Dries 1994). Such expert knowledge often covers predominantly the category of the diagnostic wear traces, whereas the category of the exceptions and uncertainties is underrepresented. A knowledge model used for educational purposes should cover this variability. It was therefore believed that a reference collection would include parts of both categories and that expert knowledge could be used to supplement the knowledge derived from such a collection.

3.2 THE NEURAL NETWORK APPLICATION

The reference collection that formed the basis for the knowledge of the expert system was also used to train a neural network application. The difference between WAVES and the network is that the knowledge was translated into a different format: into decision rules for the expert system and into presence/absence scores for the network. Furthermore, the decision rules were deduced from the raw data, whereas the network was trained with the aid of unaltered data.

Up till now, this application has only been trained to interpret polish. As only 161 examples of the reference collection showed traces of polish, this was a relatively

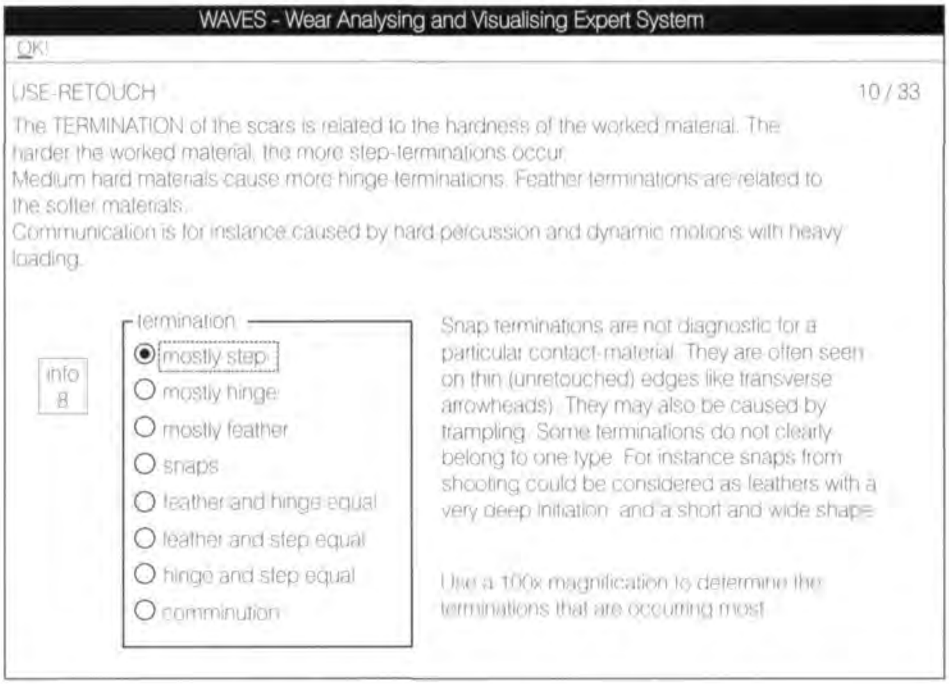

Figure 3. Example of a screen of the expert system application. It enables the user to choose the wear-attribute that corresponds best with the observed traces.

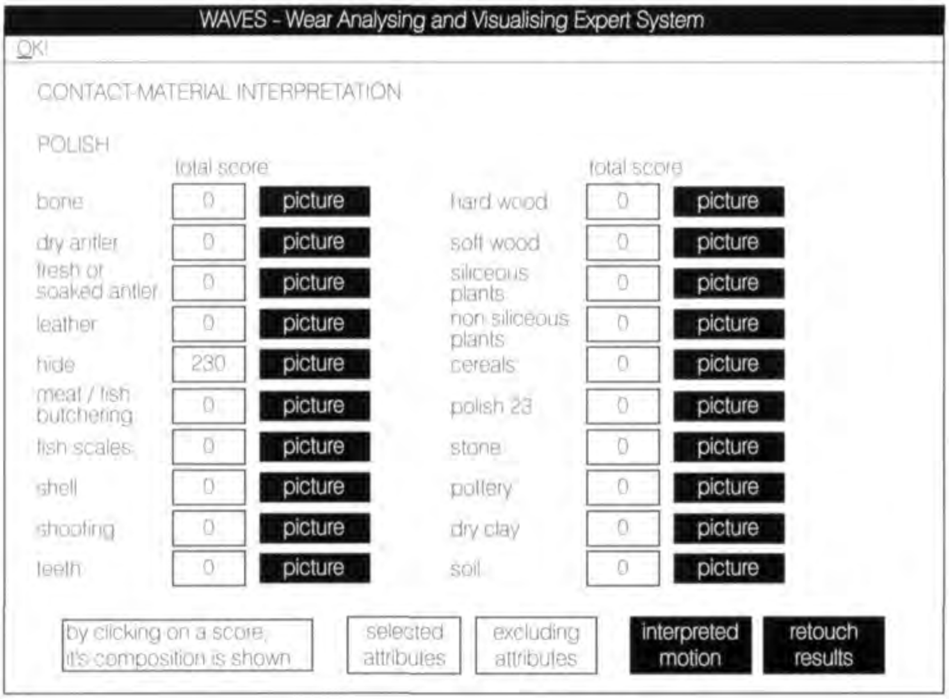

Figure 4. Screen of the expert system application showing the results of the polish analysis. By clicking on a "picture"-button photographs of the associated use-wear are being displayed. The other buttons give access to the results of the retouch analysis and of the motion analysis.

small training set. It took the network approximately one hour (650 runs through all examples) to 'learn' the input and output patterns of the examples.

The network's input layer consists of 31 neurons and the output layer of 15 neurons (fig. 5). The input neurons represent the attributes of the five variables that describe the characteristics of the polish. The neurons of the output layer represent the contact materials that may have caused the polish. As with the output of the expert system, several of the output neurons may be active at the same time if the traces analyzed indicate several contact materials. However, the degree of activity of these neurons may differ. This

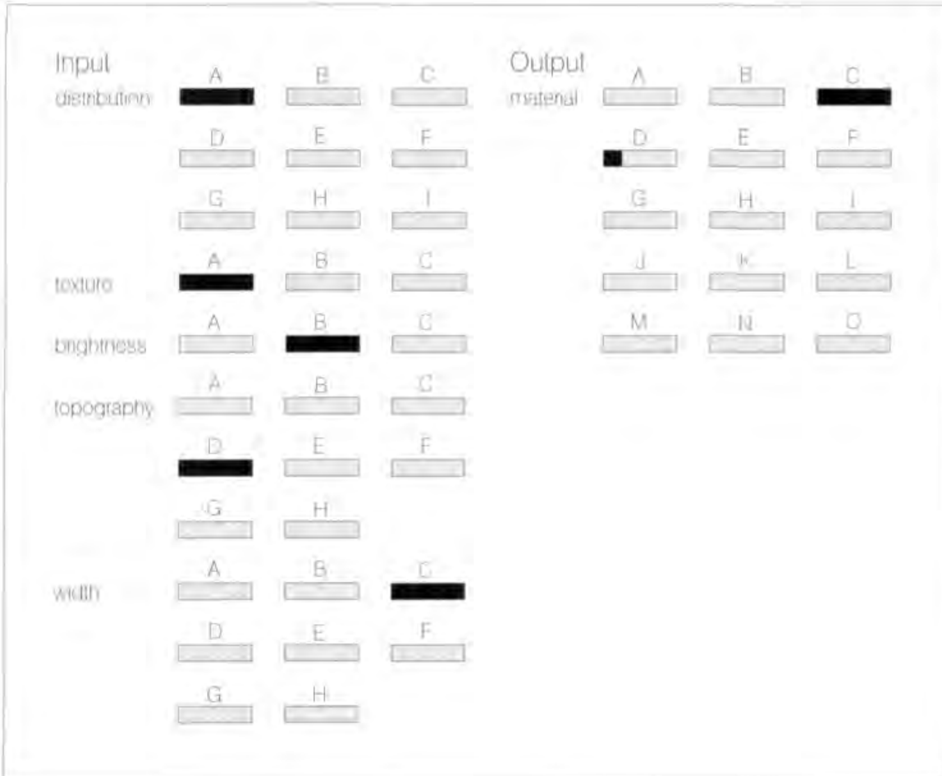

Figure 5. The only screen of the neural network application. The left hand side shows the input neurons (the polish distribution, texture, brightness, topography, and width), the other side the output neurons (the associated contact-material). The user chooses the five input neurons that correspond to the observed wear-traces and the system shows the contact-materials that may have caused that specific wear pattern.

degree of activity is an indication of the certainty of the interpretation.

