ANALECTA PRAEHISTORICA LEIDENSIA

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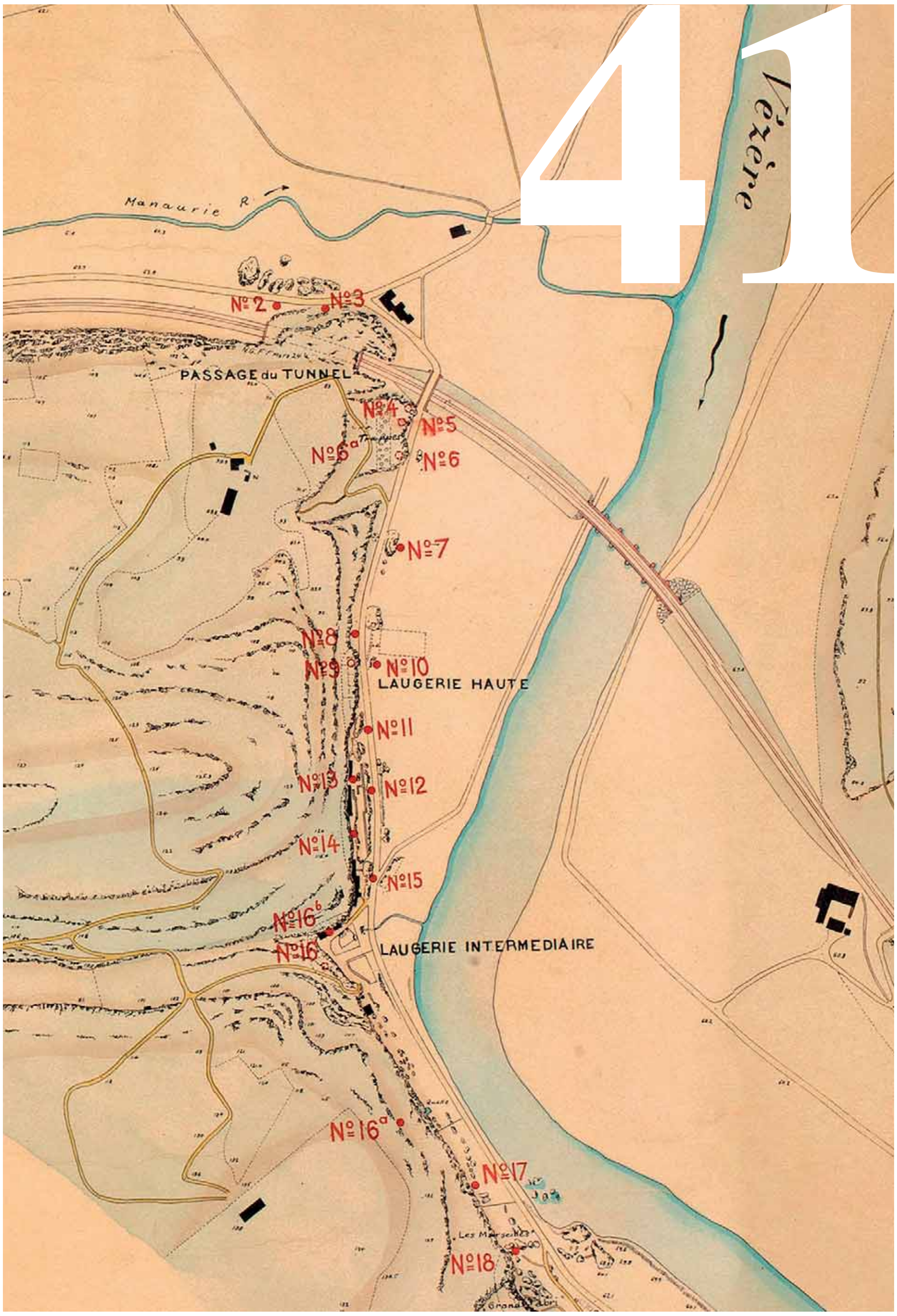

2009

ANALECTA PRAEHISTORICA LEIDENSIA 41

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PUBLICATION OF THE FACULTY OF ARCHAEOLOGY
LEIDEN UNIVERSITY

MISCELLANEA ARCHAEOLOGICA LEIDENSIA

EDITED BY
CORRIE BAKELS AND HANS KAMERMANS

LEIDEN UNIVERSITY 2009

Series editors: Corrie Bakels / Hans Kamermans

Editor of illustrations: Joanne Porck

ISSN 0169-7447
ISBN 978-90-73368-24-8

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

P.J.R. Modderman Stichting
Faculty of Archaeology
P.O. Box 9515
NL-2300 RA Leiden
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This publication was made possible with a grant from Archol, Leiden

Contents

Contents

Watching The River Flow: A small-scale survey of the floodplain deposits in the Vézère valley, between Le Moustier and Les Eyzies (Dordogne, France)

Wil Roebroeks, Hans Kamermans, Joanne Mol, Alain Turq and Thijs van Kolfschoten

Between 1997 and 2001 a small-scale survey of the geology and archaeology of the fluvial deposits of the Vézère river between Le Moustier and Les Eyzies (Dordogne, France) was undertaken. The focus of the project was a study of the relationship between the fluvial history of the Vézère and archaeology yielding deposits in some of the classic rock shelter sites in the area. This paper reports the results of this survey, which consisted of an augering campaign in the current floodplain of the Vézère river, the construction of a small test trench at the foot of the Laugerie-Haute Est rockshelter and a study of the quality and availability of lithic raw materials in the study area. We conclude that the major part of the deposits in the current floodplain of the Vézère is probably Holocene in age, with the majority of the Pleistocene deposits having been eroded away. However, at several locations Pleistocene sediments are still present below Holocene overbank deposits. Our limited fieldwork in front of Laugerie-Haute Est shows a much larger spatial extant of the abri deposits there than previously envisaged, the distal talus of the rock shelter deposits and its enclosed archaeological remains having been obscured by Holocene Vézère deposits.

1 Introduction

The Vézère valley in the Dordogne, south-western France, is a key area of world prehistory, well-known in palaeoanthropology for the high density of Palaeolithic sites, amongst which are eponymous ones such as La Micoque, Le Moustier, La Madeleine and the abri of Cro-Magnon. The valley, rightly called *La Voie Royale de la Préhistoire* (Ajoulat *et al.* 1991), appeals to an even larger audience because of its many superb cave art sites, which include Lascaux and Font de Gaume. Traces of human occupation of this area go back to more than 400,000 years ago (Turq *et al.* 2010), but most of its prolific archaeological record dates from the Late Pleistocene.

The abundance of rock shelters and cave sites in this limestone area attracted a large number of excavators from the second half of the nineteenth century onwards, following Lartet's and Christy's explorations in 1863 (Lartet and Christy 1864; 1865-1875). The excavations in the area have created a unique Palaeolithic database, remarkable by its richness as well as by the fact that it is heavily biased by work on rock shelter and cave sequences. Comparatively little information exists on the archaeology of open-air settings for the Palaeolithic of this region. Large-scale excavations of open air sites carried out in the context of *archéologie préventive*-operations have diminished this bias somewhat in recent years, with the rich record from the INRAP excavations at the *Déviation de Bergerac* providing a good illustration of the enormous "open-air" potential of the area (Bourguignon *et al.* 2004). In other regions of France, e.g. north of the Seine river, one encounters exactly the opposite situation, with almost all information coming from open air sites. Caves and rock shelters are virtually unknown there, not to mention their usage by prehistoric individuals. Studies of these open air sites have shown how fluvial and aeolian sedimentation can preserve the traces of former human presence in open settings, as testified by some of the Lower and Middle Palaeolithic sites in the Somme valley (Tuffreau 2001) or for example the pristine record from the Magdalenian sites southeast of Paris (Enloe 1991; Leroi-Gourhan and Brézillon 1972).

The Vézère valley is significantly narrower than many of the northern river valleys, especially in the trajectory between Le Moustier and Les Eyzies. This may have had negative consequences on the preservation of traces of human activities in the floodplain over vast lapses of time. On the other hand, the Vézère valley and especially the trajectory between Le Moustier and Les Eyzies has the advantage that many of the excavated key sites of world prehistory, such as Le Moustier, La Madeleine, Laugerie-Haute and Abri Pataud, are situated at a short distance from the current river. Some of these are said to contain fluvial deposits that have yielded artefacts, e.g. at the lower rock shelter of Le Moustier (Laville and Rigaud 1973; Laville, Rigaud and Sackett 1980; Peyrony 1930) and at La Madeleine (Bouvier 1977; Capitan and Peyrony 1928). Hence it may be possible to relate the abri deposits to the fluvial history of the Vézère and to chart the distribution of fluvial deposits possibly contemporaneous with the formation of the rich record from these sites.

This was the *raison d'être* of our project in the Vézère valley, set up as collaboration between the Musée National de Préhistoire at Les Eyzies (France) and the Faculty of Archaeology of Leiden University (The Netherlands). In a series of small-scale fieldwork campaigns from 1997 to 2001 attention was paid to various aspects of the geology and archaeology of the Vézère deposits in its current floodplain. This involved hand augering of the fine-grained Vézère deposits, mapping of the heights of the various deposits, especially the terraces and several key sites as well as a limited *sondage* at the foot of Laugerie-Haute Est, where hand augering had revealed the presence of flint artefacts and bone fragments in deposits of the Vézère.

This paper reports the results of these studies. First we will give an overview of some of the main characteristics of the Vézère valley landscape (section 2), which is followed by a short presentation of the geological results of our survey work (section 3) (see also Mol *et al*. 2004). We will then present a brief overview of the observations from our *sondage* at the foot of Laugerie-Haute Est (section 4). This is followed by a short review of the distribution and availability of raw material sources in the working area, carried out in parallel to the surveying work by one of us (A.T.; section 5). The combined data will then be integrated into a discussion of the history of the Vézère (section 6), concluding with several summarizing comments (section 7).

2 The Vézère valley landscape

The study area is located in the southwest of France, in the northeastern part of the Aquitaine Basin (fig. 1). Surface deposits in the study area are underlain by Upper Cretaceous (Coniacian) limestone rocks in which the famous rock shelters of Le Moustier, La Madeleine, Laugerie-Haute and Pataud referred to in this paper were formed. Between Le Moustier and Les Eyzies limestone cliffs dominate the valley of the Vézère river. On the plateaus these limestones underlie Tertiary weathering products rich in flints (alterites), while in the valley bottoms the limestones are covered by gravel, sands and silts deposited by the Vézère and its tributaries. Travertine deposits formed where the Beune joins the Vézère river at Les Eyzies.

The Vézère displays very broad meandering loops, which are very pronounced close to the La Madeleine site, and occur encased in a narrow valley, approximately 500 m wide at Les Eyzies. The distance between Les Eyzies and Le Moustier is 9 km as the crow flies, but following the meanders of the Vézère the actual length is almost twice that, about 15 km. The level of the Vézère at its lowest discharge is approximately 62 m above sea level (asl) in front of Le Moustier (Peyrony 1930) (see below, fig. 3) and about 55 m at Les Eyzies (Judson 1975), i.e. the river descends about 7 m over 15 km, a slope of 47 cm/km.

The average low water level of the Vézère near Les Eyzies is currently 54.50 m, while the floods of December 1944 and November 1952 reached heights of respectively 61.93 and 61.08 m at Les Eyzies, the 1944 *crue* (flood) reaching a level probably comparable to the 1843 one (Judson 1975). Thus we are dealing with a vertical range extension of more than 6.5 m within one century (the *grande crue* of October 4 1960, 69.44 m at Le Moustier, is not taken into consideration, as this was an artificial one, due to the opening of the floodgates of the Donzère dam (cf. Judson 1975).

The Vézère is entrenched in a deep valley with steep limestone cliffs. The gradual incision of the meandering river resulted in the formation of different terrace levels along its inner bends. Five different terraces, from top to bottom, Fv, Fw1, Fw2, Fx and Fy1, and the recent floodplain (Fz) have been distinguished in the valley reach studied (Karnay *et al*. 1999; Konik 1999). As shown by Konik (1999), these terraces show clear differences in heavy mineral content, and some of the terraces have been dated: a series of ESR and U-series dates performed at La Micoque (see below) suggest that the deposits of Fw1 date to MIS 12 and Fw2 to MIS 10 (Texier 2009).

Our work however mostly focused on the floodplain of the river (Fz), the lower part of which is still flooded frequently. The overlying overbank deposits consist of several metres of loam and loamy sand, whose age and composition have thus hardly been investigated. In our work we were able to benefit from some earlier studies on the relationship of Pleistocene occupation and the history of the Vézère valley. This previous work included studies generated by fieldwork at sites such as La Micoque (Texier and Bertran 1993), Le Moustier, La Madeleine, Abri Pataud and especialy more general surveys such as (partially unpublished) studies by Texier and by Mémoire (Bouvier and Mémoire 1992; Mémoire 1984), or the earlier ones by D. Peyrony (1939; 1947a). Mémoire's (1984) study is well known to workers in the area, especially by its graphic representation of more than 150,000 years of incision and aggradation of the Vézère. According to this scheme, the 'vertical range' of the river during the Riss II/III to Holocene time span was 10 m only. Bouvier and Mémoire's (1992) attempt at reconstruction of the history of the Vézère was based on sandy fluvial deposits found in rock shelters and usage of the age of the find layers to date the fluvial deposits (see Mol *et al*. 2004).

Konik (1999) studied stratigraphical relationships between archaeological sites, slope deposits and fluvial sediments in the Vézère valley. He distinguished two low terraces: Fy1, located ca. 4 m above the present floodplain, and Fy2, covered by overbank deposits (Fz). His heavy mineral studies showed terrace Fy1 to have a composition similar to the fluvial sediments in the lower rock shelter of Le Moustier (see below).

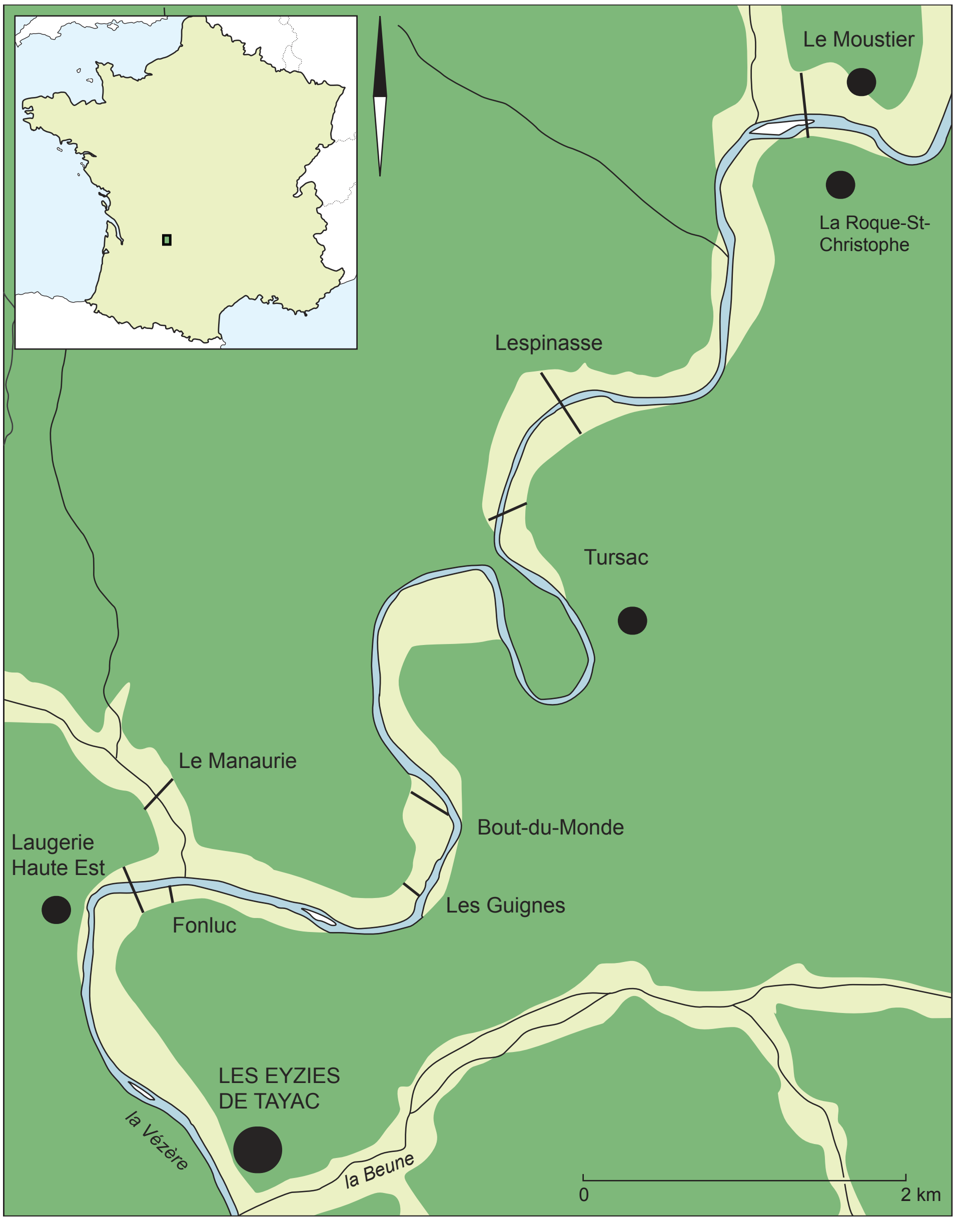

Figure 1 The study area, with the location of the transects through the valley of the Vézère and its tributary Le Manaurie. The figure shows the present valley floodplain, which is incised in limestone, as well as some of the key sites mentioned in the text.

Near the confluence of the Dordogne with the Isle, Moisan also differentiated two low terraces for the Dordogne: a low terrace (*basse terrasse*) not covered by overbank deposits, and a "very low" terrace (*très basse terrasse*), covered by overbank deposits (Moisan 1987). As with the Vézère, the low terrace is situated ca. 3-4 m above the present floodplain. Pollen analysis has assigned an Eemian or early Weichselian age to a peat level below the base of this low terrace (Moisan 1987), pointing to a Weichselian age for the terrace. The Isle river also provides data that are of interest here. Texier (1982) divided its most recent fluvial deposits into two geomorphological features: Terrace Fx and the current floodplain K. Terrace Fx is 2-4 m above the present floodplain and is not covered by overbank deposits, whereas the present floodplain contains a thick cover of overbank deposits, similar to the situation for the Dordogne.

The tributaries of the Vézère, like the majority of the valleys in northeast Aquitaine, nowadays constitute green, often humid or even swampy parts of the landscape. The infill of these valleys is to some degree known by studies carried out since the middle part of the last century. A first study dealing with the valleys of the two Beune rivers (Donner 1969) showed the existence of fine-grained organic river deposits with a thickness of 10 to 15 m, dating to the Holocene.

In the Dronne valley, northwest of our study area, major infills dating to the final part of the Pleistocene (*Tardiglaciaire*/ Late Glacial) and the Holocene have been described (Leroyer *et al*. 1998; Leroyer, Fouere and Reynet 1997; Leroyer *et al*. 2006). Comparable sequences were identified further south, in the Lot-et-Garonne, in the drainage basin of the Lémance river, all of post-glacial age (Turq, Detrain and Vigier 2000) – as was the case for the Boule, a tributary of the Dordogne (Detrain *et al*. 1996). In fact, comparable observations have been made repeatedly in the northeast of Aquitaine during geological survey work preceding large-scale construction and road building activities. In the area at stake in this paper, these deposits have been encountered (apart from the valleys of the Beune rivers – see below) in the valley of the Manaurie during fieldwork by Texier, below La Micoque, as well as occasionally in other tributaries during systematic surveys of earth moving activities in the valleys (e.g. building activities, constructions of fisheries, cleaning of ponds etc.).