Whenever a user consults the network, he only has to select five of the input neurons which correspond to the characteristics of the use wear traces observed. The network compares this information with its reference matrix and calculates the degree of activity of the output neurons. Because a network consists of compiled data matrices only, a processing session takes less than a second.

Since the application was intended for studying the potentials of a neural network, it was not provided with a user-friendly interface; it is not suitable for computer-assisted instruction. However, it can certainly be used for its achievements comparing to those of an expert system. It can also be a useful tool for a professional use-wear analyst who is interested in studying the diagnostic value of specific attributes. It may be interesting to observe the consequences for the output of manipulation of the input. If the preliminary results are promising, this application may be trained to interpret other use-wear categories as well.

4. A test-case

The expert system and neural network application described above have been applied to a test-case to enable comparison of their achievements. This comparison referred to the interpretation of polishes only, because the network had been trained for this purpose only.

The test-case consisted of the analysis of 16 replicated flint artefacts used for experimental purposes and of 10 archaeological artefacts from the Dutch Linearbandkeramik site of Elsloo, Limburg, the Netherlands. The traces on these implements were entirely new to both systems as none of them had been used to compose their knowledge.

For the purpose of studying the reaction of both systems, the test set was composed of implements displaying polishes that were difficult to interpret. For instance, three experimental tools (346, 378, 385) were included that had been used on materials of which it was known beforehand that neither system would be able to identify them. Many of the other experimental tools were selected because they displayed slightly different polishes although they had been in contact with similar materials and because they showed less diagnostic wear patterns.

Because the contact materials of the tools that had been used in the experiments were known, the interpretations for these tools could be evaluated as a 'blind test'. The interpretations for the prehistoric polishes were more difficult to evaluate because the worked material was, of course, unknown. Therefore, these results were compared with those given by a professional human use-wear analyst.[11] The assumption was that in the case of dissimilar interpretations the human expert would be right.

Table 1. The actually worked materials versus the interpretation of the expert system and the neural network.
* Both systems have not been provided with knowledge about these materials.

tool nr.	worked material	expert system interpretation	neural network interpretation
344	soaked antler	-	dry antler/ fresh bone
345	medium hard wood*	hard wood/ soft wood	soft wood
346	shell*	-	soft plants
350	soft wood	soft wood	soft wood
351	soaked antler	-	hard wood
352	soft wood	soft wood	dry hide
360	soft wood	-	fresh bone
363	soft wood	-	fresh bone
367	fresh hide	fresh hide	fresh hide
370	fresh hide	fresh hide	fresh hide
371	fresh hide	fresh hide	fresh hide
378	hide with ochre*	-	soft wood/ dry antler
383	soft wood	soft wood	soft wood
385	dry clay*	soaked antler	soaked antler/ soft wood
386	fresh hide	fresh hide	fresh hide
388	dry bone	butchering	fresh bone/ dry antler

The test procedure consisted of two steps. First, the characteristics of the wear traces were described by an experienced analyst. Then these descriptions were presented to the two systems. The reason for this was that the test was intended to validate the knowledge. An experienced analyst was used to exclude the possibility of a system's poor achievements being ascribed to a user's lack of experience — something which otherwise may very well have happened because with both systems the actions of the user were not yet perfectly controlled.

4.1 THE EXPERT SYSTEM'S ACHIEVEMENTS

The results obtained for the experimentally produced polishes (tab. 1)[12] show that the expert system could not identify the traces of 6 tools (344, 346, 351, 360, 363, 378). This is a rather large part of the test set. There are two possible explanations for this. First of all, the traces analyzed may have differed from the traces on which the system has knowledge. This is due to the fact that this knowledge was derived from experimentally produced traces. An experimental programme cannot cover the entire range of possible traces. Experience has shown that some traces occurring abundantly on archaeological tools cannot be replicated on experimental tools. An example of such traces is what has been termed polish '23' (Van Gijn 1989, 85). This type of polish (bright, plant-like on one side, hide-like on the other) has been observed by several analysts (Cahen *et al.* 1986; Van Gijn 1989; Juel Jensen 1989; Keeley 1977), but its origin has not yet been experimentally determined. Such problems reveal one of the limitations of expert systems. If a situation or problem differs too much from those from which the knowledge was derived, a system may be unable to deal with it. For this application it is therefore very important that the knowledge base is supplemented with expert knowledge. Only the human expert has knowledge about the variability of the traces exhibited by the archaeological record.

The second possible explanation has to do with the subjective nature of the variables used to describe the wear traces. Most of the descriptions are based on relative 'measurements'. It is, for instance, difficult to decide whether a polish looks 'bright' or 'very bright'. This implies that the descriptions of the wear characteristics given by the analyst need not necessarily match those given by the expert, on which the system is based. This may cause discrepancies between the descriptions, yielding information the system cannot interpret correctly. Presumably, this problem will be eliminated when the system will be expanded with more photographs and schematic images giving examples of the attributes. As pictures give a much better impression of what is meant, they will facilitate the selection of attributes.

In one case (tool 385) the system gave an incorrect interpretation. However, this implement had been used for an entirely new experiment (carving dried clay), of which the system had no knowledge. The fact that the system did come up with an interpretation means that, according to the system, the observed traces bore some resemblance to those produced in working soaked antler. For a use-wear analyst this may be a strange misinterpretation. It can however be explained by the fact that the observed traces were non-diagnostic and happened to look like other non-diagnostic traces (produced in cutting soaked antler) which were included in the knowledge base.

This example of a misinterpretation illustrates the problem of identifying non-diagnostic wear patterns. Even though some similar problems may be avoided by expanding the application with expert knowledge and by enlarging the experimental reference collection, it is likely that no system will ever have sufficient knowledge to exclude all such misinterpretations. Non-diagnostic wear and especially generic weak polish is very difficult to interpret, even for the best professional analysts.

In two other cases (tools 345, 388), the system's interpretation was acceptable because it approached the right answer sufficiently. In some cases this may be justified because different activities may cause similar traces.[13]

As already mentioned before, the results of the analysis of the prehistoric polishes (tab. 2) are less easy to validate. Although the expert system could not analyze all the artefacts, the results obtained for those that it could are in accordance with those given by the human analyst. This is promising and it is encouraging that the system can already do this while its knowledge is still based on the results of experiments only.

4.2 The neural network's achievements

A major difference between an expert system and a neural network is that the latter will always generate an answer, even if it is a very unsure one.[14] This explains why the network made more mistakes in interpreting the experimentally obtained polishes (tab. 1). Most of these mistakes concerned precisely those tools (344, 346, 351, 360, 363, 378) which the expert system could not identify either. The network tried anyhow and failed. It searched for the material that came closest. Unfortunately, in the case of a use-wear analysis the resultant answer is often misleading rather than helpful. But in some cases it may give a correct indication of the hardness category of the contact material. The problem, however, is that you never know when the answers are reliable; misinterpretations that are not due to a lack of knowledge cannot be explained. This is because the reasoning process of neural networks is invisible.

The network correctly interpreted the traces of six tools (350, 367, 370, 371, 383, 386). The interpretation of tool 345 was accepted as being correct, because the system has no output neuron for medium hard wood, only for hard wood and for soft wood. In two cases (tools 344, 388) the network's interpretation was almost correct. It turned out that the network had some difficulties distinguishing between materials showing comparable traces, like hard animal materials such as bone and antler. However, this is not surprising. Professional analysts may also have difficulties in such cases.

It is peculiar that, like the expert system, the network interpreted the implement which had been used for carving dried clay (385) as used on soaked antler. This means that the observed traces must indeed have been comparable with those produced in working soaked antler.

With no fewer than eight of the archaeological artefacts (3b, 5, 6, 10, 19, 20, 31, 34), the network's interpretation was similar to that of the human expert (tab. 2). In three of these cases (tools 6, 10, 31) the network's interpretation corresponded to that of the human analyst, whereas that of the expert system did not. The traces of only two implements were misinterpreted (tools 1, 3a).

Table 2. Interpretation of polish on 10 Linearbandkeramik artefacts, given by a human analyst, the expert system and the neural network.

tool nr.	analyst	expert system	neural network
1	dry hide	-	fresh hide
3a	dry hide	-	fresh hide
3b	bone	butchering	butchering
5	hide ?	fresh hide	fresh hide
6	bone	-	butchering
10	fresh hide	-	fresh hide
19	wood	hard wood/ soft wood	hard wood/ soft wood
20	fresh hide	fresh hide	fresh hide
31	hide	-	fresh hide
34	antler	soaked antler	soaked antler

4.3 Conclusion

From a comparison of the achievements (tab. 3) it can be concluded that as far as the experimental tools are concerned, the expert system performed slightly better than the neural network. With respect to the interpretation of the archaeological implements, however, the network yielded a better result. This difference may be due to the composition of the test set. The selection of the replicated tools displayed relatively more wear patterns that were not very diagnostic, whereas the archaeological tools contained more diagnostic patterns.[15] If provided with the appropriate knowledge, expert systems may be better at interpreting

Table 3. Final comparison of the test results.
* In this case true and false means that the answer is respectively equal and unequal to the answer of the human analyst.

interpretation of:	expert system	neural network
experimental replica's (N=16)		
true	9	7
false	1	9
none	6	-
archaeological artefacts (N=10)*		
true	5	8
false	0	2
none	5	-
total (N=26)		
true	14	15
false	1	11
none	11	-

exceptions than neural networks. When interpreting data, the latter focus on recognising similarities with the examples that they have learned. They try to relate new data — and thus also exceptions — to their generalised knowledge. Therefore, they can only interpret exceptions correctly if they have been provided with enough 'learn examples'. Unfortunately, the difficulty with exceptions is that there are only few examples. However, when it comes to real exceptions that have never before occurred, the expert system will not be able to give an interpretation. It will simply lack the appropriate knowledge. A neural network, on the other hand, might be able to give an interpretation that is in the right direction (for example the right hardness category).

From the results it can also be concluded that both systems, but especially the expert system, can be useful if a human analyst wants a second opinion on his interpretation. For example, the analyst was uncertain about the traces on tool number five, and both the expert system and the neural network confirmed the interpretation. It is, however, the expert system that is best suited to this purpose; no less than 93 percent (14 out of 15)[16] of its interpretations endorsed those of the professional analyst. Moreover, in contrast to those of the neural network, the expert system's performances for the replicated tools and those for the archaeological implements show no significant difference. Because of this the expert system is the most reliable of the two applications.

The final conclusion is that both applications already performed quite well. Especially in view of the fact that they were based on a rather small and unbalanced set of examples, their achievements were encouraging. The expert system interpreted 54 percent (14 out of 26 tools) correctly and the neural network 58 percent (15 out of 26 tools) — a difference in performance which seems small. However, if the wrong interpretations are also taken into consideration the difference is greater: 7 percent of the expert system versus 42 percent of the neural network.

Nevertheless, it cannot yet be concluded that one of the techniques is more suitable for this kind of analysis than the other, because the misinterpretations of both applications are still due to insufficient knowledge rather than to inadequacies of the applied techniques. More tests will have to be carried out to obtain a more clearly defined picture of their specific potentials for the analysis of use-wear traces. Such tests should incorporate a comparison of the performances of all three 'types' of analysts. This means that both applications should be employed in a real 'blind test' in which human experts also participate.

5. Some facts and fictions

As mentioned in the introduction, it is not only ignorance that may discourage people from employing artificial intelligence techniques, but also threshold fear. This threshold fear is mainly due to the endless discussions on the potentials, applicabilities and threats of specific techniques as well as of artificial intelligence in general. Unfortunately, most of these discussions are either based on fictions or cause new fictions. In the following I will therefore concentrate on three major points of discussion and will attempt to divorce some facts from the fictions.

A first point of discussion concerns the potentials of the techniques discussed above. It is said, for instance, that neural networks are superior to expert systems in terms of functional abilities and social acceptability (Gibson 1992, 265). But, first of all, as this is comparing apples and oranges, it is, strictly speaking, impossible for either one to be superior to the other. If this were possible it would imply that a person who is specialised in reasoning through association is superior to a person who is specialised in reasoning through deduction. Furthermore, neither one is superior to the other since both techniques have their advantages as well as their disadvantages. They are equipped with different knowledge representational and reasoning methods, which implies that they may only be more suitable for specific purposes. It is a fact that expert systems perform best in tasks involving explicit knowledge and deductive reasoning, while neural networks perform best in recognising complex non-linear patterns or tasks in which the relations between the variables are unknown. Therefore, if both techniques are used for the kind of tasks they have been designed for, they are equally useful.

The same line of reasoning can be used for the idea that neural networks can overcome the major functional disabilities of expert systems. The functional ability of any system depends on whether the applied technique suits the task it is employed in and on the composition of the knowledge that is utilized.

One of the arguments that is used to demonstrate the superiority of neural networks is that they work well with incomplete data and that their performance at the edge of knowledge is far better (Gibson 1992, 265). This suggests that neural networks are able to interpret exceptional situations, which deviate from those they have learned. However, if the functional ability of a neural network were superior to that of an expert system, the results of the above test case would have demonstrated this. It is true that the network reacted more flexibly to exceptions, in the sense that it generated answers in all the cases that the expert system could not. But we have seen that these answers were not very reliable; 8 out of 11 were wrong. It is a fact that a neural network's interpretation is always an estimation, which means that it may be correct but it may also be very wrong. In other words, when a network has to perform at the edge of its knowledge its achievements are poorer. And the question is whether in such cases an unreliable answer is preferable to no answer and whether the latter must, therefore, be classified as a functional disability.

Apart from this, the idea that neural networks can work well with incomplete or exceptional data is an example of wishful thinking. No artificial intelligence technique can work well with incomplete data as long as even humans have great difficulties interpreting situations they have hardly any knowledge of.

Another argument for the superiority of neural networks is that they have the capacity to formulate their own representations of the expert's reasoning processes, without a designer having to make a knowledge model. However, the question is whether this is always an advantage. It makes a neural network a 'black box' and the user has very little influence on the composition of the internal knowledge. As a consequence, the user may have difficulties finding out exactly what a network has 'learned'. It may have learned to distinguish the examples from one another on the basis of properties which are background noise and have nothing to do with solving an archaeological problem. Furthermore, if a network structure is not well designed, for instance if the hidden layer is composed of too many neurons, it may learn the examples by heart and may not be able to analyze any new problem (Lawrence 1991, 123).

With expert systems, on the other hand, this is not a problem as they are 'transparent boxes'. Because their reasoning processes are based on a formal model, they are controlled by the designer and are visible to the user. The advantage of such a model is that it can be used to check the consistency of the knowledge, to localise performance deficiencies and to maintain a system. This means that if an expert system's knowledge needs to be maintained, its knowledge base can simply be adapted or extended. A network, on the other hand, must be trained all over again in such a case.

However, working with a predefined model means that the development of an expert system application is far more time-consuming than that of a neural network. As it is often difficult to build a knowledge model, it is easier for archaeologists to develop a network application than an expert system application.

This brings us to the point of the social acceptability. According to Gibson (1992, 264), this is problematic with expert systems as 'People tend to fear technology when it is professed to have qualities that humans have.' (Gibson 1992, 264). Indeed, the social acceptability of expert systems has been far from satisfactory. However, this is not an inadequacy of an expert system itself. It has to do with the readiness of the potential users and I therefore doubt whether this will not be a problem with neural networks, too. It may even be worse. A network is also professed to have qualities that humans have. And on top of this, neural networks allow less human interference. The fact that they make their own 'rules' for handling the knowledge means that their composition cannot be controlled by the developer nor recovered by the user. Moreover, their internal processing is not only invisible to the user but also more complicated to understand than that of an expert system.

One of the facts that may favour the social acceptability of neural networks is their processing speed. Since they have a neuron structure and a data matrix (representing the weights of the connections between the neurons), the analysis process amounts to nothing more than a calculation of the degree of neuron activity, which takes only a split second. Expert systems, on the other hand, involve lots of rules. During execution they must check all the rules, or at least those for retrieving the appropriate knowledge. That is why a neural network can be faster than an expert system.

To summarize this discussion, I do not think that the neural networks' performance at the edge of their knowledge and their independence in knowledge modelling give reason to believe that their functionality is superior, nor that their ease of development and their processing speed will be crucial for an improvement of their social acceptability.

A second major point of discussion concerns the suitability of archaeological knowledge for an artificial intelligence approach. It has for instance been said that archaeological knowledge does not lend itself well to representation by means of an expert system due to its subjective and intuitive nature (*cf.* Gibson 1992; Vitali/ Lagrange 1988; Wilcock 1986). Expert systems are claimed to be inadequate for representing this kind of knowledge because it can hardly be translated into explicit rules. In my opinion, such scepticism is based mainly on disappointment following overoptimistic expectations of abilities. No technique can provide answers to all questions or handle all problems. Moreover, these techniques are research and educational means instead of solution-generating tools. Their most important merit, however, is that they can play an important role in modelling knowledge (Doran 1990) and thus in understanding and improving it. And in that respect they can be applied to a vast range of archaeological research fields.