The formation of these fine-grained sediments may have been related to the presence of obstructions in the small and deeply incised valleys: tuff-travertine deposits, debris cones coming from slopes or small valleys obstructing the course of the river or even dams created by the activities of beavers, which resulted in swampy river plains with deposition of organic loam (Turq, Detrain and Vigier 2000).

Taking the thickness of these recent sediments into consideration yields a vastly different last glacial landscape. Deeply incised valleys, as those of the Beunes, were even deeper then. Some archaeological sites that nowadays are more or less at the level of the river valley, e.g. La Grotte des Combarelles, Cro le Biscot or Commarque (Peyrony 1947b) were several metres *above* the valley bottom during the (Late) Weichselian.

Furthermore, these post-glacial sediments cover the coarse-grained river deposits of the valley floor which were exposed during the Weichselian. These alluvial gravel deposits mainly consisted of limestone pebbles but they also contained flint, as can be observed in the exposures of the fluvial deposits at La Micoque (valley of the Manaurie) and in the Verdier quarry (Beune). When exposed, these deposits constituted very rich flint sources, which were renewed after every major flood. Studies of the lithic assemblages from sites in the proximity of these locations (e.g. Le Cap Blanc, Laussel) show how attractive these flint sources must have been. Flints from these river deposits are often of a very good quality, as the most fragile low quality pieces had often been destroyed already during fluvial transport (Turq 2003) (see below).

One of the particularities of the Vézère valley resides in the spectacular high cliffs bordering its course in our study area. The river meanders between these *falaises*, and in order to move over the river plain one very often has to cross the river or make detours of several kilometres and master differences in height of more than 100 metres. River crossings are however often facilitated by the presence of fords (fig. 2).

Our working area is situated between two major structural features of tectonic origin, upstream the La Cassagne fault line, and downstream the Saint Cyprien fault, both running from the southeast to the northwest. Between these two features lies the Sarlat syncline, itself influenced by two synclines, the Montignac and the Pech de l'Azé one (Turq, Antignac and Roussel 1999). Karnay *et al*. (1999) have shown the existence of an important network of faults in the study area: "Le canevas tectonique influence très nettement tout le tracé des réseaux de vallées secondaires et secteurs de la morphologie des vallées" (Konik 1999, 49). Hence, we can assume that the majority of the fords are of tectonic-structural origin and were already present at their current position during the Pleistocene. Starting from this assumption, White (1985) already showed that a large number of Upper Palaeolithic sites were located close to these fords. If one enlarges the sample by taking sites from all periods into consideration, the pattern becomes even more striking. The correlation between the location of sites and fords is clear (fig. 2). For hunter-gatherers, such fords may have been very attractive: they facilitated the procurement of wood and lithic raw materials, allowed river crossings, made catching fish (e.g. during salmon runs) easy and constituted ideal hunting locations to intercept game animals during their crossing of the river.

Along with the cliffs alongside the river, rock shelters constitute one of the characteristic elements of the Périgord landscapes. Various studies have dealt with their formation (Laville 1975; Laville, Rigaud and Sackett 1980), but it has only recently become clear that there exists a semi-continuous rock shelter horizon in the Vézère valley, at the contact of the Middle and Upper Coniacian strata (Ajoulat 2002). The largest rock shelters, occupied during prehistoric or medieval times, are situated at this level: the Abri du Château des Eyzies, Laugerie-Basse, Laugerie-Haute, La Madeleine, the *abri classique* at Le Moustier and La Roque Saint Christophe.

Another important element to take into consideration is the use life of these rock shelters. The time period between the

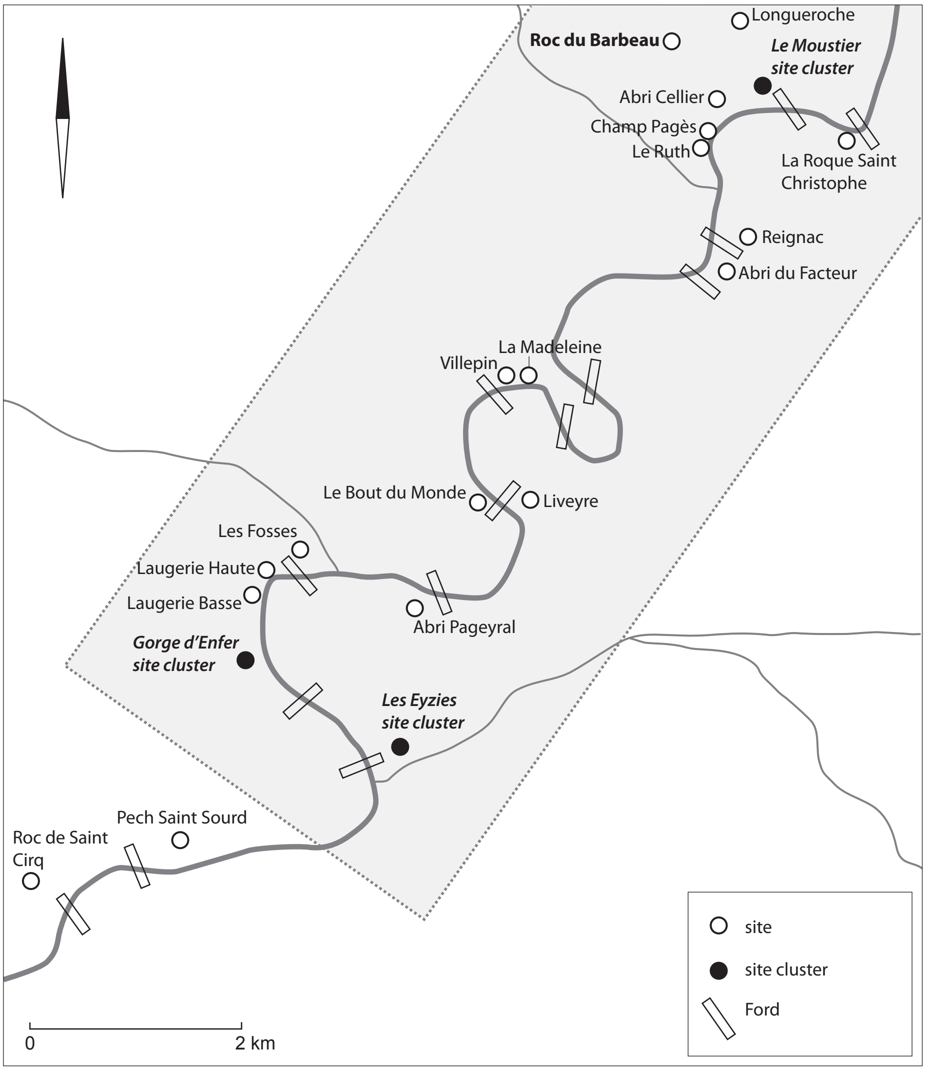

Figure 2 Location of the fords and the main Palaeolithic sites: the shaded rectangle indicates the part of the syncline in which the large rock shelters of the *Périgord noir* developed. The complex of shelters at Les Eyzies corresponds to the sites of Cro Magnon, Pataud, Vignaud, the Abri du Chateau, Casserole, Chadourne, Grotte des Eyzies, Abri Audi, the complex of the Gorge d'Enfer to the sites of the Abri Lartet Christy, the Abri du Poisson, Abri Pasquet, Abri d'Oreille d'Enfer, the Grotte d'Abzac, and those of Le Moustier to the *abri classique*, the *abri inférieur* and the Trou du Bréchou.

first and last occupations of such shelters, i.e. the moment at which a structure becomes interesting for humans to occupy and its collapse, can on archaeological grounds be inferred to be 10,000 to 15,000 years (Bouvier and Mémoire 1988). At Laugerie-Haute the rock shelter was in use between the *Périgordien final* and the middle part of the Magdalenian, at the Abri Pataud between the early Aurignacian and the Solutrean. This means that these structures change over time and relatively fast too.

3 THE SURVEY

3.1 Introduction

In this section we present the results of the various forms of fieldwork we undertook from 1997 to 2001. Through a geomorphological survey of the area, the study of maps and aerial photographs and an extensive augering programme we tried to develop an insight into the sedimentation history of the sediments in the floodplain and of the potential of these sediments for the preservation of Palaeolithic material in a primary archaeological context. In this we could profit from the rich database of J.-P. Texier (Bordeaux), who was so kind to put his (unpublished) terrace map at our disposal, which afforded a first insight into the history of the river.

As a first step in our fieldwork we simply wanted to get an idea of the thickness of the valley bottom's infill, by means of a manual augering programme. In the end ten transects were made at strategic locations, totalling 237 augering holes, up to depths of almost 7 m (fig. 3-8). Usually the augering was blocked at higher levels though, often by gravel, sometimes by the limestone bedrock. This is obviously not an ideal way to probe a valley bottom, as one can usually only guess at the character of the level blocking the boring. Therefore, during the final year we used a gravel auger, which could penetrate deeper into the gravelly channel deposits.

All borings were described in terms of sediment texture, structure, colours and inclusions, and their position located by means of a Total Station or a differential GPS. Figure 1 shows the location of the various transects. The results of the augering campaign will be presented below, starting with the initial data obtained in 1997 in the area close to Le Moustier, where we made a small *sondage*, trying to establish the geology of an inferred flint knapping site, previously reported from a field (Champs Pagès) close to the river – an activity also reported on in this section. Next we move to the Lespinasse-Tursac area, then to the Bout-du-Monde/Guignes area and we end with a series of transects near Laugerie-Haute Est.

3.2 Le Moustier and surroundings 1997

Hand augered boreholes in the floodplain in front of the lower rock shelter at Le Moustier yielded a cross-section through the Vézère valley infill, of approximately 550 m long (fig. 3). In the boreholes the infill proved to be up to 5 m in thickness. The channel deposits consist of sandy gravel. Usually, the auger was blocked on top of these deposits, although occasionally gravel was sampled, thus enabling the distinction between channel sediments and the bedrock. The depth of the coring proved a valuable tool for establishing the height of the terrace gravels.

The level of the current river is located at ca. 62 m in this transect. At the southern bank the channel deposits range in height from ca. 62 m to 61 m near the present channel. At

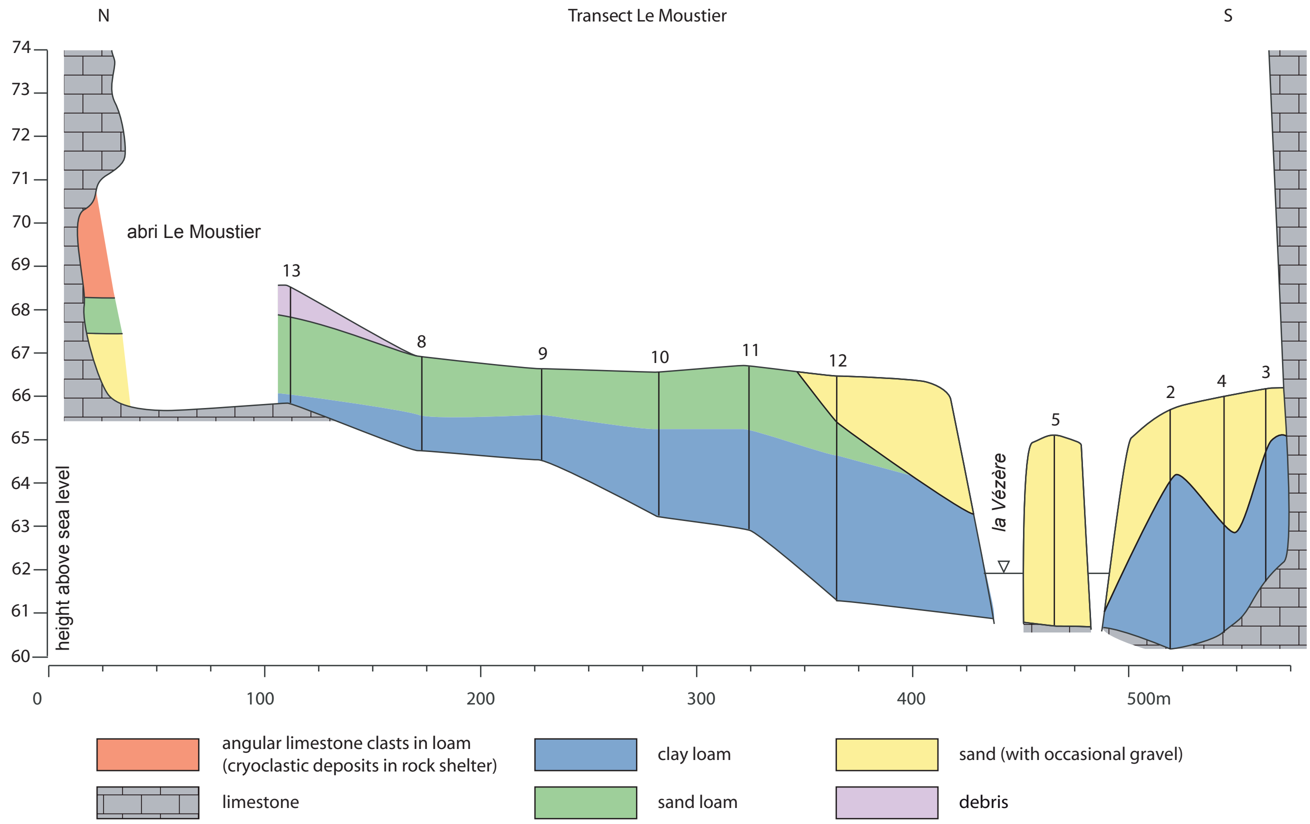

Figure 3 Transect in front of Le Moustier

the northern bank, in front of the *abri inférieur* of Le Moustier, the channel deposits are located at a much higher level, at almost 66 m, decreasing stepwise to 61 m near the Vézère. This stepwise decrease in height suggests the presence of different terrace levels, which are covered by overbank deposits. Here, at least one (65-66 m) and perhaps two (another at ca. 63 m) older levels are present above the current alluvial plain. The overbank deposits that cover these older terraces are characterized by firm clay loam, with sand loam and sand on top.

The lower part of the valley bottom infill of the north bank consists of heavy clays, brown (7.5 YR 4/4-6) to reddish brown (5YR 4/6) in colour, with many mica fragments and an occasional gravel particle, up to 5 mm in size. In borehole 12 these were underlain by pure well-sorted sands (7.5YR 5/4) at 4.20 to 4.70 m below the present surface.

The overbank deposits show a coarsening upward sequence, in which the final phase appears to have an erosional nature. This change in depositional style is probably related to formation of the present alluvial plain, which started with an incision of at least 2 m and a change to coarser-grained overbank deposits. These overbank deposits erosively overly the older terrace and overbank deposits.

The height of the top of the highest terrace, located in front of the *abri inférieur* of Le Moustier, is similar to the base of the sedimentary sequence in the lower rock shelter. These deposits have been dated to more than 55 ka by means of thermoluminescence (TL) dating of heated flints from the cryoclastic sequences on top of the fluvial sequence (*couches* G to K). This shows that the fluvial units A to F are older than 55.8 ± 5 ka, while *couche* I has a TL age of 40.9 ± 5 ka (Valladas *et al*. 1986).

It is tempting to relate these channel deposits to the fine-grained part of the fluvial sequence of the lower *abri*. However, the coarsening upward sequence as encountered in the floodplain deposits is not found in the fluvial sequence in the rock shelter. Here, the deposits clearly show a fining upward sequence, ranging from (gravelly) sand to silt loams at the top. Therefore, it is more likely that the Vézère valley's infill as documented in our boreholes at Le Moustier is younger than the fluvial deposits in the lower *abri*, as visualized in the transect. It suggests that the Vézère at Le Moustier is currently eroding an earlier floodplain, dated to > 50 ka.

This interpretation finds an independent support in work by Konik (1999), who studied the heavy mineral composition of samples from mechanical boreholes from the Vézère valley between Montignac and Le Bugue. He found strikingly consistent differences in heavy mineral composition between the erosional and aggrading banks of the Vézère over this large distance, which, again, implies that the Vézère is eroding an ancient valley fill (S. Konik, pers. comm. June 1997; Konik 1999). The heavy minerals of the eroding side of the floodplain resemble the composition of layer E at Le Moustier, the fluvial loam referred to above, with a TL age of more than 55.8 ± 5 ka (see below).

Our altimetric studies at the lower abri of Le Moustier showed that the limestone bedrock at the base of the sequence is at 65.60 m, roughly similar to the top of the terrace deposits, with the top of the fluvial (overbank) deposits at Le Moustier (Layer F) being situated at 68.29 m. Layer F is overlain by a series of cryoclastic deposits, G to K (Valladas *et al*. 1986), in which Peyrony has mentioned the presence of a 20 cm thick layer of sands (*sable fluviatile, couche I*) (Peyrony 1930). This layer is situated about 2 m above the top of the lower fluvial sequence, i.e. at a height of approximately 70 m (see also Hauser 1911, Plan 5). Peyrony's fluvial origin interpretation has been corroborated by Laville, though on the basis of mineralogical studies only (Laville 1975; Laville and Rigaud 1973). Alternatively, one could interpret the *Couche* I sands with their typical Vézère mineral association along the lines suggested by Farrand for the Abri Pataud sequence (Farrand 1975; 1995). There, the sandy matrix of some stratigraphical units clearly derived from the Vézère floodplain, likewise on the basis of heavy mineral analysis. Farrand attributed their presence to aeolian activity though, as he did not observe any indications of the action of running water in the abri (Farrand 1975).

Champ Pagès 1997

In his study on Le Moustier, Peyrony (1930) paid considerable attention to the discovery of a Levallois *atelier de débitage* in the floodplain of the Vézère between Le Moustier and Le Ruth, at a few metres from the river only. Following initial finds by the farmer Robert Pagès in 1928, large quantities of Levallois flakes and cores were excavated there, reportedly at only 40 cm below the surface and over quite a "large area". The flakes, mixed with river pebbles, formed a regular layer of about 5 to 10 cm thick (Peyrony 1930, 154). In a section at the Champ Pagès, Peyrony observed basal gravels of the same type as those of the lower abri at Le Moustier, overlain by a thick layer of loam on top of which the finds were present, covered by only 40 cm of sediment (Peyrony 1930, 154). During our augering work at the Champ Pagès we did encounter such a sequence in our boreholes, be it without the find level, which has probably been destroyed over most of the field as a result of the extensive excavations there. The sequence was encountered very close to the river only, where a gravel layer blocked our auger, at about 15 m from the Vézère at a depth between 1.05 and 1.35 m (boreholes 20 and 21), while more than 40 cm of coarse sand was encountered from a depth of 1.60 m onward in borehole 22. Such sequences were not documented further north, in the floodplain at the foot of Le Moustier.

Peyrony interpreted these findings as the remains of a Middle Palaeolithic flint workshop, focused on the production of Levallois flakes from flint nodules collected in the Vézère gravels. He was clearly puzzled by the presence of these finds so close to the river and so close to the present day surface. Peyrony even envisaged the possibility that the material had been recently collected at another site and had been brought to the field to form the floor of a house. He rejected this eventually because of the large find distribution. The presence of Upper Palaeolithic elements, such as endscrapers and burins, in the assemblage was likewise puzzling.