Moreover, part of the criticism is momentary and not as absolute as it sometimes seems to be. The knowledge representational abilities of expert systems are not confined to rules. Since these techniques are relatively new they are still evolving. Each new development creates new knowledge representational abilities or facilitates application building.

Finally, I would like to comment on the use of artificial intelligence techniques in general. It is often thought that they can only be used by mathematically grounded archaeologists or that they should not be used at all because they threaten the position of human experts. First of all, the idea that artificial intelligence techniques are difficult to learn is a relic from the early days of computing. Until a few years ago, applications could only be developed with the aid of complicated computer languages. However, this is changing rapidly. Artificial intelligence technologies are still evolving and are already designed to be applied by different groups of users: many of these techniques are commercially available as user-friendly packages.[17] The consequence is that application development no longer requires an awful lot of hardware or software knowledge.

In this respect expert system technology in particular has evolved much. So-called expert system shells have been developed to facilitate application building. Shells are software packages which offer all kinds of knowledge representational and reasoning facilities. With those shells it is possible to build applications without having to program complex procedures. That means that archaeologists who have no experience whatsoever with sophisticated computing techniques can now build an application.

Anxiety should not be an argument for not using artificial intelligence tools either. The fear of these tools becoming a substitute for human intelligence is probably due to the fact that the consequences of future developments cannot be known.[18] The risk of a computer application threatening the work or position of an archaeologist is however entirely fictional. An artificial intelligence application can serve as an assistant only. It can simulate predefined reasoning processes but can certainly not generate intelligence[19]. In other words, an artificially intelligent archaeologist is artificial, not intelligent; it cannot replace an expert. On the contrary, it may even consolidate the expert's position, because it enables the expert to expand his knowledge and to exploit exactly those human abilities that a computer cannot simulate.

6. Concluding remarks

Since papers on computing techniques are often intended to show the disabilities rather than the abilities of artificial intelligence techniques, the majority of the potential users of these techniques among archaeologists have definitely been negatively influenced by this scepticism. They think of them as techniques with a limited potential or as too complicated. In spite of the scepticism surrounding these techniques, there is a lot of work they could do in archaeology. They offer a means for formalising and modelling subjective expert knowledge and they can make this knowledge accessible to and usable for non-experts. In that respect they can be useful tools for educational as well as research purposes. I hope that this paper will help archaeologists to think of ways of using artificial intelligence techniques to approach archaeological tasks or solve problems. Only by building or using an application will archaeologists be able to discover the abilities of artificial intelligence techniques and realize that there is a broad range of potential applications.

However, both purposes and techniques must be selected with care. As argued above, neither one of the artificial intelligence techniques is more useful than the other. Each performs best when the principles of the applied technique suit the problem being tackled. There is, for instance, no sense in applying these techniques to problems having an algorithmic structure which leads to a clear solution. These problems are best handled by conventional programming techniques. But problems that can only be solved by searching for associations with similar situations are probably best tackled via a neural network application. Neural networks are good at recognizing patterns in non-linear problems and at revealing relationships between a problem's input and output variables. However, they cannot be used for problems that require (mathematical) precision. The output of a network is always an estimation which is based on generalisations. The output of expert systems is based on rules of deduction. Because of this neural networks may be less accurate than expert systems. As the deduction process of expert systems is based on a formal model it is also more controlled. If such a model has been developed well, the interpretation of the application will hence be accurate and reliable. Furthermore, an expert system may explain its reasoning process to its user, and thus show how its output was established. That is why expert systems can make better educational and hypothesis verifying applications than neural networks.

The emphasis in this paper has been on the differences between these artificial intelligence techniques and their specific abilities. However, this does not mean that they should only be used for different applications. In archaeology, many research fields involve several types of knowledge. The advantages of different techniques should be combined so as to make artificial intelligence a useful approach for these fields, too. Future discussions should therefore also concentrate on the possibilities of joining different techniques within single applications.

notes

1 Such tasks may be diagnosis, process control, instruction, prediction, classification, planning, *etc*.

2 Knowledge can be represented by means of several methods, not only IF-THEN decision rules, but also Object-Value-Attribute triplets, Inheritance frames, Logic rules, *etc*. For more detailed information the reader is referred to Lucas/Van der Gaag (1988) or Payne/McArthur (1990).

3 Information may consist of observations or facts. The external world may be, for instance, a human user, a database or an instrument.

4 Many different types of neural networks are commercially available. They all have different layer structures, learning algorithms, weight-processing and signal-transfer functions, *etc*. The interested reader is referred to Carling (1992) or Lawrence (1991) for detailed information.

5 Both applications run on a stand-alone computer with a 80386DX processor.

6 A.L. van Gijn

7 WAVES stands for Wear Analyzing and Visualising Expert System. An expert system shell called LEVEL5 Object (version 2.5) is used for the implementation of this system. LEVEL5 Object is a registered trademark of Information Builders Inc.

8 A software package called BrainMaker (version 2.3) is used for this application. Brainmaker is a registered trademark of California Scientific Software.

9 For instance, polish may have been obliterated by post-depositional processes and edge removals may have been caused intentionally.

10 For more information on the composition of the scores the reader is referred to Van den Dries (1994).

11 M.J. Schreurs.

12 The interpretations were evaluated exclusively on the basis of the materials that scored best.

13 Since traces of butchering include traces of bone, the system's identification of either one of the two was accepted.

14 An unsure interpretation was recongisable as an output showing several materials with low scores.

15 Because of the diversity of the experiments the replicated tools showed a large variety of traces, including generic weak polishes. The archaeological tools analyzed, on the other hand, had been carefully selected. Tools without diagnostic traces could often not be analyzed. The remaining archaeological tools showed more diagnostic traces than the experimental tools and may therefore have been easier to interpret.

16 This calculation included the interpretations of the implements used in the experiments because these interpretations were based on descriptions given by a human analyst.

17 These packages are available for all kinds of computer systems at varying prices.

18 Something similar happened when calculators were introduced: people were so afraid of loosing their jobs that they went on strike. It is natural for people to tend to look before they leap when innovations are introduced, especially when those innovations aim to unravel the key to humanity, intelligence.

19 It has been said that a neural network can beat the human brain as far as the speed of signal interchange is concerned (Carling 1992). The speed of the interchanges in the human brain is restricted by chemical processes whereas neural networks can exploit the advantages of using much faster electronical processes (Vuik 1993). Nevertheless, the processing capacity of an artificial network does not even approach that of a biological network. This is due to the fact that biological neurons can all be active at the same time whereas the activity of artificial neurons is restricted by the hardware, which is only capable of sequential processing. Furthermore, a neural network has only few connections compared with the brain; some ten thousands versus billions. Only if it should prove possible to equip future computers with such massive parallel processing capabilities (or human brains) could the speed of the information transfer of artificial intelligence applications possibly defeat that of human beings. But even then, those computers would only be extremely fast, not intelligent.

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Underwater heritage management: cultural and legislative perspective

A regional or national policy for heritage management or a specific sector thereof should be deployed on a firmly scientific basis. The underwater heritage is no exception. The environmental and theoretical basis for archaeological heritage management in Dutch waters is subject to research by the author. The present article is an introduction on the European cultural and legislative perspective.

1. From accidents to policy

The potential of archaeological sites in wet or submerged conditions has been appreciated from the very start of modern interest in the remains of past cultures. During the Renaissance this interest not only included the architectural aspects of palaces and temples, but encompassed for instance the remains of imperial barges that were found to have foundered in the Nemi Lake (Lehmann 1991). In the late seventeenth century the collection of dispersed antiquities was recognized as a serious corollary of engineering works aimed at canalization and promotion of navigability of for instance the river Tiber. The Dutch engineer Cornelius Meijer devised modern methods to do so (Meijer 1685) (fig. 1). Exactly the same preoccupations did still apply in the early nineteenth century (Gianfrotta 1982; Mocchegiani Carpano 1982) (fig. 2). In the development of archaeology as a serious discipline underwater sites have played a marginal role, but their potential importance has always been recognized.

The most telling example of early, but absolutely serious attention for underwater sites are the Swiss lake-border settlements from Neolithic and Bronze Age date. As soon as their importance was established due to extreme drought in 1853 (Keller 1853), the geologist Count Adolf von Morlot from Geneva even went as far as to inspect a submerged site near Morges with the aid of a then acceptably modern, manpower pumped diving apparatus (Arnold 1986, 25; Martin-Kilcher 1979; Ruoff 1981).

For long, however, systematic attention and care for underwater remains was far beyond the technical means of all but a very restricted group of technical specialists. Archaeological exploration under water has thus been confined to individual actions. In a few instances these had scientific aims, such as the undertaking of the Scottish Reverend F. Odo Blundell in 1908, who borrowed diving gear from the Clyde Navigation Trust in order to investigate the submerged foundations of the ancient artificial island Eilean Muireach (Dixon 1991; Muckelroy 1978, 11). Mostly, however, they just aimed at the collection of artifacts.

Systematic concern about the preservation and exploitation of archaeological sites under water is thus a recent phenomenon. Both the development of 'wetland'-research and the fact that the remains of ancient ships and their cargoes and inventories got more and more attention were crucial in this respect. Public concern gradually followed suit. Excellent overviews of early incidents of archaeological diving are given by Bass (1966) and Gianfrotta and Pomey (1980). An assessment of the importance of submerged sites for our understanding of past developments can be grasped from Masters and Flemming (1983) and Coles and Lawson (1987), whereas the archaeological potential of shipwreck-sites is well-argued in McGrail (1987) and in the several collections of articles edited by Reinders (Reinders 1987, 1991; Reinders/ Oosting 1991; Reinders/ Paul 1991).

In the following paragraphs a short interpretation of the recent developments will be given. Research issues (or their absence), technical restraints, legal solutions and varied cultural backgrounds will be reviewed.

2. On the underwater cultural heritage

2.1 Legislation and government policy

It is only less than fifteen years ago that the Parliamentary Assembly of the Council of Europe, in its 'Recommen-

Figure 1. The fact that the underwater world holds a plenty of antiquities was well understood since the very onset of antiquarianism. So was the notion that their discovery would be corollary to the realization of extensive civil works. The Dutch engineer Cornelius Meijer worked in Italy in the late 17th century. As protégé of pope Innocentius XI he designed and developed all sorts of contraptions to help in the canalization and the promotion of navigability of rivers such as the Tiber and drainage of (for instance the Pontinian) marshes. Judging by this drawing he was well aware that these works would reveal numerous remains of the past (courtesy Accademia Nazionale dei Lincei, Rome).

dation 848: on the underwater cultural heritage', made an urgent appeal to member state governments to seriously concern themselves with a sofar neglected branch of cultural heritage management (Roper 1978). Since then the issue has been seriously considered in most European countries. This happened in quite varied ways. The cultural background varies and the developments sofar had resulted in different policy-bottlenecks in different regions of Europe. Still the impact was that heritage management issues were discussed internationally and that in many cases the approach at a national level was adjusted so as to match the policies elsewhere.

In several countries — the Netherlands included — the terrestrial archaeological legislation was adapted so as to cover under water sites (Kristiansen 1985; Lund 1987; Maarleveld 1983; Monumentenwet 1988). In other countries this had happened earlier (Cederlund/Haasum 1978; Nævestad 1991).

An anomalous situation exists in those countries were maritime and underwater finds are covered by a totally different law than those on land. In France, the early legislation of 1961 has recently been substituted by a new law that still specifically addresses finds in the maritime domain, but which is more in keeping with the policies elsewhere (Loi du 1 Décembre 1989; Décret du 5 décembre 1991). Proposals in the United Kingdom to supersede the most awkward systematics typifying the impromptu Historic Shipwreck's Act of 1973 by regulations that would further a more significant protective policy (Joint Nautical Archaeology Policy Committee 1989) have not (as yet?) met with success. Nevertheless, even in the United Kingdom some movement towards a seriously archaeological approach of the underwater cultural heritage can be observed, allbeit in administration rather than legislation. For the first time the same government department is responsible for policies regarding sites above and below water, whereas the Royal Commission on the Historical Monuments of England, one of the organisations bestowed with their implementation has recently begun the extension of the National Archaeological Record for England to include underwater sites.

In fact the English situation as opposed to that in Mediterranean and Scandinavian countries is the outstanding illustration that underwater archaeology has roots in fairly diverse traditions. In its primary development it owes as much to outside influences as to the gestation of archaeology. With gross oversimplification we can recognize three distinct lines of development on the European scene. Two of these are regionally bound, the third has overlaps with both and is less specific in that it hardly differs from mainstream continental archaeology and archaeological heritage management. All three traditions did gain a lot of momentum since the Cousteau/Gagnan invention of the aqualong at the end of World War II. All three will roughly be outlined hereafter.

2.2 THREE TRADITIONS

2.2.1 The Mediterranean tradition

Of the three European traditions in underwater archaeology the Mediterranean one is the first obvious example as we should consider that area as the cradle of modern-day diving. Indeed it is diving and idolation of the

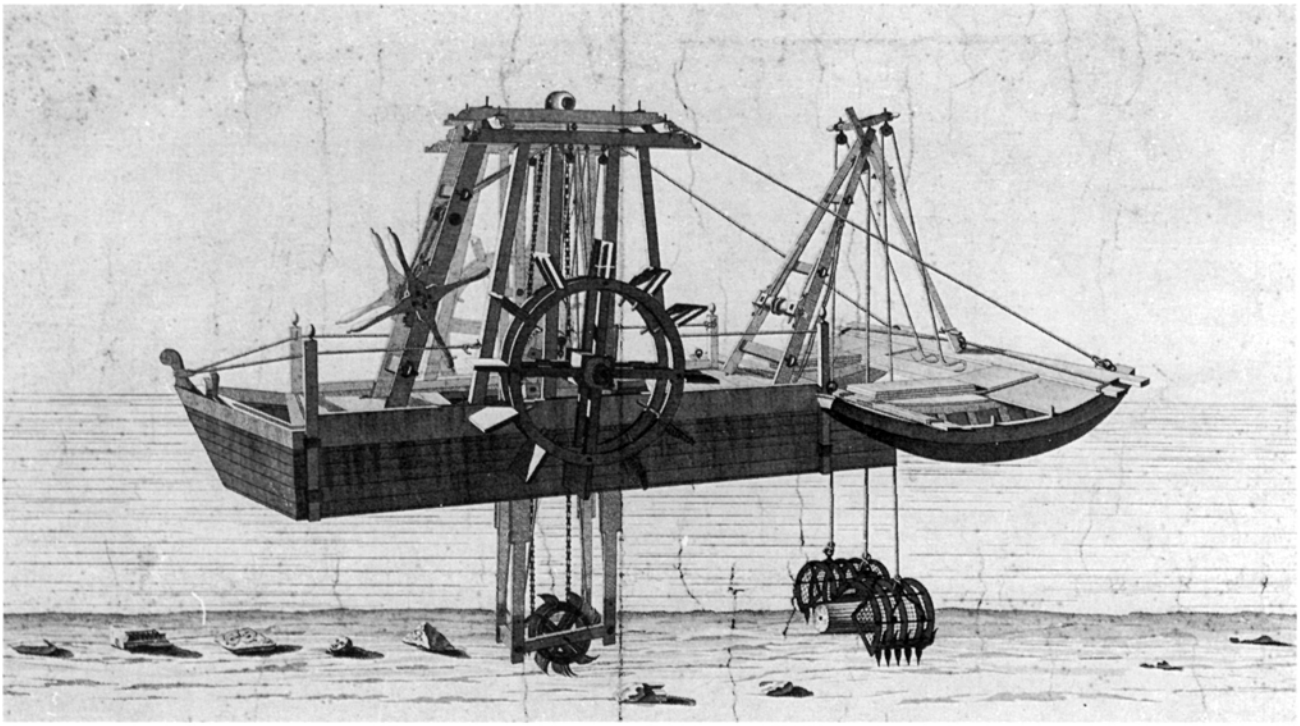

Figure 2. By the beginning of the 19th century the scale of works -and again the Tiber draws attention- was increased. So was the machinery used for excavation and the collection of antiquities (courtesy Istituto Nazionale d'Archeologia e Storia dell'Arte, Rome).

skills involved that determined the first stages of development in this tradition. More significantly though, it was vital for the discipline that sponge-divers in clumsy standard-diving outfit had extensively surveyed the ridges and seaboard up to quite significant depths ever since the late 19th century. More or less unawaredly they collected a body of aggregate topographical knowledge which proved essential for archaeology later on. Occasionally they brought up archaeological items. In a few instances (Antikythera, Mahdia) this led to purposeful actions in which archaeological sites were systematically cleared of their contents under the authority of archaeologists (Bass 1972; Casson 1939; Fuchs 1963; Merlin 1930; Weinberg *et al.* 1965). The actual on-site work was carried out by divers with their magic skill, whereas the responsible archaeologists stayed well clear of the water and studied the raised works of arts.