In June 1997 we tried to establish the geological context of the Champ Pagès finds, but because of the fact that major parts of the fields had been disturbed by earlier excavations and the construction of a water pipe line and because of the extreme high water level of the Vézère, this part of the 1997 fieldwork was not very productive (Turq *et al*. 1997). The disturbed sediments in our small trench yielded a few hundred flint artefacts, mostly waste products, probably rejected by earlier excavators who went for the *belles pièces*. The finds included blades and blade fragments – some soft hammer struck –, a fragment of a *lame à crête*, a borer and small cores for the production of bladelets, all indicating an Upper Palaeolithic component. These were associated with flakes with a centripetal or convergent dorsal pattern with facetted butts and a few backed knives, all probably of Middle Palaeolithic age. The sediments also contained many fist sized river pebbles, which are very common on the surface of the field, and might, again, reflect the intensity of “excavations” at the site.

We were not able to make a definitive statement on the character of the assemblage uncovered at Champ Pagès by earlier workers. However, in view of the results of our work at Le Moustier (see above), we are inclined to reject the interpretation that the Champ Pagès assemblage was in a primary archaeological context. Its close association with large river pebbles and the co-occurrence of Middle and Upper Palaeolithic artefacts suggests that it is a secondary association. In view of the possible implications of an in situ occurrence of a Levallois workshop at that location, however, this hypothesis definitely needs to be tested by further fieldwork at the site.

3.3 The Lespinasse/Tursac area

La Madeleine and environs

The excavations by Bouvier at La Madeleine have demonstrated the importance of the Vézère deposits in the infill of this large rock shelter. The earliest archaeological level is a Magdalenian IV, in the basal part of a fluvial sequence, which is up to 3m thick (Bouvier 1977). The Magdalenian IV is at about 1 m above the Vézère’s present water level (Bouvier and Mémoire 1988, fig. 3) and its matrix consists of loamy sand with some gravel (Bouvier 1973, 2627).

The deposits were interpreted as fluvial. It is difficult to correlate this depositional flooding phase to a specific terrace level, as observed in the transects in the present floodplain, since the terrace deposits are coarse-grained channel (lag or bar) deposits related to an average water level within the channel, in contrast to the fine-grained deposits in the rock shelter, that were deposited as flood deposits. The majority of these deposits is not preserved, but probably eroded during a later flooding phase.

Situated at about 100 m downstream from the centre of the La Madeleine abri, in the same cliff, is the Abri de Villepin, where Peyrony (1936) excavated two Magdalenian VI layers, situated in deposits of the Vézère. It is very well possible that these constitute only the final part of a much more important fluvial sequence, as demonstrated at La Madeleine by Bouvier (1977, 77).

Over 2.8 km upstream (or 500 m in a straight line) of La Madeleine two transects were sampled in the alluvial plain of the Vézère in 2001, transects Tursac (fig. 4) and Lespinasse (fig. 5). Roughly 1.6 km downstream of La Madeleine, another transect, Bout-du-Monde (fig. 6), was cored. The corings were all intended to sample the alluvial deposits up to the coarse-grained channel floor.

Transect Tursac 2001

Transect Tursac (fig. 4) shows the valley bottom of the present river, which consists of gravel, at a depth of ca. 59 m. The gravel is covered with ca. 4.5 m of mainly overbank deposits. Directly on top of the terrace gravel (clayey) laminated overbank loams are present. The clayey loams are erosively overlain by loamy sands. These sands can be interpreted as levee sands, related to the present channel course. In the east these levee deposits are overlain by sand loams with locally some clayey intervals. The present river course appears to be dominated by coarser overbank deposits and to have incised in older overbank loams.

Transect Lespinasse 2001

Transect Lespinasse (fig. 5) has a complex sequence. From the valley sides, the top of the gravelly valley floor deposits decreases stepwise in height, down to the present thalweg, which is located at a height of ca. 58.7 m. At both valley sides the top of the sandy gravel deposits is located at a height of ca. 62 m. This level decreases to a height of 61.2 m in the north. In the south, the height decreases further to 59.7 m and finally 58.7 m near the present river.

The stepwise incision points to buried terrace levels. At least two, perhaps three higher terraces can be distinguished from the present river, based on the height of the terrace gravel. In the uppermost terrace, in the east, a palaeochannel

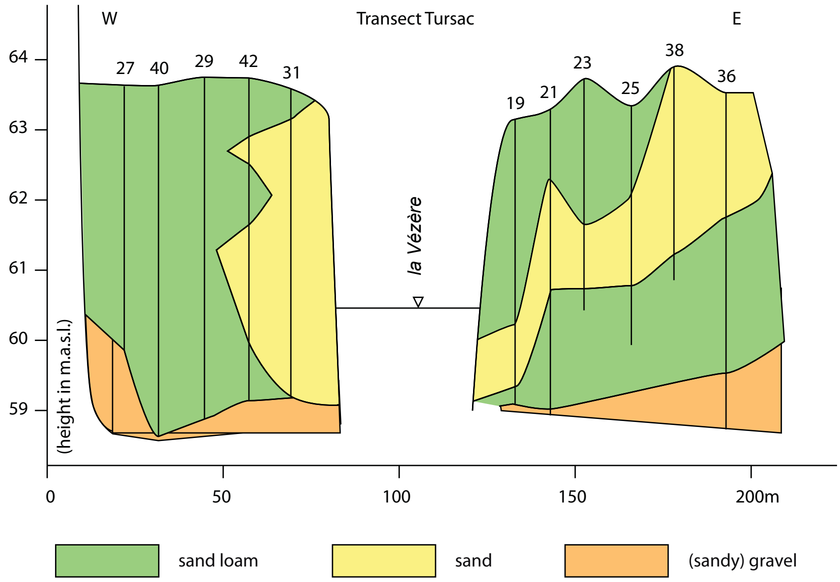

Figure 4 The transect at Tursac

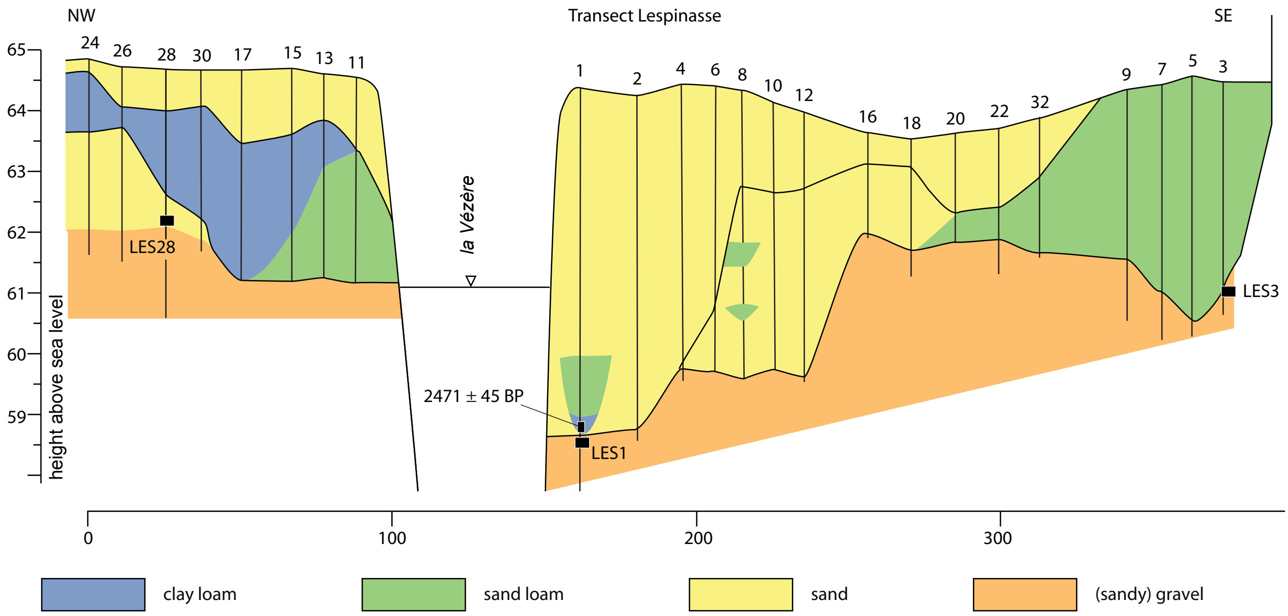

Figure 5 The transect at Lespinasse

has been preserved, which is filled with clayey overbank deposits. In the north, loamy fluvial sands are present on top of the highest terrace, at a height of ca. 1.0-2.8 m above the present water table, which may be related to similar deposits at La Madeleine. The terraces are capped by overbank deposits. The upper terrace is covered by ca. 2.5 m of overbank deposits, and the following terraces by 3.2 and 4.8 m respectively.

The present river has incised deeply into the older fluvial deposits and laid down predominantly (loamy) sand, suggesting a change in river regime to a more energetic system, similar to our observations in the Transect Tursac.

The relative chronology of the sequence could roughly be established by C14-dating and by Optically Stimulated Luminescence (OSL) dating. Near the present river course an organic interval at 10 cm above the channel base was sampled, which contained many leaves and several seeds as well as a fragment of catkin from *Alnus glutinosa*. The fragments were probably not transported over a long distance, as the delicate organic remains were relatively well preserved. The seeds and catkin dated to 2471±45 BP (UtC-11501), i.e. 760-410 cal BC (calibrated with Oxcal 4.1). Furthermore, three OSL samples were dated. Two were sampled from sandy intervals on top of the highest terrace (LES28 and LES3) and one (LES1) was obtained from the sandy interval just below the C14 sample. The luminescence dates showed inconsistent results, which is either due to improper bleaching, according to M. Bateman (Sheffield University, United Kingdom) or to inhomogeneous dose rates between the different grains, as suggested by J. Wallinga (Delft University, The Netherlands).

The OSL results obtained by M. Bateman are shown in table 1. The resulting OSL ages are not unproblematic and spread widely, however they do seem to suggest that the final incision phase is very young (LES1). The radiocarbon date points to the Iron Age for the time of sedimentation, while the OSL-sample LES1 obtained from below the C14 sample points to an even more recent date. The other two OSL-samples indicate a Late Glacial to Early Holocene age for the sediments on top of the terrace sequence, suggesting a Weichselian Pleniglacial age for the underlying channel deposits.

3.4 Transect Bout-du-Monde 1998

At 700 m straight or 1.8 km along the present river downstream from La Madeleine is the Abri Bout-du-Monde (Peyrony 1947a). The limestone bedrock of the *abri*, situated approximately at the current level of the Vézère (Peyrony 1947a, 182) is covered by about 1.55 m of sandy Vézère deposits which yielded a reindeer antler. These sediments are covered by 0.5 m of calcareous *eboulis* from the disintegration of the rock shelter's roof mixed with fluvial sands, on top of which a Magdalenian assemblage was uncovered from fluvial sands ("sables fluviatiles abandonnés par la Vézère", Peyrony 1947b, 184-186). The assemblage contained various Magdalenian facies, with late Magdalenian elements being the most important ones.

Transect Bout-du-Monde (fig. 6) starts near the rock shelter and shows the fluvial deposits from the limestone cliff up to the present river. It was sampled in 1998 and the first coring next to the abri shows a sandy fluvial sequence of almost 4 m. The coring could not penetrate deeper and it was believed that the calcareous basement was reached, since only calcareous flakes were sampled. The fluvial sand is covered by ca. 1.8-2.0 m of overbank deposits, increasing to 4.5 m to the present river. The overbank deposits consist of sand loam, overlain erosively by loamy sand. This loamy sand usually contained gravelly intervals and a gravel base, suggesting an erosive nature. The presence of the older fluvial sand near the limestone cliff agrees with the data of Peyrony (1947b), and may suggest that the fluvial sand in this transect also dates from the Magdalenian. The overbank deposits on top are younger.

The stratigraphical data from Bout-du-Monde correlates well with transects Lespinasse and Tursac, which also show the incision and a change to a more energetic system, dated roughly to the Iron Age in Transect Lespinasse. The top of the fluvial sand near the *abri* is located on the same (relative) height as the top of the sandy deposits on the highest terrace north of the present river in transect Lespinasse. Both are situated ca. 1.5 m below the average surface level. This may suggest a similar age, with the OSL-date (9.5 ±1.0 ka) and the Magdalenian dates for Bout-du-Monde forming a – admittedly very rough – match.

3.5 Transects Le Manaurie 1998 and Laugerie-Haute Est 1999

Transect Le Manaurie samples the small tributary just upstream of Laugerie (fig. 1 and 7). It was cored in 1998 and shows a sequence that is characterized by relatively fine-grained deposits. The current thalweg is located at 59.5-60 m and the top of the channel deposits do not increase in height towards the valley side. The channel deposits are covered by clayey loam and sandy loam, a coarsening upward sequence similar to the transects in the Vézère valley. Since the channel deposits are situated roughly at the same height it can be concluded that the valley has no older terrace remnants. This is common for smaller rivers: they often react

Lab code	Field ref.	Depth (m)	Dose rate (μGy/a)	Palaeodose (Gy)	Age (a)
Shfd02018	LES1	6.3	1995±112	2.77±0.02	1415±80
Shfd02019	LES28	3.5	2892±254	16.66±0.38	5760±520
Shfd02020	LES3	3.5	2938±219	35.98±0.48	12250±930

Table 1 OSL-age estimates (in years) for sediment samples from the Lespinasse transect (see fig. 5 for position of the samples) (data pers. comm. M. Bateman, Sheffield University, UK).

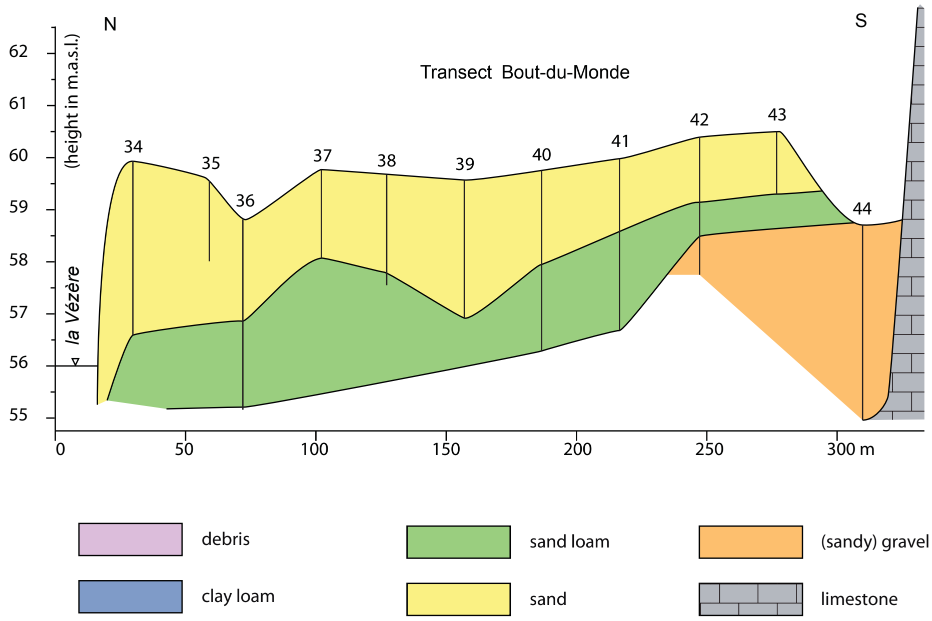

Figure 6 The transect Bout-du-Monde

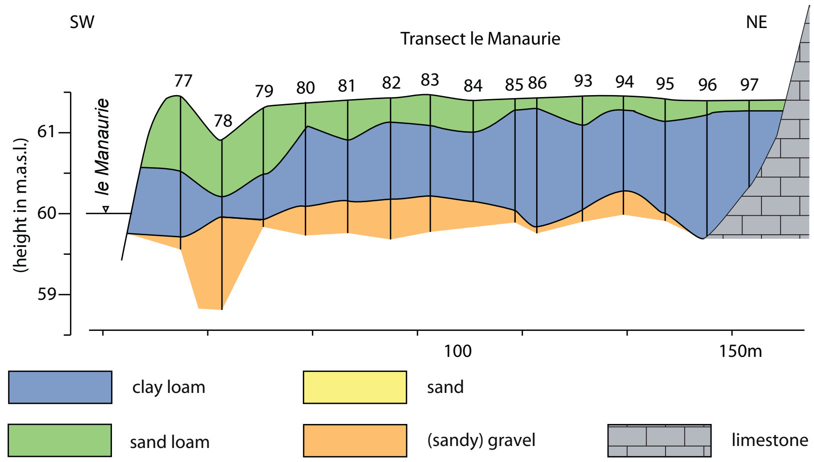

Figure 7 The transect through the valley of the Manaurie river.

less sensitive to changes in climate or hinterland. Apparently here, the threshold for an incision to a new alluvial plain was not passed, in contrast to the Vézère river.

Transect Laugerie-Haute Est is located just below the Laugerie-Haute Est rock shelter (fig. 8) and sampled the floodplain in front of that abri in 1999. The fluvial deposits were sampled from directly in front of the abri deposits that were excavated in 1999 (see below). These abri deposits were covered by the *déblais* from earlier excavations by Peyrony and others including Otto Hauser (fig. 9 and fig. 10) (see below). On the transect this pile is well visible in the steeper slope.

The fluvial sequence consists of gravelly sand and gravel at the base, which range in height from ca. 56 m near the present channel up to 59.5 m near the front of the abri. The southeastern bank shows one terrace step at 57-58 m, while the channel deposits in front of the abri, on the opposite bank (NW) show a more complex topography, with at least two

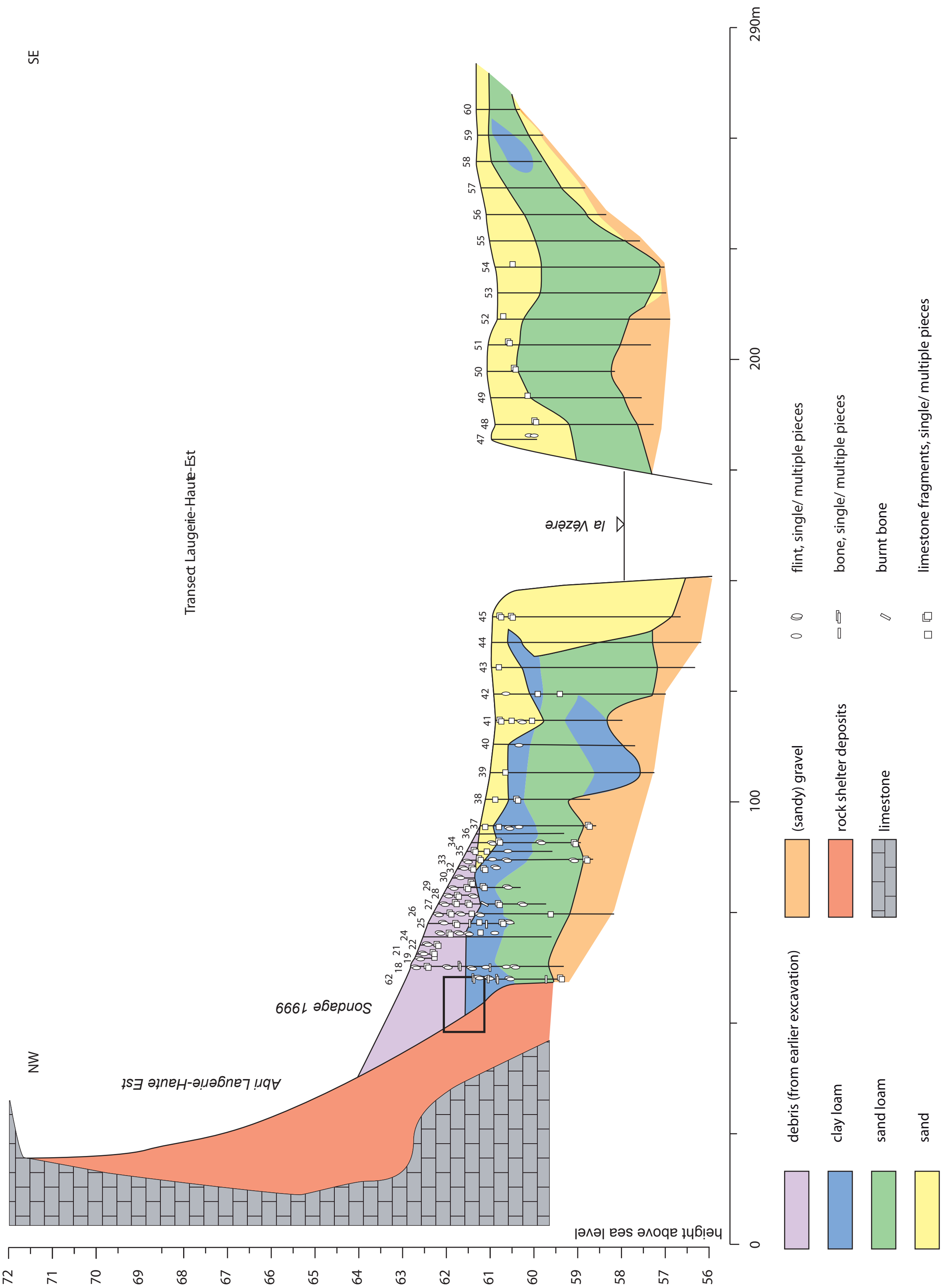

Figure 8 The transect in front of Laugerie-Haute Est, from the back wall of the rock shelter via the departmental road (RD47) and the location of the sondage to the Vézère river. The position and depth of the augering holes is indicated by a vertical line.

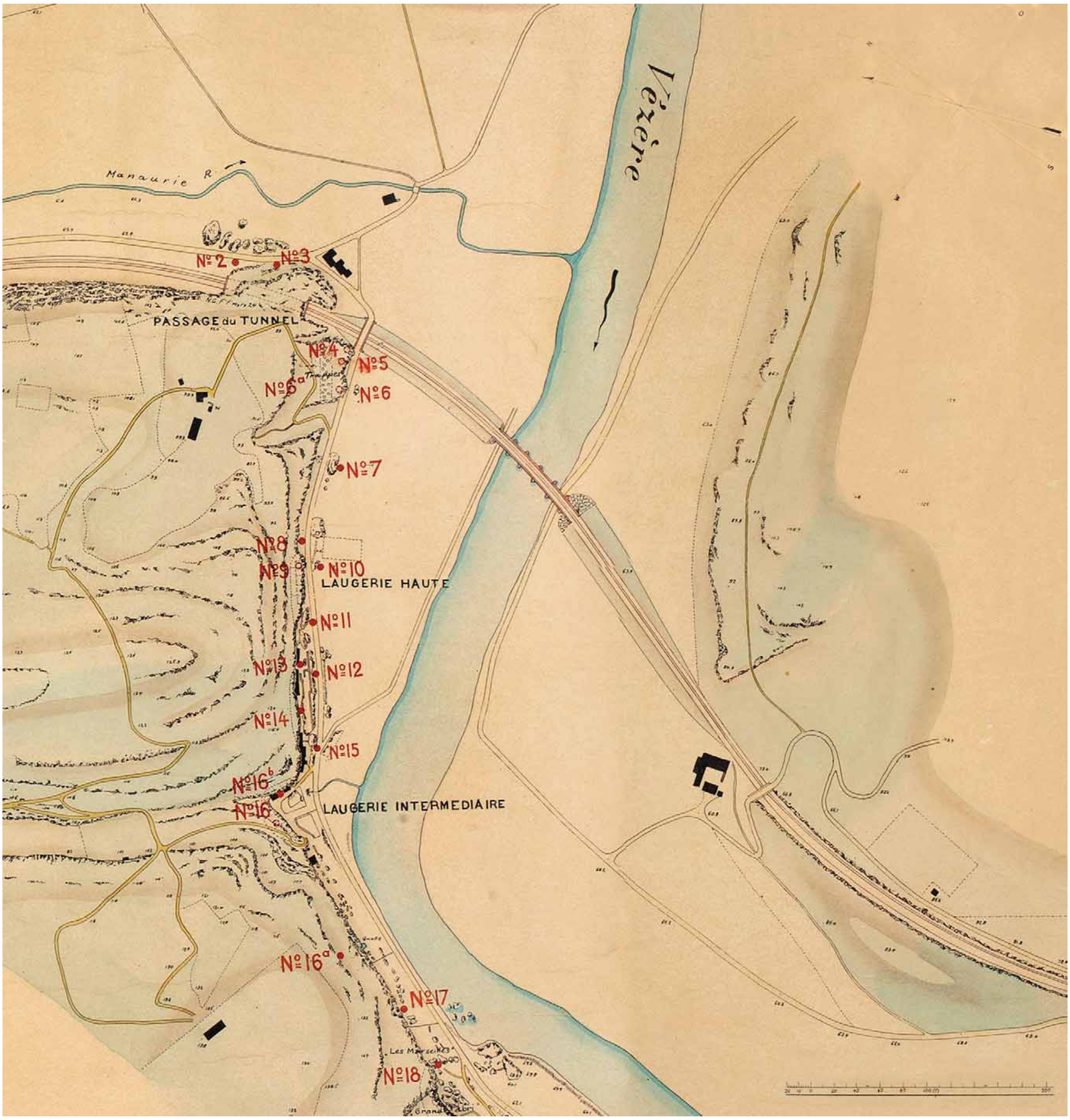

Figure 9 Detail of a map of Les Eyzies and environs, produced by Otto Hauser, zooming in on the Laugerie-Haute site complex, early 20th century (*Übersichtsplan der prähistorischen Fundstätten No. 1-41 und Font de Gaume in der Umgebung von Les Eyzies im Tale der Vézère. Aufgenommen und gezeichnet von April 1907 – Mai 1908 von Th. Baumgartner, Ingenieur u. Konkordatsgeometer Seebach-Zürich*). Scalebar = 220 m.

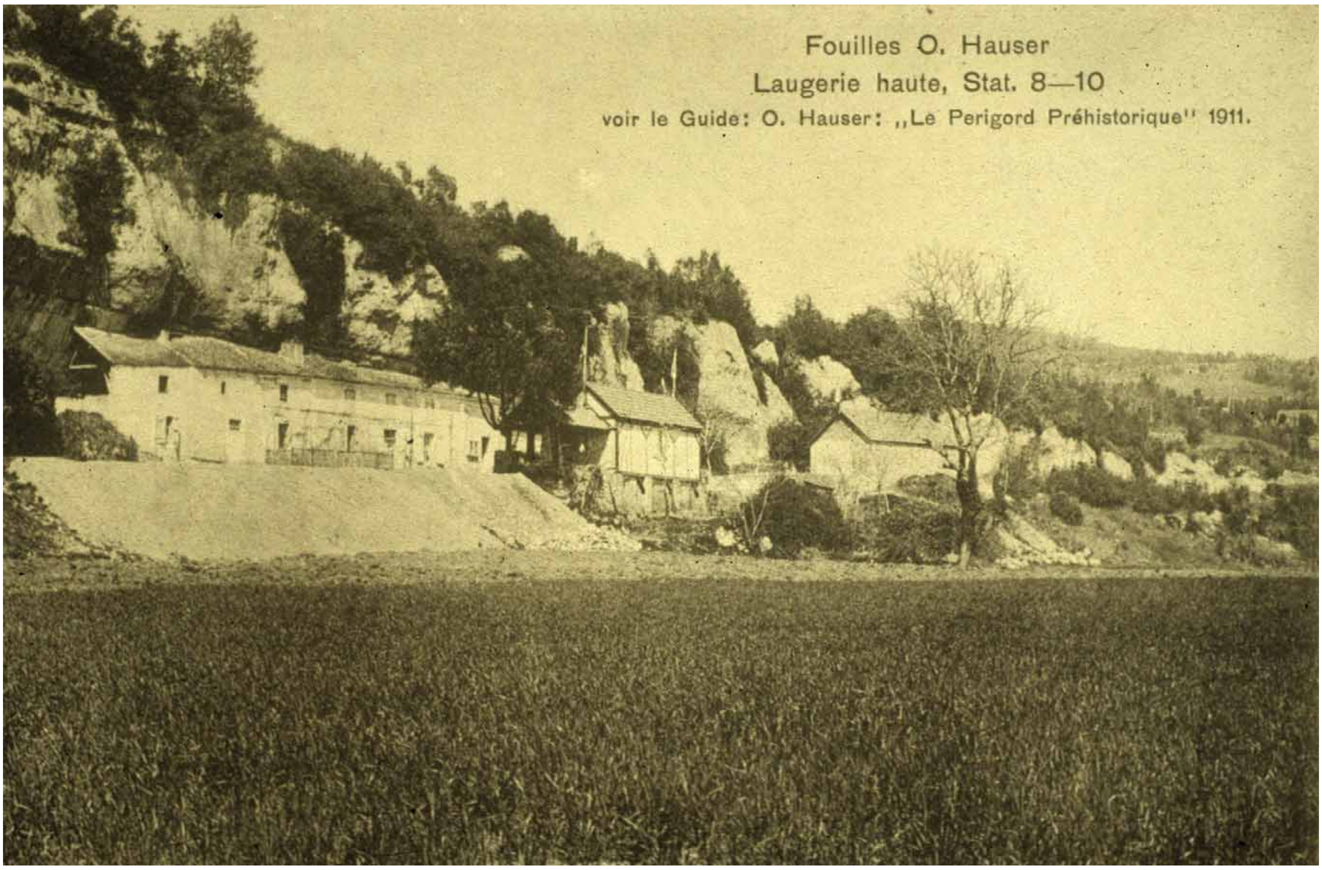

Figure 10 Early 20th century postcard of Laugerie-Haute, showing the location of Otto Hauser's excavations at the base of the cliff.

different steps, at 59.5 m and at 57 m. The latter might be similar to the terrace on the opposite side of the river. The upper level may relate to the upper terrace level in transect Lespinasse. The gravel is overlain by overbank deposits, which consist of sandy loam at the base, with locally some clayey intercalations. This sandy loam is overlain by clayey loam in front of the rock shelter and all deposits are finally erosively overlain by (loamy) sand. During augering, artefacts were recovered in these fluvial sediments at various depths, up to ca. 3 m (Roebroeks *et al*. 2000).

In general, the overbank deposits show a coarsening upward sequence, similar to the other transects. The loamy sand cover is related to the young erosional phase that has incised into the older deposits of the river. This phase has also been sampled in transect Tayac (published in Mol *et al*. 2004). At 5.25 m below the surface, the sandy deposits yielded a branch of *Populus* wood interpreted as driftwood, which was C14-dated to 1215±40 BP (OxA-8503). Although this date is much younger than the date in Transect Lespinasse, it also strongly suggests a young age for the final incisional phase and accompanying deposition of sand. Near the rock shelter the older overbank deposits show a clayey interval on top of the sandy loam, similar to the left bank in transect Lespinasse. They overlie the southern part of the excavated abri/slope deposits that contain Magdalenian artefacts (see below).

3.6 Conclusions

Similar to the other larger river valleys in this region, the valley of the Vézère is dominated by a large sequence of terraces that date to the Pleistocene. During the final phase of the Late Pleistocene, the period at stake in this study, the Vézère still displayed an erosive character: older gravelly terrace deposits were eroded and replaced at lower levels by a younger, gravel-dominated alluvial plain. Since then, during the Holocene, the river has changed from an erosive to a depositional style, in which several meters of overbank loam have been deposited on top of the older terraces.

The current, Holocene, infill of the valley of the Vézère mainly consists of coarser, loamy, sands. This depositional phase is preceded by an incision phase which is probably relatively recent. The radiocarbon evidence points to an Iron Age or an even younger date for these deposits and hence for the final incision phase. Since then, the depositional style of the river has changed to a more energetic one, with sand and levees. Currently, the river is probably still eroding its older deposits, as suggested by the data from Lespinasse and Le Moustier. The sand covers older, finer-grained clayey and loamy overbank deposits. These loams completely cover an older terrace sequence, thus concealing an important episode of the history of the Vézère river (see also Mol *et al*., 2004). The OSL-dates, although disputable, point at least to Weichselian ages for the buried terraces and correspond to some extent with the archaeological evidence. At some localities the overbank loams also cover fluvial sands (Lespinasse, Bout-du-Monde) or very firm loams (Le Moustier). It is believed that these deposits are remnants of older fluvial depositional phases that once covered the channel deposits, but are now eroded in most places. It has become clear that the best chance of finding an old terrace sequence with fluvial sand on top (and possibly with primary context traces of Palaeolithic human presence) is near the steep valley sides, located far from the present river.

4 Laugerie-Haute Est: Sondage 1999

4.1 Introduction

In the 1998 fieldwork, hand-augering of the deposits at the foot of Laugerie-Haute Est (see the transect discussed above, fig. 8) showed the presence of small flint artefacts and faunal remains at various depths in fine grained deposits interpreted as Vézère sediments (fig. 8). We considered the presence of these finds in front of the prolific *abri* sequence of Laugerie-Haute as indicating that this might be a good area to study the relationship between *abri* and river valley deposits and for retrieving material remains of human activities in the river valley proper. The 1999 fieldwork focused on these questions, more specifically on the question whether 'intact' *abri* deposits were still present south of the Route Départementale 47, and if so, how they would relate to the fine grained river deposits of the Vézère, which are up to 5 metres thick there[1]. In order to answer these question we opened a small *sondage* (fig. 11).

4.2 The Sondage

The aim of the *sondage* being to identify the presence and the character of the artefact bearing deposits encountered in the 1998 boring and their relationship to the *abri* deposits, we started to remove the ploughsoil and the back dirt (*déblais*) of earlier excavators by hand. This was done, over an area of about 3 by 5 metres, in the northwestern part of *parcelle* no. 1193 (see fig. 12), where earlier work carried out during road extension suggested that the *abri* deposits might still be present (pers. comm. A. Morala and A. Turq 1998). This was a time demanding enterprise, as the thickness of the *déblais* proved to be considerable, up to about 1 m. As already stressed by other workers at Laugerie-Haute (Chadelle 1994), these deposits contain large numbers of flint artefacts and faunal remains, alongside modern material, especially fragments of broken bottles. They are probably part of the 2000 cubic metres back dirt of earlier excavators, which D. Peyrony removed in July 1921, before starting his own excavations at the site (Peyrony and Peyrony 1938).

Once these deposits were removed and the probable *abri* deposits were encountered, the trench was narrowed down to an area of roughly 2 by 6 metres, the central part of which could not be deepened because of the presence of a major north to south running water pipe which had cut right into the *abri* deposits and necessitated relocation of the layout of our sondage.

After removal of the *déblais* over the 2 by 6 metres area, a square metre grid was laid out by means of a Total Station, and these square metres were subdivided into four 50 by 50 cm squares (1A up to and including 10D). These squares and sub-squares formed the basic collecting units for the remainder of the 'excavation', with the deposits of squares 5A, 5B, 6A and 6B largely having been destroyed during the insertion of the water pipe. As our operation was not aimed at an excavation per se, we limited ourselves to a documentation of the find distribution in the 'clean' top of the abri deposits (fig 13). Hence artefacts and faunal remains encountered during the superficial (2-5 cm) *décapage* (D1) of the *abri* deposits were collected per quarter of a square metre, while all the sediment was wet sieved through a 1 mm screen. The location of all finds was recorded by means of a Total Station. For artefacts and faunal elements more than twice as long as their width, the slope angle and direction were registered.

During the first *décapage* it became clear that the sediments encountered below the *déblais* south of the squares 3 and 4 were not the same as those from squares 1, 2, 3 and 4. As visible in the section drawing and description of the east wall of the sondage (fig. 14), in the southern part of the trench an extra layer wedged in between the top layer and the unambiguous abri deposits, up to a maximum thickness of 50 cm in square 10. The removal of these intermediate deposits included collecting of all artefacts and faunal remains encountered and sieving of all sediments. All finds from this setting obtained the provenance L99 *D1 Verdiepingsvlak*, with the additional information on their provenance within the grid system. The finds from this fluvial matrix were probably "displaced" from the abri deposits by the (Holocene) activities of the

Figure 11 A view of the sondage, taken from the north, with the limestone cliff of Laugerie-Haute in the background. The cars are parked next to the Route Départementale 47, which separates the field with the sondage from the cliff. The entrance to the actual excavation area at the Laugerie-Haute Est rock shelter is to the left of small row of houses, once in use by Otto Hauser.

Vézère, and will not be considered further here. Wet sieving of these deposits yielded some interesting finds though, e.g. three small beads, two of which were made out of agate, one out of quartzite.

After removal of these – very probably: fluvial – deposits (see below), the top of the abri deposits proved to display a slope angle of about 18 degrees in the southern part, i.e. steeper than in the north, where the angle was around 12 degrees. The abri sediments and the enclosed finds were recorded in the same way as had been done for the northern squares.

Hence, artefacts registered as being from the first (and only) *décapage* in the northern part (D1 in squares 1-4) are the stratigraphical equivalent of those from the second *décapag*e (D2) in squares 5 and higher numbered squares. All of the finds from that same level have been assigned to level D1_2, and only these will be described here.

One metre to the south of the main trench a second, smaller trench (2 by 3 m) was opened in order to chart the distribution of the abri deposits and their relationship with the river sediments. Once the abri deposit level was reached (D2), at about a depth of 1.4 m, this was treated in the same way as in the main trench. However, it proved to be preserved over a north-south extension of 0.8 m only, the deposits having been eroded further south, very probably by the Vézère (see below).

In the second trench, the loamy Vézère deposits contained flint artefacts and the occasional faunal element, with a notable vertical concentration about 80 cm below the top of the sequence, i.e. at 61.60 m. Our initial field interpretation was that these finds had been ‘excavated’, reworked by the Vézère from the abri deposits during various high water level events, and that they were in secondary position, occasionally concentrated into a kind of ‘lag’ deposit as reflected by the concentration with extremely ‘flat’ orientation of flint artefacts.