Exactly the same setup was applied as soon as the aqualong set the diver free of his more cumbersome equipment. Capt. Jacques-Yves Cousteau incorporated archaeology in his promotion of diving (Benoît 1952; Cousteau 1954). The archaeologist, however, was not supposed to do the fieldwork. He was supposed to study the raised items in an erudite way (Benoît 1961; Frondeville 1965). Their collection as well as on-site observations were better left to the diving supermen (fig. 3). With the best of intentions these evidently messed things up quite a bit, out of sheer unfamiliarity with basic practical knowledge of archaeological stratigraphy (Harris 1989) or the nature of archaeological observations (Schiffer 1976). The dismantling of the Grand Congloué site, where later analysis showed two ancient shipwrecks to have been superimposed is a good example (Long 1987).

As a result of this approach diver's lore in the Mediterranean context has been stuffed with amphoras as one of the assets of the deep. In a more general sense the awareness that 'the silent world' is to be regarded as a museum (*cf.* Cousteau 1953, 1954), with huge stores opening up new vistas on antiquity was established.

It was only the next step that was made by archaeologists. Dissatisfaction with the procedures sofar (Lamboglia 1952) as well as the assessment of the importance of a meticulously scientific approach led to the establishment of the 'Centro Sperimentale di Archeologia Sottomarina' in Albenga in Italy in 1958 and its subsequent activities (Lamboglia 1959; Pallarés 1983). More influential

Figure 3. The beginnings of archaeology under Mediterranean waters saw a strict division of labour between divers who did the job and archaeologists that were supposed to comment on the findings in a erudite way. Divers in the mess of the 'Calypso' swap tales of *undersea salvage at the occasion of the Grand Congloué excavation*, as the original caption has it. Occasionally one of them fed an octopus into the suction pipe to startle scientists at the filter end, but they were good chaps and worked hard (courtesy The Cousteau Society).

internationally, however, has been the work of the team centered around George Bass (Bass 1967; Bass/Van Doorninck 1982). It is one among many of Bass's great merits that he broke through the he-man-like aura of the diver. He firmly established the principle that like everywhere else archaeological excavation under water is to be carried out by trained archaeologists for whom the additional — technical — problem of doing research in an underwater environment is no excuse to proceed in any less scrupulous way (fig. 4). One of his renowned statements is that it is easier to teach an archaeologist to dive than to teach a diver to be an archaeologist (*cf.* Bass 1966, 15-17).

The early diving activity in the Mediterranean and the incidental recovery of bronzes and statues by fishing had made the respective governments well aware of the fact that a new area featuring important cultural heritage — major works of art amongst it — had come within reach. Legislative and administrative measures were taken in view of the new developments. Of course these would be in line with the regional policy-tradition. All Mediterranean countries had suffered a stage of antiquarianist archaeology which in part can best be described as a stage of wholesale looting. As a consequence the governments understandably proceeded with very restrictive legislation. Research was confined to strict rules and academic principles. Institutions for control were established.

In many respects government interference has had very positive effects. The Mediterranean tradition of archaeology under water has been firmly established in Turkey — where much of Bass's activity was and is deployed — in Italy, in France and in Spain ever since the onset of the sixties (DRASM 1986; Gianfrotta/ Pomey 1980; Martin-Bueno 1985; Mocchegiani Carpano 1982; Morcos 1986; Pallarés 1983). More recently Greece could be added to the list (Tsouchlos 1990). The strict regulations do, however, have less desirable side-effects as well. They certainly contributed to the alienation of the ever growing number of divers, sports-divers, tourist-divers of the general cause for which these regulations were devised. On the other hand the reckless activities of looting 'clandestini' feeding an ever hungry antiquities market and thereby destroying the integrity of ever so many Mediterranean sites in and out of the water leaves very little alternative but to try and suppress them.

In summary we can typify the Mediterranean tradition of underwater archaeology by the following characteristics:
- comprehensive survey
- repressive protective legislation
- a sharp division between archaeologists and 'clandestini'
- thirty years of significant archaeological excavations.

2.2.2 *The northern European tradition*

In northern Europe the situation is quite different from that along the Mediterranean. In the first place there is no sponge or other crop that is collected by divers, so very little undersea landscape has been surveyed through direct visual observation prior to the adoption of diving as a sport. Traditionally governments have been less preoccupied with looting and export of archaeological material. In the antiquarian stage this region was importing rather than exporting antiquities, which for instance resulted in significant national collections of Mediterranean material.

Diving in northern European waters has traditionally been confined to localized jobs of construction and salvage carried out by a relatively small group of professional divers. It is they who more or less set the scene. Apart from dealing with the salvage of recently foundered vessels they also regularly looked into older sinkings. Whenever it was documented that a ship with a salvagewise attractive content had sunk somewhere and had not previously been worked or salvaged they went to great effort to try and pinpoint this particular wreck in order to procure themselves with its commercial assets (Van der Hidde 1943; Van der Molen 1970). This course of action is still of major influence. When the documentary sources seem reliable salvage firms will — if possible and legally feasible — concern themselves with remains of significant age (fig. 5).

Figure 4. The notion that archaeological excavation is first and foremost to be carried out by archaeologists was strongly promoted by George Bass in the sixties and the seventies. It was not so much the fact that he adapted excavation techniques to suit underwater conditions, but the fact that he brought archaeological thinking down there where the primary archaeological observations can be made, that was to be of vital importance. Fieldwork is done scrupulously. The technical problems to do so are just a hurdle to leap, in the partial excavation of the Hellenistic Shipwreck at Serçe Liman as anywhere else (Courtesy Institute of Nautical Archaeology).

In the early stages of development the borderline between salvage and archaeology has insofar been diffuse that it was mostly through salvage-actions that the archaeological potential was opened up. Antiquarian interests started to accompany the commercial ones or even to supersede these. In a way the development is similar to that which mainstream archaeology went through about a century earlier. The people concerned went into more and more archival research in order to track down attractive historical wrecks (*e.g.* Franzén 1961; Kist/Gawronski 1983; McKee 1982; Sténuit 1977; Wignall 1982).

In contravention of Dr. Bass's dictum referred to above, we see quite a few divers turned 'archaeologist' or historical researcher on the northern European scene. They started to consider their activities as more and more archaeologically meaningful. In the field the emphasis has been on search-techniques and artifact-retrieval, whereas in many instances little contemplation was given to stratigraphy and archaeological context. Nevertheless such actions have added to our aggregate knowledge by producing secondary archaeological data that can be derived from artifact collections (*e.g.* Kist/Gawronski 1980; Martin 1979; Pol 1989). The fact, however, that the study of artifact collections from crude or uncontrolled salvage operations can yield significant results (Kleij in prep.; Gawronski *et al.* 1992) is often presented as an implicit excuse for the continuation of outdated practices (Jörg 1986; Mörzer Bruyns 1987).

Both in its more positive and its negative manifestations the northern European tradition has very specific characteristics. For one thing all attention is confined to the remains of larger ships from periods which are well-documented. The historical documents are the basis on which the search for wrecks is started. Also there is a

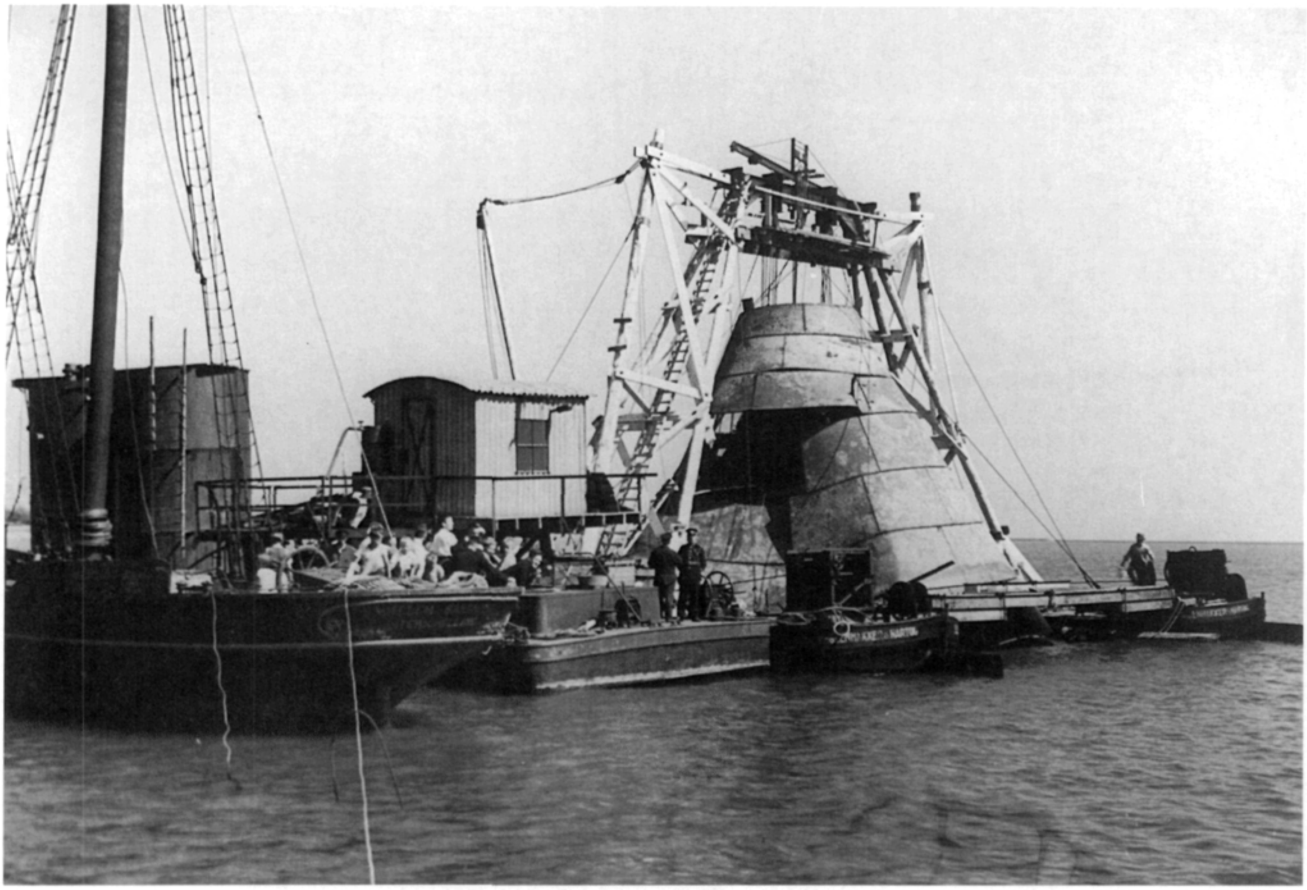

Figure 5. In Northern Europe diving used to be construction diving or salvage. Salvors never shunned wreck of considerable age. The firm of G. Doeksen & sons of Terschelling addressed the remains of hms. Lutine of 1799 in the late twenties and early thirties (courtesy Hille van Dieren).

strong bias towards naval ships and ships involved in particularly big commercial enterprises or particular historic events: ships of the Spanish Armada, ships of the East India companies, ships of the respective royal or republican navies.

Whereas evidently we can observe some nationalistic pride in the way in which the underwater cultural heritage is protected around the Mediterranean, nationalistic feelings are particularly paramount in the highlights of the north European exploitation of the underwater cultural resource. From that perspective it is hardly accidental that there seems to be more emphasis on display than on research.

With its roots in salvage the consideration of legal issues in this tradition has been concentrating on rights and ownership concerning specific wrecks rather than on the general issue of protection of cultural heritage in public law (Agreement between the Netherlands and Australia concerning Old Dutch Shipwrecks; Korthals Altes 1973; Maarleveld 1983; Protection of Wrecks Act 1973).

Although it is evident that this tradition has been as influential in the Caribbean and elsewhere it is denoted as northern European for two reasons. All over the world this approach can preponderantly be observed in relationship to the remains of western-colonial shipping and trade (*e.g.* Allen/Allen 1978; Daggett/Shaffer 1990; Earle 1979; Mathewson 1986; Sténuit 1979). On the other hand it is in northern Europe that the tradition has its more positive and prestigious examples: Wasa 1628, Mary Rose 1545, Amsterdam 1748 (Gawronski 1990; Kvarning 1984; Marsden 1974; Rule 1982; Soop 1986) (fig. 6).

In summary we can typify this second tradition of underwater archaeology by the following characteristics:
- a historic approach, where the documentary sources dominate what to look for in the archaeological record
- an approach in which to search for a particular wreck is seen as more meaningful than the survey of other, as yet unidentified sites

Figure 6. The localization and recovery of the Wasa is the outstanding example of the Northern European approach to historical salvage in its more positive manifestation (courtesy Maritime Museum and Warship Wasa, Stockholm).

- a legislative approach based on rights as opposed to responsibility
- a sliding scale of commercially and/or academically interested parties
- emphasis on display rather than on research.

2.2.3 The 'prehistoric' tradition

Side to side with these two traditions of approach of the underwater cultural heritage, the one different from the other and each with its own merits and assets we can discern a third tradition which has its background in regular European pre- and proto-historic archaeology and which has its exponents both in Scandinavia, along the shores of sheltered waters in the British Isles and in the up-mountain lakes in the Alps, notably in Switzerland (*e.g.* Andersen 1985; Arnold 1986; Billamboz/Schlichtherle 1985; Bocquet 1979; Crumlin-Pedersen 1984; Dixon 1982, 1991; Ruoff 1981).

This underwater archaeology is just the logical extension of the European tradition of archaeological field-research beyond the limits set by the waterline (fig. 7). On the one hand archaeology has learned to cope better and better with waterlogged sites under the groundwater table through draining, on the other it has learned to break the water surface where draining is either impossible or relatively expensive (fig. 8). As referred to above this approach goes as far back as the realization of the importance of wetland-sites with Count Adolph von Morlot and the date of 1854 as a significant starting point.

As in land archaeology the contribution of serious amateur archaeologists is fairly significant. Even though the tradition has high standards of archaeological professionalism it has not alienated the casual amateur researcher. It is notably in that respect that this third tradition is different from the Mediterranean one. It also stands out from the more historically oriented north European tradition in several aspects. It may not be the most conspicuous tradition in underwater-archaeology in that it has no wish and no need to distinguish itself from archaeology as

Figure 7. The logical extension of the European tradition of archaeological field-research beyond the limits set by the waterline. Paul Vouga uses a three meter deep caisson for test excavations at the late Bronze Age settlement of Cortaillod in the spring of 1925(courtesy Archives du Musée Cantonal d'Archéologie, Neuchâtel).

pursued on the basis of field research in the dry, but it might well turn out to be the most significant of the three.

One thing is very clear in its approach and that is that: underwater archaeology is archaeology or it is nothing (freely rendered from Willey/Phillips 1958, 2; *cf.* Binford 1962). In line with the mainstream of archaeological fieldstudies in Europe this third tradition can be typified by the following characteristics:

- a geographical, ecological and stratigraphical approach in field studies
- a comprehensive geographical approach in protective legislation
- a significant contribution by non-vocational archaeologists.

3. The necessity of a consistent policy

3.1 International alignment

For reasons of simplification three general approaches to the underwater cultural heritage were presented above: the one more repressive, the second more outspoken and the third more unassuming. In pursuance of Recommendation 848 the Council of Europe has promoted the alignment of all approaches throughout Europe. To this end the Division for Higher Education and Research has organized several international courses in the conservation of the 'underwater, nautical and maritime heritage'. More consequential, however, was the attempt to align protective policies in the respective countries through the drafting of a Convention on the Protection of the Underwater Cultural Heritage. The importance of such an alignment can not be overstressed. It is of especially great consequence for the excrescences of the second tradition distinguished above.

Divers turned archaeologists or considering themselves as such who try and localize shipwreck sites that they consider relevant on the basis of historical documents are not motivated or restrained by geographical considerations or responsibilities. They will move from one area to another, sometimes honestly motivated by a specific research theme, more often, however, by the accidental accessibility of a site in terms of both infrastructure, legal restrictions and political climate. The only way to coach their activities or at least their standards, the only way, in other words, for archaeological activities under water to profit from 150 years of archaeological development and the only way to protect the underwater cultural heritage from the pitfalls of antiquarianism from which its on-land counterpart suffered so much, is to do so in international cooperation.

This of course is easier said than done. It is quite clear that the second tradition with its particularistic and nationalistic bias is the anomaly but even to align the Mediterranean and northern European approaches to protection and research takes a lot of counselling. Nevertheless 1985 saw the completion of a draft for the convention on the protection of the underwater cultural heritage to the principles and wording of which the delegations of the respective member states could subscribe (CAHAQ 1985). It is only for rather technical — all be it essential — political reasons that the convention has not as yet been opened for signing and ratification.