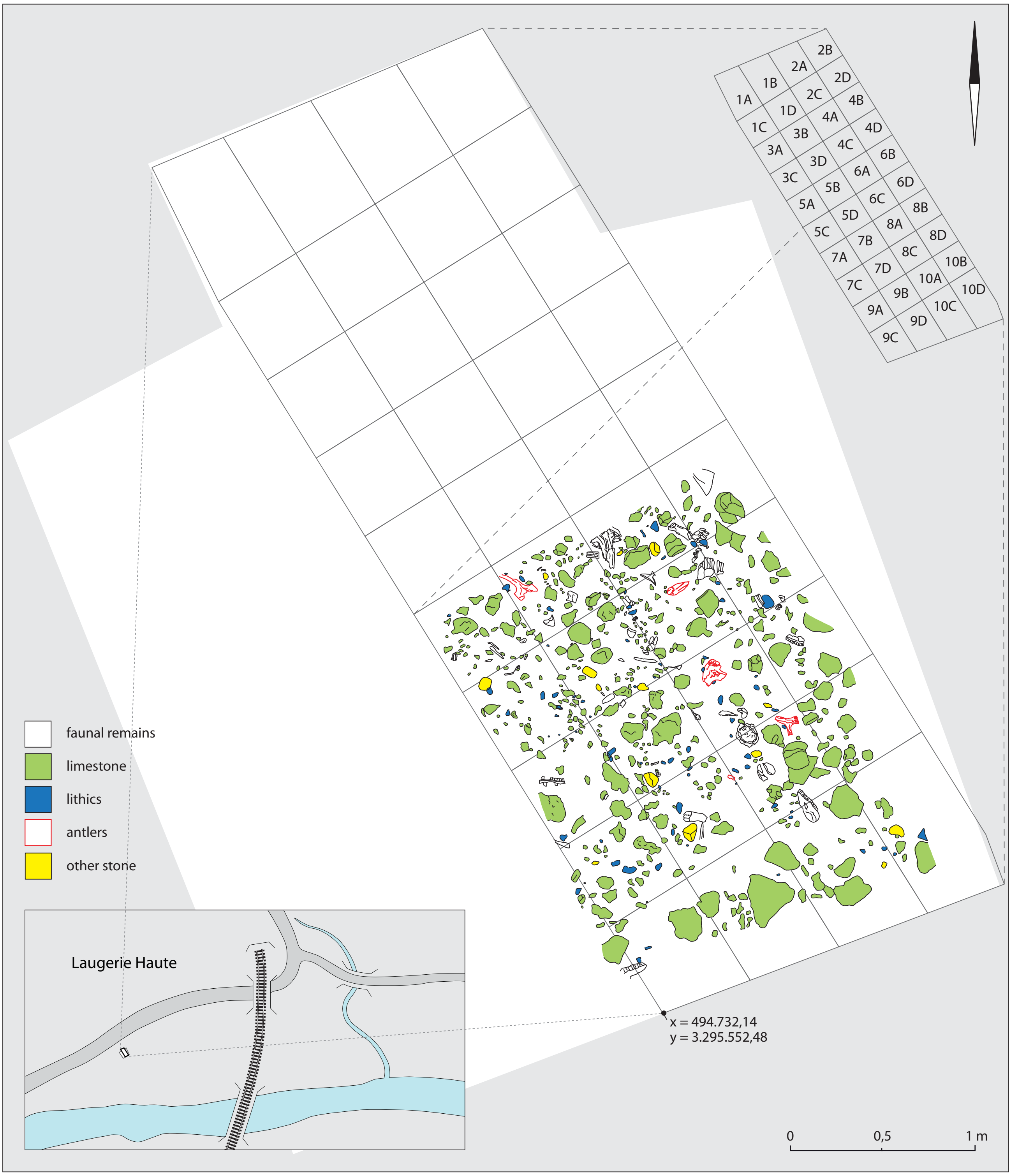

Figure 12 An overview of the spatial distribution of the D1-D2 finds (outlines traced only) in the southern part of the sondage. Indicated are the excavation grid and the coordinates of the excavation trench.

Figure 13 An overview of the top of the abri deposits during sampling, in the northern part of the sondage.

4.3 Stratigraphy

Figure 14 gives a schematic drawing of the east section of Sondage 1999, with a description as well as an interpretation of the various layers.

4.4 The Finds

Lithic industry

Most of the stone artefacts recorded from the top of the abri deposits were made out of dark gray to black flint, generally locally collected as judged from the rolled cortex of the raw material. Small numbers of artefacts were made out of Bergerac flint, jasper (*jaspe*), chalcedoine and hyaline quartz.

Tables 2 to 4 give a general overview of the assemblage recovered from the top of the abri deposits, following the typology of de Sonneville-Bordes (1960). Comparing the assemblage with the earlier observations by Peyrony and Peyrony (1938), the bulk of the 1999 *sondage* assemblage fits very well into Peyrony's Magdalénien III: *lamelles droites à bord abattu*, sometimes denticulated, are common,

Flint artefacts < 3cm	3126
Flint artefacts > 3cm	1278
Blades and blade fragments	384
Cores and core fragments (see Table 3)	14
Tools and tool-fragments (see Table 4)	112
Chutes de burin	74

Table 2 Composition of the Laugerie-Haute Est 1999 Sondage lithic assemblage, recorded from the top of the abri deposits, i.e. D1_2 (tools from the sieving residue included).

Nucleus prismatique à un et deux plans de frappe	2
Nucleus pyramidal	3
Nucleus globuleux	2
Nucleus informe	6
Nucleus discoide	1

Table 3 The cores from the Laugerie-Haute Est 1999 Sondage lithic assemblage, recorded from the top of the abri deposits (typology cf. De Sonneville-Bordes 1960).

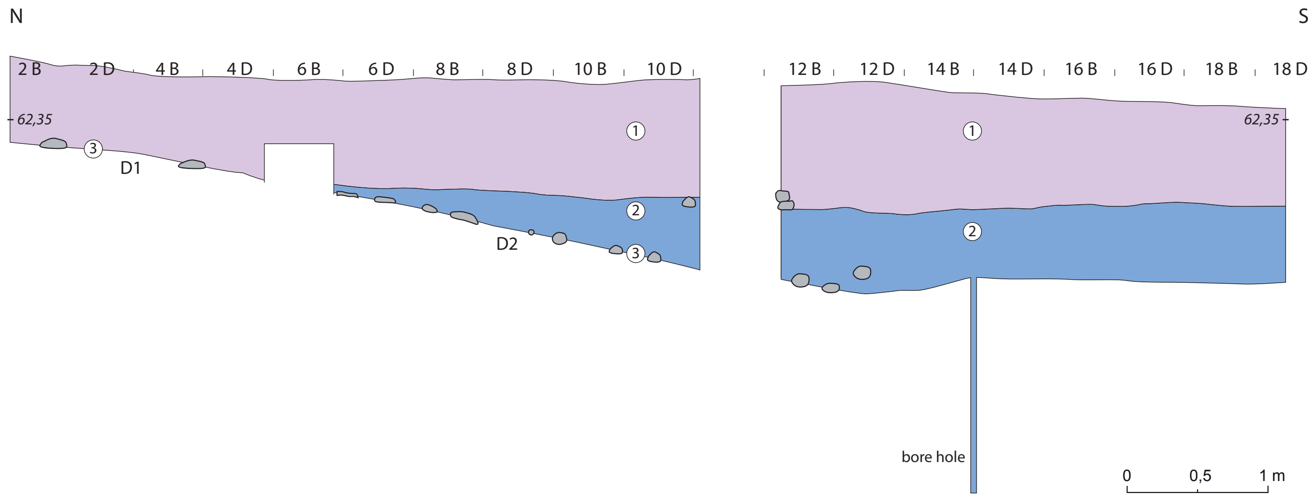

Figure 14 Schematic section of the east wall profile of the 1999 sondage.

Description

1) Loamy silt (7.5YR3/3), friable, with abundant chalk fragments (up to 25 cm diameter), flint artefacts and pebbles, common fine and larger biopores, the upper 35 cm somewhat lighter in colour (7.5YR3/4). Boundary with horizon below sharp (<5cm) in the southern half of the exposure (Trench 2), less visible in the north. In Trench 2 many horizontal flint artefacts are present at the sharp boundary with the horizon below.
2) Loamy silt (5YR4/4), friable to firm, with especially in the northern part common chalk fragments – some burnt -, flint artefacts and bone fragments, common medium biopores, boundary with horizon below vague (10cm) (sediment sampled by J.-P. Texier, Bordeaux, for thin section analysis, October 20th 1999).
3) Loamy silt (5YR3/4) with many chalk fragments (from 1 mm up to 25 cm), many of which are burnt (orange, 2.5YR6/8), many flint artefacts and bone fragments, fragments of quartz pebbles and other cultural material.

Interpretation

1) Ploughsoil developed in a mixture of excavation *deblais* and fluvial deposits, in the northern part of the section the ploughsoil has developed in the abri deposits.
2) Fluvial deposits of the Vézère floodplain, with reworked archaeological material "excavated" by the action of the river, which nowadays still reaches the location of the sondage, be it very rarely.
3) Top of the Laugerie-Haute abri deposits, in the southern part of the exposure ending abruptly, very probably as a result of erosion by the river. The height of the"talus" of the eroded abri deposits is more than 2.10m, as shown by a boring south of the sondage.

while *triangles scalènes*, typical for his Magdalenian II, are virtually absent (Peyrony 1938, 56). In a comparison of cumulative graphs of the assemblage from our sondage to those published by Francois Bordes (1958) for Magdalenian assemblages retrieved during his excavations at Laugerie-Haute Est, Kamermans *et al.* likewise conclude that the D1_D2 assemblages display a striking resemblance to Bordes' Magdalenian III assemblage (Kamermans *et al.* 2003).

Indices (N=112)		
Indice de grattoir IG	23.2	(26)
Indice de burin IB	25.0	(28)
Indice de percoir IP	3.6	(4)
Indice de burin dièdre Ibd	17.0	(19)
Indice de burin sur troncature Ibt	8.0	(9)
Indice de grattoir aurignacien IGA	0.9	(1)

Table 4 Survey of the tools from the Laugerie-Haute Est 1999 Sondage lithic assemblage, recorded from the top of the abri deposits, D1_D2 (typology and indices cf. De Sonneville-Bordes 1960).

Apart from the typology of the assemblage, the raw materials also point to a correlation with Peyrony's (and Bordes 1958) Magdalenian III: the 1999 Sondage assemblage contains various flakes of hyaline quartz, described as very striking for the Magdalenian III assemblage by Peyrony and Peyrony (1938). Likewise, thick scrapers and flakes with an abrupt retouche (*raclettes*) are very rare.

The 1999 Sondage yielded a few unambiguous Solutrean tools, in the middle of what looked like a "classical" middle Magdalenian assemblage. They include a fragment of a *feuille de laurier* recorded during the excavation (Square 8C/D2, no. 5101). Comparable observations have been made for the Magdalenian III couche 2, excavated by Francois Bordes in 1955, which likewise contained three fragments of *feuilles de laurier* (Bordes 1958, 214).

Faunal remains.
The find level contained a large amount of faunal remains, including lower jaws of horse and reindeer, skulls and skull fragments as well as antlers (mainly of red deer). Some remains, e.g. vertebrae, were in anatomical connection. In the field the number of astragali and fragmented parts of metacarpals and metatarsals was striking. Detailed analyses of the faunal complex showed that cranial parts and bones from front- and hind leg dominate the assemblage. Vertebrae and costae are poorly represented. Table 5 gives an overview of the smaller mammals remains recovered during wet sieving of the sediments, table 6 lists the large mammal species identified deriving from the find horizon D1_2.

Small mammal remains (N=538)
The small mammal assemblage (table 5) consists of species that are extant in the region. The assemblage includes species indicative for the presence of forest vegetation (*Eliomys quercinus, Apodemus* sp., *Clethrionomys glareolus*), but taxa that are semi-aquatic (*Arvicola terrestris*) and those that inhabit more open landscapes (*Microtus agrestis* and *M. arvalis*) dominate. Small mammals that prefer a dry steppe habitat (e.g. hamsters and ground squirrels) as well as those that tolerate cold climate conditions (e.g. tundra dwellers such as lemmings) are absent.

Large mammal remains (N=452)
The larger mammal fauna (table 6) is dominated by horse (*Equus* sp.) and reindeer (*Rangifer tarandus*). Both species are represented by at least 3 adult individuals and one juvenile based on the occurrence of a milk molar. Red deer (*Cervus elaphus*) and *Bos/Bison* are less frequent. Typical steppe dwellers (e.g. *Saiga tartarica*) and species characteristic for the Pleistocene Mammoth Steppe faunal community (e.g. *Mammuthus primigenius* and *Coelodonta antiquitatis*) were not observed. The mammal assemblage is characteristic for a post-glacial period in which only remnants of the previous cold stage fauna that are able to adapt to milder climate conditions (e.g. reindeer) still occur in the area.

Peyrony and Peyrony (1938) described the sequence exposed at Laugerie-Haute Est and presented data on the mammal fauna they recovered from their levels B-K. According to Peyrony and Peyrony (1938) smaller mammals are only known from the levels F and I'. The small mammal associations from both levels hardly differ from the one from the 1999 Sondage. Remarkable is that the garden dormouse *Eliomys quercinus*, a forest dweller, occurs in both small mammal associations.

The larger mammal fauna in all levels described by Peyrony and Peyrony (1938) is dominated by *Rangifer tarandus*. In the lower levels (B to H), of Gravettian and Solutrian age, *Mammuthus primigenius* occurs (although the amount of remains was small). The woolly mammoth is, together with *Coelodonta antiquitatis* (Level B) and *Ovibos moschatus* (level H"'), indicative of more glacial conditions during deposition of the lower part of the sequence. In the absence of these species, the 1999 Sondage fauna can best

SPECIES	NISP
Insectivora	
Sorex araneus	2
Sorex sp.	2
Talpa europaea	5
Lagomorpha	
Leporidae indet.	1
Rodentia	
Eliomys quercinus	1
Clethrionomys glareolus	5
Arvicola terrestis	97
Microtus (St.) gregalis	
Microtus oeconomus	16
Microtus agrestis	9
Microtus arvalis	7
Microtus agrestis/M.arvalis	68
Microtus sp.	319
Apodemus sp.	6
Total number of specimens	538

Table 5 Survey of the small mammal species recovered from the top of the abri deposits during the 1999 Sondage (NISP: Number of Identified Specimens).

SPECIES	NISP	MNI
Perissodactyla		
Equus sp.	99	3
Artiodactyla		
Cervus elaphus	16	1
Rangifer tarandus	78	3
Cervidae indet.	75	
Bos/Bison	9	1
INDET	175	
Total Number of Specimens	452	

Table 6 Survey of the large mammal species recovered from the top of the Laugerie Haute Est abri deposits during the 1999 Sondage (NISP: Number of Identified Specimens, MNI: Minimum Number of Individuals).

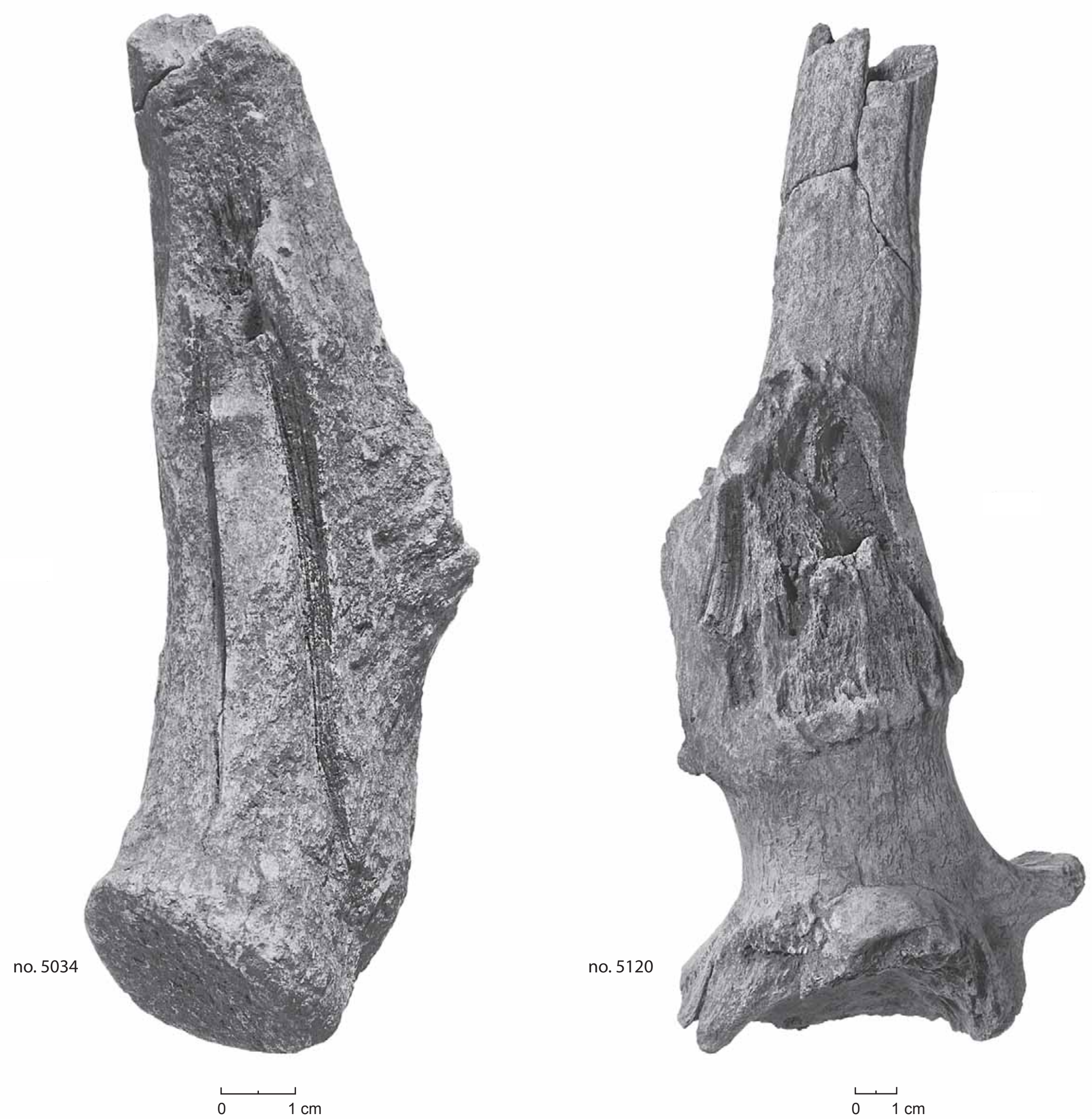

Figure 15 Fragment of shed antler with signs of groove and splinter technique (no. 5034) and antler attached to skull showing signs of working (no. 5120).

be correlated to the ones from the Magdalenian levels. The sample from our (very limited) sondage displays some differences with the Magdalenian fauna uncovered by Peyrony and Peyrony though. For instance, we did not recover remains of the saiga antelope (*Saiga tartarica*) and in the 1999 Sondage horse is one of the dominant larger mammals whereas in the Laugerie-Haute Est levels the reindeer/horse ratio is often greater than 5/1 (Boyle 1990; Madelaine 1989). Reindeer dominates the late Upper Palaeolithic larger mammal fauna and only disappears from the region at the very end. The fact that reindeer does not dominate the fauna from the sondage could be seen as an indication that we are dealing with a late- or post-Magdalenian association. However, given the very limited size of the sondage and of the resulting faunal assemblage compared to Peyrony's work, it is probable that the differences can be explained by differences in sample size.