The question on which the convention failed is under the authority of what concept of international law a coastal state can interfere in all sorts of activities in order to further the research and protection of the underwater cultural heritage beyond the shore-line.

The most restricted option (acceptable to all) is the concept of the TERRITORIAL SEA, where the coastal state exerts full jurisdiction. Its width is now usually set at 12 nautical miles (*cf.* Wet grenzen Nederlandse territoriale zee).

An alternative is to extend the jurisdiction of the coastal state over a CONTIGUOUS ZONE, if declared, under the juridical fiction formulated in Article 303(2) of the United Nations Law of the Sea treaty of 1982 (hereafter referred to as UNCLOS 1982). A contiguous zone may extend beyond the territorial waters up to a maximum of 24 nautical miles from the baselines from which the breadth of the territorial waters is measured (UNCLOS 1982 Art. 33). Under this option, that was formulated in the final draft of the convention, a strip of coastal seabottom, 24 nautical miles wide, may be administered under the convention.

To tune the convention completely to the aforementioned Article 303 in the General Provisions of UNCLOS 1982, as was done in the draft convention, leads to a somewhat crooked solution one might argue. The reason is that in itself that article is not at all particularly crisp and clear. It is a compromise on the basis of several very different proposals at the 1980 UNCLOS meeting, reflecting different traditions in the approach of the underwater cultural heritage as well as different approaches to control over the marine environment (Platzöder 1987, 299-303). It deals with 'objects' rather than sites. It emphasizes the control of traffic rather than of excavation. It even consolidates customary salvage practice, although it specifically refers to 'other international agreements or other rules of international law regarding the protection of objects of an archaeological and historical nature'. Watters (1983) is right in his opinion that its inclusion in the UNCLOS treaty is an impediment for progress in international heritage management.

As a basis for the implementation of the European convention the concept of the contiguous zone was and is unacceptable to one of the Council of Europe member-states: Turkey. Instead Turkey promotes a third option, the concept of the CONTINENTAL SHELF, a morphologically defined zone to which coastal states claim varying degrees of limited control. Others, such as Norway would (while not opposing the UNCLOS-supported concept of the contiguous zone) be in favour of ranging heritage management under yet another concept, that of the EXCLUSIVE ECONOMIC ZONE, a zone stretching up to 200 nautical miles from the littoral in which coastal states may claim exclusive rights of exploitation of natural resources.

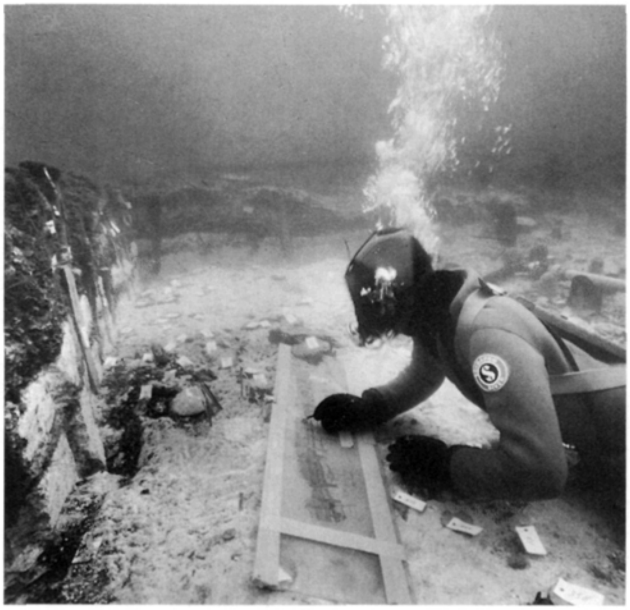

Figure 8. For prehistoric lake-border settlements in the Alpine region the decision to undertake fieldwork under water or in drained conditions has gradually become a management decision as any other: what is the best or cheapest solution to safeguard archaeological information? If that seems to be excavation, draining or underwater work both have their assets and limitations. Stratigraphical excavation of submerged sites as at Kleiner Hafner near Zürich is certainly a viable option (courtesy Baugeschichtl. Archiv Stadt Zürich/Büro für Archäologie).

Norway is strongly urging North Sea states to declare an EEZ and is an ardent proponent of extending the jurisdiction of coastal states.

The discussion about an encompassing protection of the European or the world's maritime and submerged heritage is a most complicated one. Sharing responsibilities between nations means sharing of rights and the impact thereof on economic, political and strategic relations tends understandably to easily overrule any initiative in this field. On the other hand the international developments in the protection of the natural heritage show international regulations such as the Convention on the Conservation of European Wildlife and Natural Habitats and the Oslo and Paris Conventions or even declarations of intent such as Article 123 of the Law of the Sea (UNCLOS 1982) to be worthwhile (Bos 1990; see also below).

In this light the consultations on a European convention have had their effects, even though the problems referred to above did sofar arrest progress: the 1985 draft does exist and it functions as a unifying force as it strongly influences policy development in many states. Moreover, the (revised) European Convention on the Protection of the Archaeological Heritage (that was opened for signature on january 16 1992) for the first time specifically mentions underwater sites (Art. 1, third entry). In order to circumvent the complications of defining the area of application it elegantly deals with protection of the archaeological heritage wherever a contracting state has jurisdiction (Art. 1, second entry under iii). The general principles it sets out will possibly be applicable over the largest possible area by the simple omission of a statement on what kind of jurisdiction is meant.

3.2 CONSISTENCY AT THE NATIONAL LEVEL

The process of achieving more alignment in regulations internationally is reflected at the national level. Serious attention for the underwater cultural heritage is recent everywhere and it has proved difficult to develop consistent policies, especially in those countries that display more than one of the three traditions provisionally defined above.

In protective policies legislation is a major tool and as referred to above several countries saw the inclusion of some sort of protection of underwater finds and sites in their national legislations over the last few decades. Some states such as Norway, Denmark, the Netherlands and France have adapted their national legislations since 1985 and have thus been able to take the draft convention into consideration. Denmark in particular has adopted many of its principles, including the application of the contentious concept of a contiguous zone (Lund 1987).

The Dutch law of 1988 (Monumentenwet 1988) is less elaborate. It sets out the principles of research and management. Collaboration of the general public is sought in the general obligation to report any discovery which one 'might reasonably suspect' to be both at least 50 years old and 'of general interest because of its esthetic value, its scientific value or its (cultural-) historical value' (Art. 47). Sites are under a blanket protection in that all activities with the aim of prospection or recovery of items that comply to that definition in which the soil is (even lightly) disturbed are considered to be excavation, whereas excavation is the prerogative of (a limited number) of authorized academic or governmental archaeological institutions (Art. 39). The authorization is granted by the Minister of Culture on advice of the Heritage Council and is dependent on several criteria such as staffing, facilities and continuity in funding (Art. 40 and Wet Raad voor het Cultuurbeheer). An even more rigid protection can be given to a selected number of registered sites of proven importance, banning all on-site activities (even those of archaeologists) or rather subjecting them to a most restrictive system of specific licences (Art. 6 & 7, resp. 11-14 & 17-21).

As a LEX SPECIALIS the Monumentenwet 1988 overrules other regulations. It does not interfere in private law other than determining the ownership of finds from excavations (Art. 43). Whatever the private law position of a site, the regulations of the Monumentenwet do apply. It applies in full to the entire Dutch territory, including the bottom of the territorial sea. Beyond the limits of that zone were the Netherlands have limited jurisdiction over the Netherlands sector of the continental shelf it can analogously be applied in connection with concession- and license-bound activities in which the seabottom is stirred (Josephus Jitta 1986; ICONA 1990; Maarleveld 1983).

In the Netherlands thinking and developments regarding underwater archaeology are strongly influenced by the second and third traditions defined above. This dualism has been particularly evident in the incidents that led to the political decision to consistently apply heritage legislation to wrecksites at sea in 1985 (Maarleveld 1993). It can be observed in many policy-discussions and debates (Brand *et al.* 1987; Donker 1987; KNAW 1985; Reinders 1986). The legislative approach, however, is unequivocal.

Legislation is a fundamental tool for the deployment of a meaningful policy. Nevertheless, it is only one of the conditioning starting points. The environmental conditions and the theoretical framework or frameworks which apply to our dealings with the past are at least as important. In this troika the environmental basis has great impact on both others. The theoretical basis and the legislative solutions do mutually affect each other. It is on their interaction that a consistent policy for the management of the underwater heritage should be formulated. Although regional differences will result it is only by allowing for those solidly founded differences that consistency can be attained. **(manuscript closed march 1993).**

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