Non-stone artefacts

A remarkable find category in the 1999 sondage consists of a few red deer antlers displaying traces of the groove and splinter techniques (fig. 15). During D. Peyrony's excavations at Laugerie-Haute Est, the Magdalenian III layer yielded a large number of worked deer antler, as in our small *sondage*, much more than reindeer, to the degree that: “On dirait que les troglodytiques avaient une prédilection pour cette matière, alors qu’elle est plutôt rare dans les autres niveaux” (Peyrony and Peyrony 1938, 58). The sieve residue of square 9B contained various incisors and canines of reindeer, “cut” off about halfway of the root in a comparable way. We were able to conjoin a set of 6 incisors and 2 canines of a reindeer calf (fig. 16). Comparable finds are known from other Magdalenian sites, for instance, Gönnersdorf and Andernach in the Neuwied Basin in Germany (Alvarez Fernández 1999; Bosinski 1992; Poplin 1972; 1983), Petersfels, Baden-Württemberg, Germany (Albrecht *et al*. 1994), Neuchâtel-Monruz in Switzerland (Affolter *et al*. 1994; Egloff 1995) and at a number of French Magdalenian sites, such as Pincevent, Sergerac and Mas d’Azil (Poplin 1983). The sieve residue furthermore yielded a pierced premolar of a fox (fig. 17) and a decorated piece of bone, resembling a fragment from Peyrony’s Magdalenian III level interpreted as a “poignard” (compare fig. 18 with Peyrony and Peyrony 1938, fig. 45-4).

4.5 Site formation

In view of the angle of slope of the deposits, we expected the archaeological material to have undergone some horizontal displacement towards the Vézère, and that hence the finds were not in a primary archaeological context (Butzer 1982; Schiffer 1983). The degree of reworking is difficult to quantify though. As a minimum statement, the fact that some faunal remains, e.g. vertebrae, were found in anatomical connection indicates that we are not dealing with a heavily reworked assemblage. The fact that the eight ‘conjoining’ reindeer teeth described above were found in the sieve residu of one quarter of a square metre also indicates that displacement may have been limited. As all size classes are represented both in the sediment matrix and in the finds, displacement, if any, may have been of a ‘mass flow’ character.

To study the character of the possible reworking of the assemblage, the location of all finds was registered with a Total Station, with the x, y and z coordinates entered along with a code for the type of find and, for finds more than twice as long as wide, slope angle and slope direction (see Kamermans *et al*. 2003, for details). These last two variables were used to shed light on the mode of genesis of the assemblage. Fluvial transport or mass movement would have oriented the finds according to a specific pattern (Texier *et al*. 1998) and these measurements could help us to establish possible patterns. The orientation of 54 finds from level D1_2 was measured, and figure 19 and table 7 show a preference in orientation of these finds. This preference has the same direction as the slope. Almost 50% of the artefacts are oriented towards the slope.

Figure 16 “Refitted” incisors (6) and canine teeth (2) from lower jaw of reindeer calf, retrieved from the wet sieving debris (see text for explanation).

Figure 17 Fragment of a pierced premolar of a fox.

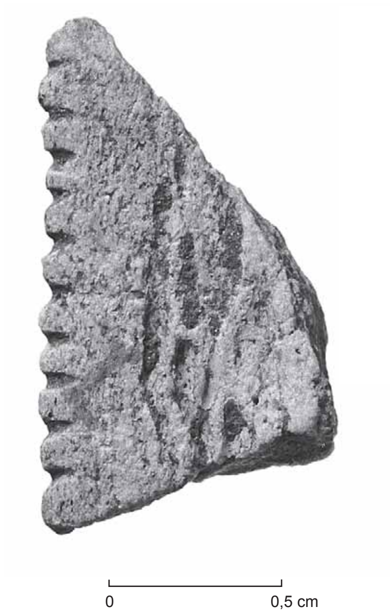

Figure 18 Worked bone fragment, possibly a fragment of a bone “dagger” (see text for explanation).

Experiments in periglacial settings (Texier *et al*. 1998) and observations elsewhere in France (Texier 1997) show that slope processes such as solifluction result in an orientation of the main axis of artefacts perpendicular to the direction of the slope – although subsequent studies have shown that these results might need to be qualified (Lenoble and Bertran 2004; Lenoble, Bertran and Lacrampe 2008; McPherron 2005). However, looking at the orientation of the artefacts from the sondage, our tentative conclusion is that the archaeological layers are not heavily disturbed and that the orientation is probably the result of a very moderate mass movement.

Of 45 artefacts from layer D1_2 the dip was measured and figure 20 and table 8 show that all artefacts dip between the horizontal and 40 degrees. 67% of all the artefacts are lying flat or parallel to the slope between 12 and 18 degrees. The orientation diagram (fig. 21 right) summarizes this information. Only the artefacts with both orientation and dip (N=45) were used (table 9). The mean orientation is 108.8 degrees. The spherical variance (s.var.) equals 0.688. Low values (towards 0) indicate a strong preferential direction; high values (towards 1) are an indication of no preference.

Given the fact that we found archaeological material from all size classes, very small stone pearls, reindeer teeth that once formed a necklace lying close together, as well as burin spalls and flint cores, the archaeological material in front of the rock shelter as encountered in the D1_2 level is most probably in primary context.

If we compare our findings with the results of Texier's work in Laugerie-Haute Ouest (Texier 2009, 132) we see a difference. Texier has clear indications for solifluction while we have not. His analysis of the orientation of 40 elongated objects, originating from the Solutrean layers (unpublished geological research in 1998), produced a mean orientation of 197.1 and a spherical variance of 0.449 (fig. 21 left). The

Orientation	Number of finds
N – NE	5
NE – E	5
E – SE	13
SE – S	12
S – SW	4
SW – W	8
W – NW	3
NW – N	4

Table 7 Orientation of 54 finds from the 1999 Sondage (general slope direction ESE). (Kamermans *et al*. 2003).

Dip	Number of finds
0-10 degrees	15
10-20 degrees	15
20-30 degrees	9
30-40 degrees	6

Table 8 dip of 45 finds (general slope between 12 and 18 degrees) (Kamermans *et al*. 2003).

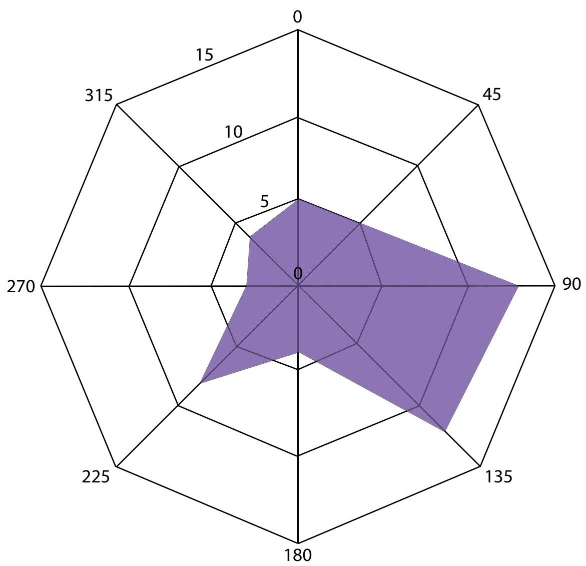

Figure 19 Rose diagram (in degrees) of the orientation of 54 finds. The number of finds is indicated along the Y axis. (Kamermans *et al.* 2003)

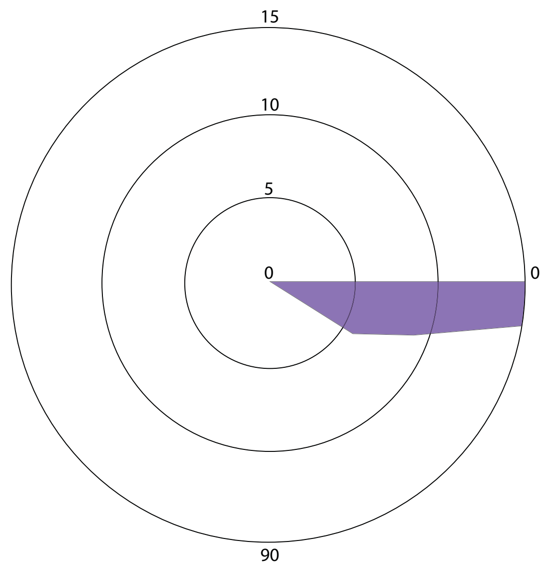

Figure 20 Graph indicating the dip (in degrees) of the finds (N=45). The number of finds is indicated along the Y axis. (Kamermans *et al.* 2003)

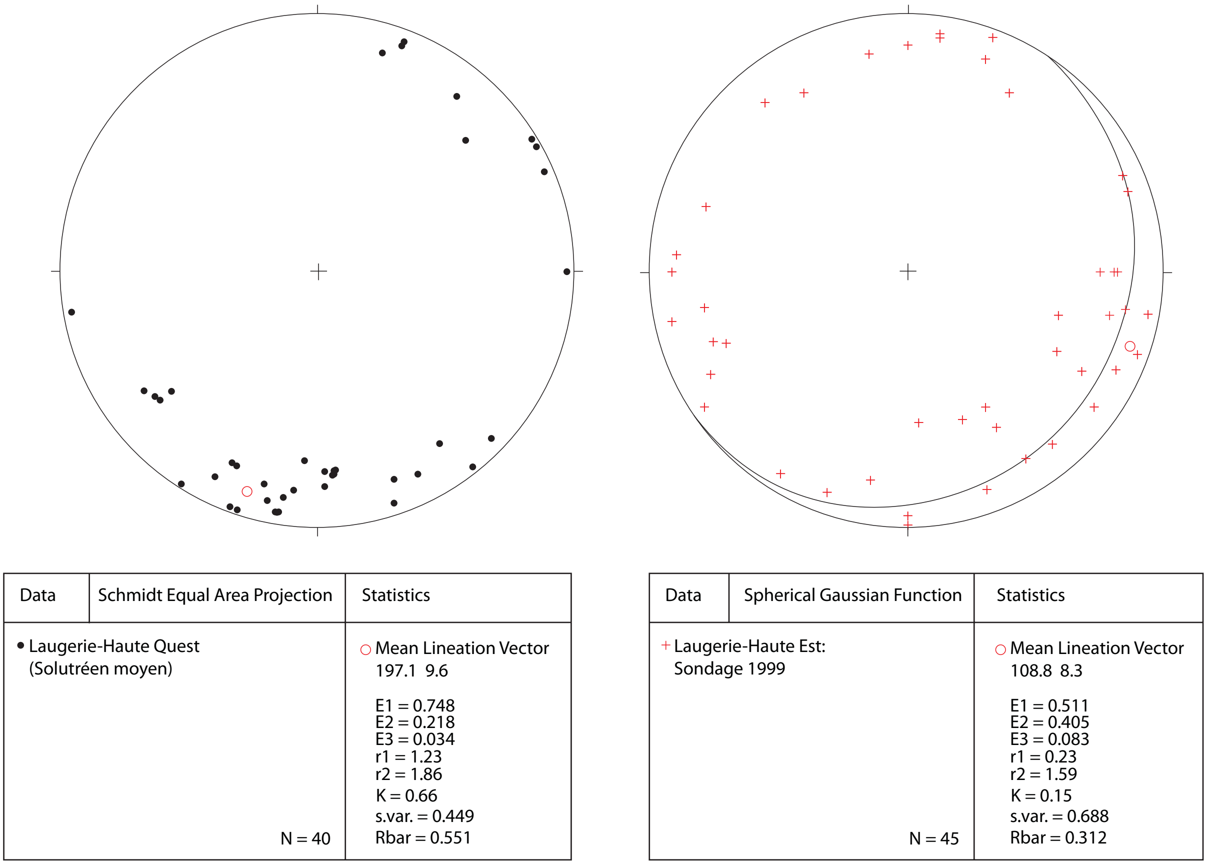

Figure 21 On the left the orientation diagram for Laugerie-Haute Ouest with objects dating from the Middle Solutrean (Texier 2009: 138). The spherical variance (s.var) indicates solifluction in a South Western direction (mean orientation is 197.1 degrees).
On the right the tentative orientation diagram for Sondage 1999 in front of Laugerie-Haute Est. North is pointing upward. Mean lineation vector is the mean orientation of the artefacts. A low s. var. indicates a strong preferred direction.

Find no.	X coordinates	Y coordinates	Z	Direction in degrees	dip in degrees
995039	494734.115	3295555.878	61.715	180	0
995057	494734.161	3295555.726	61.714	330	20
995058	494734.664	3295555.531	61.628	160	10
995059	494734.729	3295555.532	61.616	150	30
995071	494733.512	3295554.407	61.567	90	25
995072	494733.664	3295554.084	61.510	115	10
995074	494733.869	3295554.605	61.559	30	20
995083	494734.346	3295554.289	61.490	90	20
995084	494734.437	3295554.142	61.453	350	14
995085	494734.281	3295554.173	61.490	0	12
995088	494733.972	3295553.991	61.494	70	8

Find no.	X coordinates	Y coordinates	Z	Direction in degrees	dip in degrees
995092	494734.087	3295553.949	61.504	250	20
995094	494734.082	3295553.437	61.426	66	8
995097	494734.835	3295555.266	61.567	106	38
995099	494734.499	3295554.921	61.561	180	4
995102	494734.553	3295554.862	61.544	274	10
995103	494734.576	3295554.873	61.554	118	34
995111	494734.564	3295554.535	61.508	288	18
995114	494735.012	3295554.337	61.439	320	14
995115	494734.793	3295554.365	61.471	102	20
995116	494735.24	3295554.171	61.360	110	4
995123	494735.311	3295551.891	61.168	236	4
995124	494735.388	3295551.854	61.190	242	14
995125	494735.344	3295551.874	61.161	120	22
995127	494735.513	3295552.418	61.218	20	12
995128	494735.348	3295552.597	61.231	176	40
995140	494735.786	3295552.159	61.189	212	6
995141	494735.81	3295552.156	61.181	200	8
995144	494736.22	3295552.896	61.218	270	8
995150	494736.414	3295552.492	61.175	20	2
995152	494736.308	3295552.406	61.176	140	12
995153	494736.279	3295552.337	61.194	148	14
995154	494736.122	3295552.234	61.218	248	24
995155	494736.699	3295552.566	61.117	260	20
995160	494733.476	3295555.652	61.74	8	8
995161	494733.435	3295555.251	61.686	100	14
995162	494733.395	3295555.087	61.681	190	18
995163	494733.475	3295555.007	61.667	270	8
995164	494733.548	3295555.088	61.675	160	38
995165	494733.674	3295554.859	61.600	90	18
995166	494733.98	3295554.837	61.580	258	6
995167	494734.104	3295554.737	61.561	100	4
995168	494735.022	3295555.073	61.501	150	38
995169	494734.416	3295554.468	61.499	126	10
995170	494733.816	3295554.033	61.476	8	6

Table 9 Findnumber, x and y coordinates (French coordinate system), z values (above mean sea level), orientation (degrees) and dip (degrees) of artefacts from the trial trenches in front of Laugerie-Haute Est. N = 45 (Kamermans *et al*. 2003).

solifluction has deformed the find layer and created a number of pseudo archaeological layers (Texier 2009, 137). In our small *sondage* in Laugerie-Haute Est we do not find this phenomenon. This clearly shows the different processes at work in different parts of this vast rock shelter.

4.6 Interpretation

In terms of our main research question, i.e. the relationship between the *abri* deposits and the Vézère sediments at the foot of Laugerie-Haute Est, our preliminary conclusion is straightforward: the Vézère deposits encountered in our sondage and in our hand-augered boreholes are (in all probability significantly) later than the Pleistocene infill of the *abri*. The Vézère loamy silts wedging against the slope of the abri in our *sondage* are part of the current floodplain and hence of (late) Holocene age. This assessment is confirmed by a 1999 observation in an exposure made by the SOGEDO water company in the very same field of our *sondage*, at about 60 m south of our *sondage*. At a depth of about 2 m below the present surface remains of iron ore processing were encountered here, underlining the late Holocene age of the upper part of the Vézère deposits at this location.

The presence of small flint artefacts and faunal remains in our 1998 and 1999 boreholes, up to 3.5 m below the present surface of the floodplain at Laugerie-Haute Est, is therefore very probably caused by erosional activities of the Holocene Vézère, occasionally reaching up to the cone of abri deposits and displacing artefacts and faunal remains, eventually incorporating them in its loamy silts and sands. The steep erosional talus of more than 2 m high encountered in our second trench suggests that a phase of erosion of the abri deposits by the Vézère, possibly by a high water level, *occurred at its earliest* after the formation of the Magdalenian III layer, but probably significantly later, during the last two to three thousand years of the Holocene.

Does this mean that we have to infer that no primary context Palaeolithic site is to be expected in the uppermost two to three metres of the fluvial deposits at the foot of Laugerie-Haute Est? All that we can state positively is that this indeed seems to be the case for the areas surveyed by our hand augering. It is, of course, possible, that small remnants of older fluvial deposits are still preserved, even close to the surface (Chadelle 1994), but we did not find evidence for this. Chadelle (1994) furnished some indications, which point in such a direction though. Presenting the preliminary results of the study of a series of small trenches made close to the *Route Départementale* in 1994, about 200 m east of our *sondage*, he discusses the possible presence of primary context Solutrean finds in the field of our sondage, in brownish-reddish loamy deposits at a depth of 61.07 to 60.50 m, i.e. at about the same level as the fluvial deposits in our trench (Chadelle 1994, Sondage 94-3 and 94-4). Chadelle explicitly mentions that it is impossible to decide whether the Solutrean material is in primary context or displaced by the Vézère's activities: "S'il y a eu déplacements, ce qui est probable vu la situation de ces niveaux, ils ont dû être relativement limités" (Chadelle 1994, 17). Our interpretation of the 1999 *sondage* evidence, with the Vézère gradually eroding artefacts from the *abri* cone, would agree with this last interpretation, of the artefacts in the Vézère sediments there having been reworked from the abri deposits into a (Holocene) fluvial matrix, resulting in some displacement over a very short distance only.

A positive outcome of the 1999 fieldwork at Laugerie-Haute Est is that it has shown the vastness of the archaeological debris cone from this classical site. Whereas earlier workers have repeatedly stressed the large lateral and vertical extension of the deposits along the *falaise* at Laugerie, our work unambiguously demonstrated that the cone of abri deposits has an extension into the floodplain in front of the abri, which gives the deposits there a rough north-south extension of about 70 m, the later erosion of the deposits – and hence an earlier much wider extension – even not taken into consideration. With such large areas it might become interesting to compare in future studies archaeological remains collected from the back of the abri with those excavated close to the distal part of the debris cone closer to the river, especially as far as faunal remains are concerned.

5 Raw material sources in the Vézère valley

5.1 Introduction

Despite of some stable features, such as the location of the impressive rock faces, the fords and, to some degree, the rock shelters, Palaeolithic landscapes were different from the present-day ones. As described above, the tributary valleys were incised much deeper and some of them may have looked like canyons, with the gravelly infill of their valley floor channels constituting virtually inexhaustible flint resources. Nowadays, flint materials are present in a wide range of settings, from still in primary context in their limestone parent material up to having been transported into coarse grained river deposits (fig. 22).

The flints in primary context as well as the alterite sources have been the subject of several studies (Chadelle 1983; Demars 1980; Geneste 1985; Horan 1977; Larrick 1983; Platel 1989; Rigaud 1982b; Seronie-Vivien 1972; Seronie-Vivien and Seronie-Vivien 1987; Turq, Antignac and Roussel 1999) and are hence well documented as far as their stratigraphical and geographical position is concerned. However, little is known about their morphology and their flaking characteristics (Turq 2003; 2005). Moreover, even though the Vézère valley has been famous for its richness in flint for a long time (Lartet and Christy 1865-1875), the

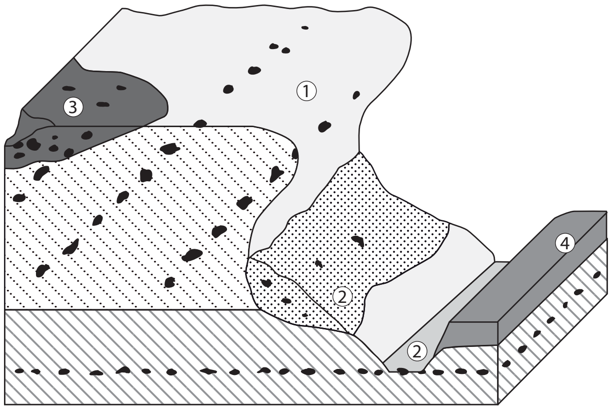

Figure 22 Schematic representation of the various type of flint sources: 1. in primary context in the parent material; 2 secondary autochthonous position (in slope deposits); 3 sub-allochthonous or residual (alterites or "siderolithique" colluvial deposits); 4 allochthonous (having been transported by fluvial processes).

river deposits themselves have never been studied from this perspective. That was a reason to focus on the Vézère deposits in this project, especially on the gravels from the current riverbed.

5.2 *Methods*

We focused on 26 observation points in the current bed of the river, between Aubas and Limeuil (fig. 23 and table 10). There, systematic counts of pebbles larger than 4 cm were carried out within a one meter square, which yielded a good overview of the lithological composition of the coarse-grained river deposits. All flints were tested for their flaking properties (see below). A second sampling activity consisted of the systematic collecting of all flint nodules at the location (duration: 15 minutes, every gravel beach revisited to refine the first observations). Of this flint nodule sample, dimensions, morphology, type of flint as well as flaking properties were consistently documented.

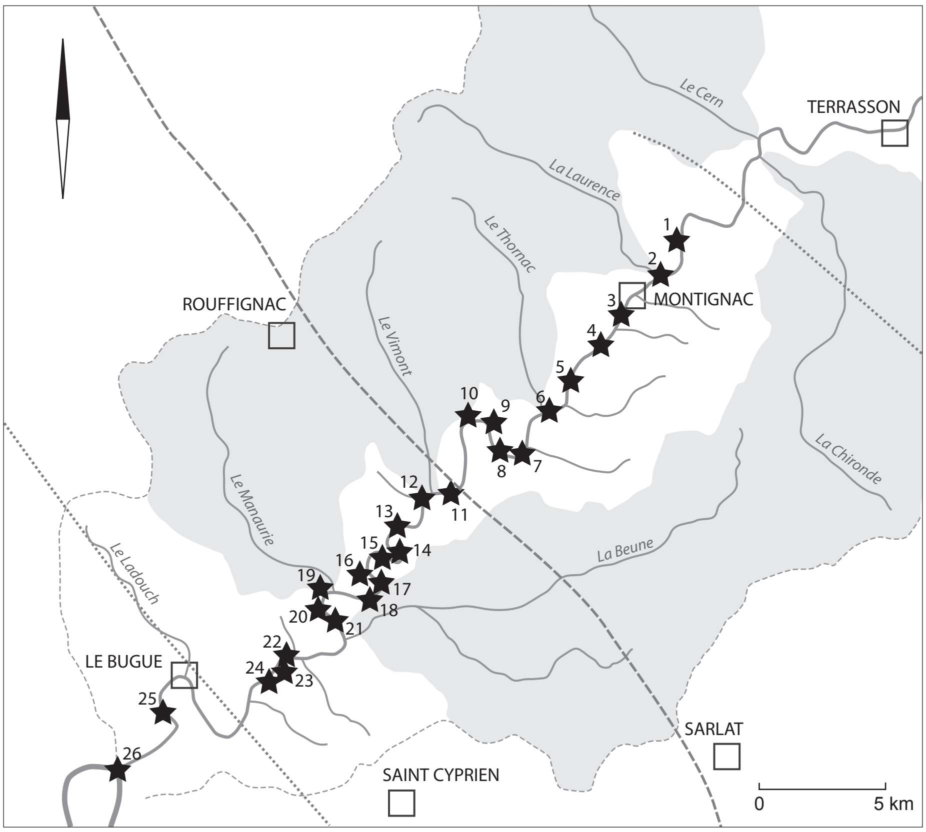

Figure 23 Position of the sampling locations in theVézère valley. In dark grey the drainage basins of the main tributaries. The two dotted lines indicate the two main fault lines bordering the syncline that is traversed by the Vézère. The dashed line indicates the axis of this syncline.

N°	Type of exposure	Village	Coordonnées Lambert III X	Coordonnées Lambert III Y
1	beach	Aubas	509,675	3310,725
2	beach		509,375	3308,900
3	beach	Montignac	508,075	3308,150
3b	beach	Montignac	507,1	3307,075
4	beach	Montignac	506,425	3305,900
5	beach	Montignac	505,225	3304,925
6	beach	Thonac	503,900	3303
7	beach	Saint Leon	502,850	3301,050
8	island	Saint Leon	502,150	3301,150
9	island	Saint Leon	501,600	3302,050
10	island	Saint Leon	500,775	3302,550
11	island	Le Moustier	499,550	3299,800
11b	dead arm	Le Moustier	499,350	3299,775
12	island	Le Moustier	498,800	3299,200
13	island	Tursac	497,950	3298,250
14	island	Tursac	497,525	3297,200
15	beach	Tursac	497,550	3297,150
16	island	Tursac	496,475	3296,675
17	island	Les Eyzies	496,700	3296,100
18	island	Les Eyzies	496,150	3295,200
19	beach	Les Eyzies	494,650	3295,400
20	beach	Les Eyzies	494,525	3294,700
21	island	Les Eyzies	494,775	3294,325
22	island	Saint Cirq	492,600	3292,300
23	island	Campagne	491,425	3291,225
24	island	Campagne	491,425	3291,225
25	island	Limeuil ?	488,325	3291,875
26	beach	Limeuil	485,675	3287,950

Table 10 Position of the sampling locations in the Vézère valley.

5.3 General results

All the one metre square samples were dominated by metamorphic rocks from the Massif Central, mainly quartz. Limestone and flint take second and third position (table 11) and seem to be more frequent in the downstream part (for comparison with the Dordogne valley see Turq 2005). The second sampling activity yielded a large sample of 1100 flint nodules, which allowed us to obtain a good overview of the general composition by raw material type (table 12).

Main types of flint encountered

The grey or black and the beige Senonian flints dominate. They are present in almost equal proportions, with the grey-black group slightly dominating the beige one (51.5% against 48.5%). The grey or black flints dominate in 11 cases, the beige ones in 10 and in 3 cases they were present in comparable numbers. Next are the flints of chalcedony type which can be of Cretaceous origin (Turq 2003) or derive from the Massif Central (around 1%), followed by some Jurassic flints (less than 0.5%) and finally some jaspers and argilites.

One of the striking observations is that the samples do not reflect the total potential of the substrate of the slopes and basin. There is a marked under-representation of flint from the alterites on the right bank of the river (around Thenon, Rouffignac, Mauzens, Miremont), in particular of banded flints or flints with red bands directly under the cortex and Sainte-Foye type flint, characteristic for the basis of the

Site	Number of samples	Quartz	Other metamorphic rocks	Limestone	Flint
1	127	46 (36.2%)	43	37 (29%)	1 (0.8%)
2	106	34 (32.1%)	51 (basalt 2)	21 (19.8%)	–
3	139	37 (26.6%)	92 (basalt2)	10 (7.2%)	–
4	101	42 (41.5%)	44 (basalt 2)	13 (12.9%)	2 (2%)
4	117	34	73 (basalt 2)	10 (8.6%)	–
5	120	45	68	–	7 (5.9%)
6	102	31	65	3 (2.9%)	3 (2.9%)
7	116	29	84	2 (1.7%)	1 (0.9%)
8	129	46	78	4 (3.1%)	1 (0,8%)
9	111	42	50	11 (9.9%)	8 (7.2%)
10	135	58	75		2 (1.5%)
11	108	65	38	5 (4.6%)	–
12	144	58	75	7 (4.9%)	4 (2.8%)
13	99	60	27	4 (4%)	8 (8.1%)
14	225	126	88 (basalt 5)	3 (1.3%)	8 (3.6%)
15	92	30	62 (basalt 2)	–	–
16	124	50	69 (basalt 1)	2 (1.6%)	3 (2.4%)
17	251	95	144 (basalt 24)	1 (0.4%)	11 (4.4 %)
18	435	240	161 (basalt 1)	4 (0.9%)	30 (6.9%)
19	180	119	34 (basalt 2)	5 (2.8%)	22 (12.2%)
20	111	71	31 (basalt 2)	1 (0.9%)	8 (7.2%)
21	159	83	62	5 (3.1%)	9 (5.66%)
21	161	72	74	–	15 (9.3%)
22	111	62	35	5 (4.5%)	9 (8.1%)
23	97	55	21	6 (6.2%)	15 (15.5%)
24	125	65	46 (basalt 1)	6 (4.8%)	8 (6.4%)
25	105	46	38	6 (5.7%)	15 (14.3%)
26	110	47 (42,7%)	39	2 (1.8%)	22 (20%)

Table 11 Composition of the samples

Campanian (Turq 1992). How to explain this? Observations made in the working area on present day exposures (Turq, Detrain and Vigier 2000), on the river catchment area, on changes in the landscape and the development of the drainage system in the final Pleistocene and the Holocene (Donner 1969; Leroyer *et al.* 1997; 1998; Turq, Detrain and Vigier 2000) lead to an explanation in terms of diachronic changes in exposure of various types of raw materials. Areas, which contain in a primary context or in alterites the flints that are underrepresented or even completely absent in the extent alluvial gravels, are simply not exposed anymore. Hence, these materials can only be brought in by erosion and slope processes, phenomena which have considerably lost importance or even completely disappeared as a result of vegetation cover and changes in the drainage system. Since the final part of the Pleistocene or from the Holocene onward, the transport potential of the tributaries has diminished – nowadays they only transport sands and silts – and their river valleys have been filled up.

Flaking properties

The exterior of a flint nodule is not a good guide to its flaking quality (Tixier, Inizan and Roche 1980) and the significant variability within one and the same type of material makes the experimental approach indispensable. However, quality estimates of flaking properties are always subjective. Every knapper has his own experiences and his particular habits, which does not facilitate objective

N° site	Number of samples	*blond du Sénonien*	*noir du Sénonien*	jaspe	*silex calcédonieux*	*silex jurassique*	argilite
1	1					1	
2	3					3	
3	7	3	3		1		
4	8	5	2				1
5	19	14	3		1		1
6	3	3					
7	1		1				
8	32	16	16				
9	8	4	4				
10	51	21-41,2%	30-58,8%				
11	10	1	9		1		
12	99	51-51,6%	46-46,5%	1-1%		1-1%	
13	8	5	3				
14-15	92	32-34,8%	59-64,1%		2-2,2%		
16	63	25-39,7	35-55,6%		1-1,6%	2-3,2%	
17	79	35-44,3%	42-53,2%		1-1,3%		1-1,3%
18	103	52-50,5%	50-48,5%		1-1%		
19	170	83 – 48.8%	85 – 50%		2		
20	8	6	2				
21	182	86-47,3%	96-52,7%				
22	37	17	19		1		
23-24	79	43-54,4%	35-44,3%		1-1,3%		
25	15	7	8				
26	22	13	9				
	1100	521-47,4%	557-50,6%	1-0,09%	11-1%	7-0,6%	3-0,03%

Table 12 Main flint types encountered at the different sites (see text for explanation)

characterization. Developing a reliable regional reference set would call for a group project, and hence the observations presented here can only be seen as preliminary ones. In the context of this study, tests were carried out with hard hammer percussion. Three groups could be discerned:

– A group of low quality, very heterogeneous flints (vacuolar or saccharoidal), with many fractures. Not suited for proper flaking, although a few flakes might occasionally be produced
– Good quality blocks are more homogeneous. They allow the production of series of flakes and of handaxes. Their quality does not allow a consistent production of Levallois flakes, of blades or the *façonnage* of Solutrean *feuilles de laurier*
– Very good materials allow the application of all direct flaking methods and the production of flakes and bifacial tools, and probably also pressure flaking.

The results regarding the argilites, limonites, jaspers, Jurassic or chalcedony types of flint are not relevant in view of the very small size of the sample. As far as the Senonian flints are concerned, the grey and black group displays better flaking properties than the beige one (table 13), independent of morphology and dimensions of the nodules. As the majority of these flints are from Coniacian and Santonian strata, these data reflect observations made over the whole of the drainage basin.

During this study, other observations were made. Important differences have been noted between gravel beaches where the majority of the nodules had a diameter smaller than 10 cm, and the other ones. For the first group, the flint percentages are much smaller. Near Saint-Cirq-du-Bugue, at a location where samples were taken from two banks of different granulometry, the small-pebble beach yielded a flint percentage of 6.4%, the other one 15.5%.

	low	high	excellent	total
noir du S	127 (23,3%)	240 (43,3%)	177 (32,5%)	544 (50,8%)
blond du D	315 (63,5%)	144 (28,5%)	45 (8,9%)	504 (47,1%)
argilite, limonite	3			3 (0,3%)
jaspe			1	1 (0,09%)
Jurassique	7			7 (0,7%)
calcédonieux	6	2	3	11 (1%)
Total	458 (42,8%)	386 (36,1%)	226 (21,1%)	1070

Table 13 Quality estimated per flint type.

Some remarks on the Senonian flints
Given the major role of this raw material in the Palaeolithic record of the Vézère valley the issue of the dimensions and morphology of this flint type was studied in somewhat more detail. As far as morphology is concerned, apart from the ubiquitous artifacts, the flints were classified as *plaquettes*, contorted, oblong, globular or "potato-like" and branch-like. As illustrated in figure 24, there are no major differences between the two types of flint. Their dimensions range mainly between 9 and 16 cm (fig. 25), with some blocks larger than 40 cm (the size of the blocks in these river deposits is determined by the dimensions of the nodules in the natural environment and by the force of the river transporting these nodules. Nowadays, the rivers transport potential is much smaller than during the Pleistocene).

5.4 *Overview of the lithic raw materials*
The data presented here concern raw material sources in the alluvial deposits of the Vézère that are currently accessible. They yield an indication only, as shown by the inter-annual variation observed in this study. This preliminary synthesis shows the kinds of factors one needs to take into consideration when discussing raw material availability. Our limited study shows again that data collected on raw material availability in the present cannot be directly applied to the Pleistocene past (Turq 1999; 2003; 2005). A detailed study of (well-dated) terrace bodies, coupled with a geomorphological study of the valley floor and the valley slopes could yield a much more precise image of the raw material sources available at a specific moment in time.

6 On the history of the Vézère river
6.1 *Introduction*
If we try to integrate the data from our geological mapping activities (section 3) and from the 1999 *sondage* at Laugerie-Haute Est (section 4) into the larger history of the Vézère valley, we are confronted with the fact that the various studies that deal with this issue yield an altogether confusing picture. To some degree this is the result of very practical limits of most of such studies, where sediments are only very rarely recorded in height above sea level; usually in rather vague phrases such as "the abri is at 12 m above the normal level of the Vézère", or "7 m above the *thalweg*", or "the cave dominates the valley bottom with a height of six metres". The early 20th century maps of the Vézère valley and the site plans published by the infamous Otto Hauser (1911; 1916) still rank among the rare exceptions in this respect.

Inconsistencies in terms of the relative height of crucial fluvial deposits between various authors add to the confusion, as do inconsistencies between publications by one and the same author. To some degree this is certainly the result of the long and complex research history of the area with its high number of prestigious sites, whose excavations have become extremely time consuming enterprises: hence, the development of approaches focussing on the analysis of one specific site rather than on a regional integration of the data from individual sites. There have been various attempts in such a synthesizing direction though, e.g. the recent important volume by Texier (2009) and some studies specifically dealing with the fluvial deposits, e.g. by Peyrony (1947b), Bouvier and Mémoire (1992), Texier and Bertran (1993) and Konik (1999).

The aim of this chapter is *not* to develop an integrative framework for the Vézère valley – that is beyond our competences and beyond the limited investment in fieldwork there -, but rather to chart where the actual discrepancies and problems in this respect lie, as these can tell us very specifically where we can learn most about these issues. In order to do this, we will focus on the small number of sites where we have reasonably good data on both altimetry and the fluvial character of find bearing sediments. We will give a very short description of the fluvial part of the site sequence for each site, mainly based on study of the literature and occasionally our own altimetric data. We will start with a group of sites around Les Eyzies, and then move stream upward, up to Le Moustier.

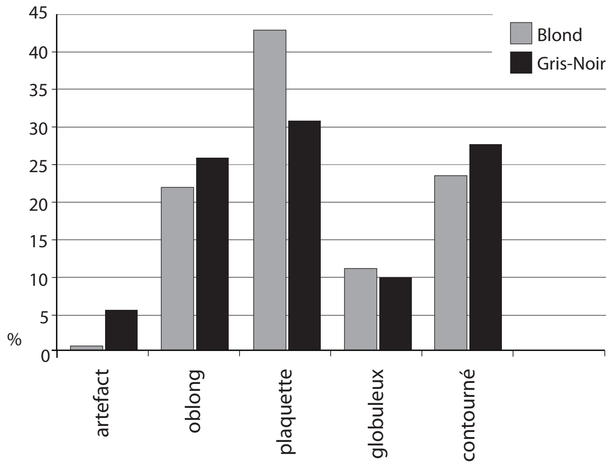

Figure 24 Alluvial deposits of the Vézère river valley floor: morphology of grey or dark and of beige Senonian flints (731 blocks).

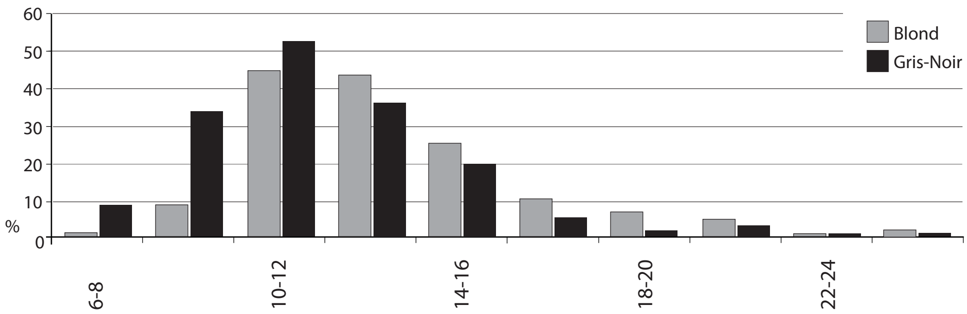

Figure 25 Alluvial deposits of the the Vézère river valley floor: dimensions (in cm) of respectively grey or dark and of beige Senonian flints (731 blocks).

6.2 The Key Sites

Abri du Musée

During excavations in the context of the extension of the Museum at Les Eyzies an important Middle Palaeolithic site was found, covered with fluvial deposits of the Vézère and its tributary, the Beune (Detrain *et al.* 1991; 1996). The *abri* is at an altitude of 73 N.G.F. and the unambiguous fluvial sequence dominates the actual confluence of Vézère and Beune with 12 to 14 m. The height relative to the present *thalweg* of the Vézère river is about 12 m (Konik 1999, 364). Study of the cold adapted fauna from the sediments and correlation to the inferred fluvial layers I and K of Le Moustier, at a relative height of 9 m (see below), led Detrain *et al.* (1996) to date the Middle Palaeolithic 'Micoquian' related industry to the end of MIS4 or the beginning of MIS3, without excluding a higher, possibly MIS6, age. The sediments from the neighbouring Abri Vignaud, at 200 m from the Abri du Musée, play an important role in opting for a "short" or a "long" chronology for the Abri du Musée, as we will see below.

Abri Pataud

This site is at about 300 m northwest of the Abri du Musée, in the same limestone cliff. In the context of geological work at and around Abri Pataud, Judson (1975) discussed the relationship between the archaeological stratigraphy of the Abri Pataud and the history of the Vézère. The archaeological sequence at Pataud starts with an early Aurignacian layer, dated at 33.3-34.4 C14 Kyr bp (Bricker *et al.* 1995). This Level 12 is situated at about 67.75 m asl. Fluvial deposits exposed in a 1953 *sondage* underlay these early Aurignacian layers. The top of these fluviatile sands is situated at 61.40 m. Extrapolating from the current floodplain sequence, Judson has suggested that the ancient floodplain prior to the early Aurignacian deposit was at minimally three metres higher than the sand and a minimum of four metres above the present floodplain, i.e. at about 64.40 m (Judson 1975). The 100 yr flood level then would be at about 66.0 m. More important than these interesting speculations is the detailed attention Farrand (1975; 1995) devotes to the provenance of the sandy matrix of some of the layers in the Abri Pataud: certain strata are conspicuously sandy, the sand being composed predominantly of quartz and mica, with also mineralogical analyses clearly pointing to the Vézère floodplain as the source of these deposits. In spite of this, Farrand emphatically rejects a fluvial explanation for the presence of these sands in the *abri*, in his 1975 publication as well as in the updated (Farrand 1995) version of his original study: "...there is certainly no evidence in the Abri Pataud that the Vézère was ever significantly higher during the past 35,000 years than it is today. None of the Abri Pataud deposits that lie at an altitude higher than that of the present floodplain show any characteristics of fluvial deposition, nor is there any evidence of an erosional interval that could be attributed to scouring by the waters of the Vézère" (1975, 28).

Abri Vignaud

Rescue excavations carried out by J.-M. Geneste between 1981 and 1983 showed an alternation of calcareous abri-type sediments with sandy deposits over a thickness of about 7 m (Ajoulat *et al.* 1991; Rigaud 1982a). Layer 13 yielded an Aurignacian lithic industry, associated with remains of horse and reindeer. These finds were contained within sands rich in mica, deposited about 30,000 years ago between the rockfall of the abri, and currently situated at 10 to 15 m above the *étiage* of the Vézère (Rigaud 1982a) (8 m according to Konik 1999, 367). Peyrony, who studied exposures at and near the Abri Vignaud, mentions the presence of a Mousterian industry below fluvial sands, at a height of approximately 10 m above the actual course of the Vézère (Peyrony 1930, 156). He assigned the fluvial sequence to the 5 metre terrace, "dont on remarque les restes sur divers points de la vallée, notamment aux cimetières des Eyzies et Tursac" (Peyrony 1947a, 182). They have been interpreted (Movius Jr. 1995) as part of the 6 to 7 m terrace, of which Movius encountered sands in his 1953 *sondage* at Abri Pataud, 40m west of the Abri Vignaud, with their top at 61.40 m asl (1995, 262) (see also above).

The Abri Vignaud provides us with an interesting problem. As mentioned above, the Abri du Musée deposits are at 12 m above the *étiage* of the Vézère, the Vignaud couche 13 at 10 m. If the Abri du Musée fluvial deposits are at 71 to 73 m (as suggested by Detrain *et al.* (1996), the Aurignacian layer at Vignaud should be situated at around 69 m asl. Following Rigaud (1982b), the fluvial deposits are at 10 to 15 m above the present low water level (55 m, cf. Judson 1975), which would situate them at 65 to 70 m asl i.e. exactly in the height range of the Aurignacian levels of the Abri Pataud, where according to Farrand the Vézère sands were brought in by aeolian activities. The interpretation of the Vignaud sediments containing the Aurignacian as Vézère deposits is thus at odds with Farrand's assessment for the neighbouring Abri Pataud, where he sees no evidence for the Vézère having reached higher levels than the current ones during the last 35,000 years. It is difficult, if not impossible, to reconcile the interpretation of Abri Pataud by Farrand (1975; 1995) with those published for Vignaud (Rigaud 1982b; Ajoulat *et al.* 1991; Detrain *et al.* 1996; Konik 1999), provided our altimetric 'reconstructions' are right. There are at least three possible solutions to these discrepancies:

1) The heights ascribed to the various deposits are incorrect
2) Farrand's (1975; 1995) interpretation of the sands in the Pataud sequence as an aeolian deposit is incorrect
3) The interpretation of the Vignaud sands as fluvial deposits is questionable.

We will return to this issue later.

Laugerie-Haute Est

The limestone bedrock of the important sequence at Laugerie-Haute Est is at approximately 62.75 m, which situates the oldest archaeological level there, Peyrony's *Périgordien III*, at around 63 m. Later studies assigned this earliest level to the final phases of the Perigordian, comparable to the Perigordian VI of the Abri Pataud, dated around 23 to 24 C14 Kyr bp (Bricker *et al.* 1995). With the infill of the vast Laugerie-Haute Est *abri* starting at its latest around 24 C14 Kyr bp, no fluvial influx has been encountered in the 10 m high sequence (62-72 m asl), which ends with a late Magdalenian occupation. The Laugerie-Haute evidence seems to corroborate Farrand's aeolian interpretation of the sands at Pataud; it is indeed difficult to imagine that if the Vézère had deposited the Eboulis 3/4 Red sandy matrix at a height of 72 m asl 25,000 to 26,000 years ago at Pataud, the river would not have left any traces of its activities at Laugerie-Haute Est, where the abri deposits started *10 m lower* only 1000 to 2000 years later. Likewise, Texier's (2009) recent study of the Laugerie-Haute Ouest sequence did not record any signal of fluvial activity there.

La Micoque

The site of La Micoque is situated on the left bank of the Manaurie, the small tributary of the Vézère, close to its confluence. The 10 m high La Micoque sedimentary sequence is situated at 75 to 85m above sea level. New studies of the stratigraphy of this famous site yielded important data on the history of the Vézère valley (Texier and Bertran 1993; Texier 2009). Texier and Bertran conclude that both the *ensemble inférieur* (2.4 m thick) and the 7m thick *ensemble moyen*, situated approximately between 75 and 82 m, are unambiguously of fluvial origin. Their coarse-grained character and sedimentary structures indicate that they were deposited under high-energy transport by a braided river system. The two ensembles represent two terraces, separated from each other by a major linear incision phase of an estimated 4 to 5 m. Texier and Bertran propose a correlation of the older terrace with Texier's Fw1 Vézère terrace (MIS12), and the of the *ensemble moyen* with Fw2 (MIS10). The series of 40 ESR and U/Th dates for the *ensemble moyen* (Falguères, Bahain and Saleki 1997, Schwarcz and Grün 1988) are in agreement with such an interpretation, which situates the incision phase in MIS 11 (Texier 2009).

La Madeleine and environs

The excavations by J.-M. Bouvier at La Madeleine have demonstrated the importance of the Vézère deposits in the infill of this large *abri*. The base of the calcareous basement is situated at 40 cm above the low water level (Bouvier 1973, 2628). On top of this limestone, cryoclastic deposits and fluvial sands with gravel are present. The earliest archaeological level is a Magdalenian IV, in the basal part of the fluvial sequence, which is up to 3 m thick and starts at 1.2 m above the low water level. The Magdalenian IV is deposited at about 2.45 m above the Vézère's present low water level (Bouvier 1973, 2627).

These Magdalenian dates correlate well with the luminescence dates of the terraces found upstream, in transect Lespinasse. The oldest (highest) sandy fluvial deposits found in transect Lespinasse are located at a similar height and an OSL date suggests a Late Glacial age (though the dates may be disputable).

Situated at about 100 m downstream from the centre of the La Madeleine *abri*, in the same *falaise*, is the Abri de Villepin, where Peyrony (1936) excavated two Magdalenian VI layers, situated in deposits of the Vézère. It is very well possible that these constitute only the final part of a much more important fluvial sequence, as demonstrated at La Madeleine by Bouvier (1977, 77).

As the crow flies at 700 m downstream from La Madeleine is the Abri Bout-du-Monde. The limestone bedrock of the *abri*, situated approximately 40 cm above the low water level of the Vézère (Peyrony 1947a, 182) is covered by about 1.55 m of sandy Vézère deposits which yielded a reindeer antler. These are covered by 0.5 m of calcareous *eboulis* from the disintegration of the rock shelter's roof mixed with fluvial sands, on top of which a Magdalenian assemblage was uncovered, from "sables fluviatiles abandonnés par la Vézère" (Peyrony 1947b, 184-186). The assemblage contained various Magdalenian facies, with late Magdalenian elements being the most important ones.

Le Moustier

Our altimetric studies at the lower *abri* of Le Moustier showed that the limestone bedrock at the base of the sequence is at 65.60 m, with the top of the fluvial deposits at Le Moustier (Layer F) being situated at 68.29 m. Layer F is overlain by a series of cryoclastic deposits, G to K (Valladas *et al*. 1986), in which Peyrony (1930) has mentioned the presence of a 20 cm thick layer of sands (*sable fluviatile, couche I*). This is situated about 2 m above the top of the lower fluvial sequence, i.e. at a height of approximately 70 m (see also Hauser 1911, Plan 5). Peyrony's fluvial origin interpretation has been corroborated by Laville (Laville 1975; Laville and Rigaud 1973), though on the basis of mineralogical studies only. Alternatively, one could interpret the *Couche* I sands with their typical Vézère mineral association along the lines suggested by Farrand (1975; 1995) for the Abri Pataud sequence. There the sandy matrix of some stratigraphical units clearly derived from the Vézère floodplain, likewise on the basis of heavy mineral analysis. Farrand attributed their presence to aeolian activity, as there was no evidence of the action of running water in the abri (1975). Thermoluminescence (TL) dating of burnt flints from the cryoclastic sequences (*couches* G to K) shows that the fluvial units A to F are older than 55.8 ± 5 ka, while *couche* I has a TL age of 40.9 ± 5 Kyr bp (Valladas *et al*. 1986).

6.3 Discussion

Combining the evidence from the sites discussed above, and focussing on the unambiguous fluvial deposits only, one can construct a straightforward picture of the archaeology-related development of the Vézère valley. The oldest fluvial deposits containing Palaeolithic artefacts are those from La Micoque, where two subsequent terraces (Fw1 and Fw2) have been documented, at about 20 m above the current floodplain. The "classic" archeological levels from the *ensemble moyen* (MIS 10) have been described as Tayacien by Breuil (1932) and as pre-Mousterian by Bordes (1984). While the *ensemble inférieur* has been said to contain no archaeology, one of us (A.T.) recently retrieved a small number of flakes from this fluviatile unit, which has been correlated to MIS 12 (Texier 2009, 25).

The next youngest body of fluvial sediments is about 8 m lower in the landscape, contains a Middle Palaeolithic industry and has been documented during the excavations at the Abri du Musée, at about 12 m above the Vézère's low water level. These deposits probably correlate with deposition of terrace Fx. The Abri du Musée Vézère deposits dominate the fluvial deposits documented by Peyrony (1930) at Vignaud and by Movius (1995) at Pataud by approximately 6 m. The fluvial sands encountered in the 1953 excavation at the base of Pataud were archaeologically sterile, but these sands covered a Mousterian layer in the 1941 exposure described by Peyrony (1947a). It is very well possible, even probable, that these sands, part of Peyrony's 5 m terrace, correspond to the fluvial sequence at the base of the lower abri of Le Moustier. If so, they should be older than 55.8 ± 5 Kyr bp. If the mica containing sand deposits of layer I at Le Moustier are indeed of fluvial and not of aeolian origin, this would imply that the Vézère still reached a 7 m level at 40.9 ± 5 ka.

From 35,000 bp onwards, one could follow Farrand's suggestion that there is no evidence for the Vézère ever reaching higher levels than the present day ones, but in order to do so one would have to reject the fluvial character of the sandy matrix of the Abri Vignaud Aurignacian, discussed above. In any case, the absence of any indication for a fluvial influx in the long sequence at Laugerie-Haute Est, which starts at a considerably lower level than the Vignaud Aurignacian is situated (see above), strongly supports Farrand's assessment. In that case, there would not be any Vézère deposits known contemporaneous with the Upper Palaeolithic before the Magdalenian IV encountered at La Madeleine. A large hiatus and probably a major incision phase would separate the final Middle Palaeolithic Vézère from the first deposits encountered at La Madeleine. The data from our small *sondage* fit very well into such a scenario, with the erosion of the long *abri* deposit talus by fluvial activities having occurred at the earliest during the later Magdalenian and probably significantly later only.

7 Conclusions

Our survey focused on a part of the Vézère where the river is encased between large cliffs sometimes creating a very narrow valley, only a few hundreds of metres wide. The trajectory between Le Moustier and Les Eyzies has been chosen because it has the advantage that many of the excavated key sites such as Le Moustier, La Madeleine and Laugerie-Haute, are situated at a short distance from the current river, and some of these were said to contain fluvial deposits. Our survey, including field- (and laboratory) work, was a very limited one and our tentative conclusions are that:

1) The major part of the deposits in the current floodplain of the Vézère river in the trajectory sampled in our survey is very probably young, i.e. mostly Holocene in age.
2) Various erosional phases have destroyed major parts of the Pleistocene deposits, but in some of our transects Holocene deposits do seem to cover sandy sediments of Pleistocene age (e.g. Transect Bout-du-Monde, Transect Lespinasse), which have been preserved in the form of terrace bodies with remnants of older sandy flood deposits on top. Future studies of these transects may yield data relevant to the history of the river valley. One way to approach this would be by starting a systematic luminenscence sediment-dating program, in which the sandy intervals are dated at various levels to obtain a better chronological control over the sedimentation and erosional history of the river. Moreover, comparing dates for the sediments with dates obtained for the archaeological levels from within the rock shelters would yield independent chronological control for some of the interpretations given here. In the course of our fieldwork we increased our coring density each year, which resulted in more detailed and better data. Some of the older transects might benefit from resampling at smaller intervals, which may yield extra dating possibilities (e.g., Bout-du-Monde 1998 and Le Moustier 1997).
3) The results of our *sondage* at the foot of the rock shelter complex of Laugerie-Haute Est suggest that archaeological material from the distal talus of the abri deposits was reworked into the Vézère deposits during deposition of the Holocene infill of the current floodplain. The *sondag*e has also shown the vastness of the archaeological debris cone from this classical site. While the large lateral and vertical extension of the deposits along the cliff at Laugerie is well known, our limited work demonstrated that the cone of abri deposits at Laugerie-Haute Est also has a significant extension into the floodplain in front of the *abri*. The deposits there have a rough north-south extension of about 70 m, the later erosion of the deposits – and hence an earlier much wider extension – even not taken into consideration. Our observation of a significant water pipe trench having been cut through these rich deposits illustrates that cultural heritage management protocols for this part of the Vézère record still need to take this significantly wider spatial extant of these and comparable deposits elsewhere in the valley into consideration.
4) The preliminary study of lithic raw material quality and availability in the Vézère raw material sources in the alluvial deposits of the Vézère currently available shows the kinds of factors one needs to take into consideration when discussing raw material availability. It also shows that data collected on raw material availability in the present cannot be directly applied to the Pleistocene past

Our survey has only scratched the surface of this interesting fluvial domain yet.

The fieldwork yielded a number of interesting results, based on a study of the river regime during the last glacial. During the Pleistocene the river regime had predominantly an erosive nature, in which downcutting and erosion dominated. Sand was deposited during floods that covered the channel gravels. Most of these sandy deposits have been eroded later, although at several locations they have been preserved below a pile of Holocene overbank loams. Several phases of downcutting could be established. At least two buried terrace levels have been identified, of which the highest one may be correlated with terrace Fy2.

In the Holocene the landscape changed dramatically to a depositional setting: loamy overbank deposits dominated and covered the older, gravelly channel deposits, thus conceiling the height differences between youngest terraces. Taking the thickness of these Holocene sediments into consideration yields a picture of a vastly different last glacial landscape. Deeply incised valleys, as those of the Beunes, were even deeper then, while some archaeological sites that nowadays are more or less at the level of the river valley, e.g. La Grotte des Combarelles, Cro le Biscot or Commarque were several metres *above* the valley bottom during the (Late) Weichselian.

Our limited survey has yielded data relevant to the Late Pleistocene development of the Vézère-valley and some information on the archaeological potential of the Vézère-deposits. Our study has also pointed out where some — potentially very informative – discrepancies exist within the current range of interpretations of the Vézère history and its associated archaeological sites. However, in retrospect our project should have been more focused on obtaining dates (especially: OSL) for the relevant Vézère deposits. Future studies focused at obtaining a more reliable chronometric framework for the fluvial deposits could set important constraints on the range of possible interpretations sketched above, and thus contribute significantly to our understanding of the (neglected) "fluvial" part of the unique archaeological record of this key area of world prehistory.

Acknowledgments

We are grateful to a large number of friends and colleagues in the Dordogne for various kinds of assistance with our fieldwork there. These include Jean-Jacques Cleyet Merle, André Morala, Jaqueline Angot-Westin, Stéphane Madelaine and Philippe Jugie at the Musée National de Préhistoire at Les Eyzies, Jean-Pierre Texier of the Université de Bordeaux, Danny Barraud and Jean-Michel Geneste at the Service d'Archéologie at Bordeaux, Jean Plassard, Rouffignac, for permission to work on his land at Laugerie-Haute Est, and all the landowners and farmers who allowed us access to their land, especially G. Delbarry of Le Ruth, Tursac. Erwan Temple, Les Eyzies, was very helpful during our 1999 fieldwork at Laugerie-Haute Est, as was Mme Reyzambeau of Les Eymaries. We also thank the Jugie family of Laugerie Basse for their continuous excellent culinary support of our fieldwork.

We owe much to Henk van Steijn (University Utrecht) who performed the orientation analysis for our finds from Laugerie-Haute Est. Mark Bateman (Sheffield University) performed the initial OSL-dating in 2001 and Jakob Wallinga (University Delft) helped us out with an alternative interpretation of our OSL-samples. In Leiden, André Ramcharan took great care of the material from the Laugerie-Haute Est sondage, and enabled students to work on the material. Jan Pauptit (Leiden) did some of the photographic work, while Joanne Porck took care of the figures. Philippe Jugie (Les Eyzies) made a series of old and new photographs of the Vézère valley available. Finally, many thanks to the large number of students, who participated in the field campaigns.

Notes

1 Additional to the sondage itself, we dug four 50×50 squares between 35 and 50m NE of our trench (SW coordinates 494.769/3.295.564 ; 494.774/3.295.568 ; 494.779/3.295.575 ; 494.782/3.295.576) to check a local amateur's story (communicated to one of us, A.T.) of finding a 'pebble floor' at 40 to 50 cm below the surface of the field. The small pits were up to 1m deep and did not record any pebble at all. We do have a straightforward explanation for the presence of pebbles in the field though: on a early 20th century map produced by Otto Hauser of the area of Les Eyzies and Font de Gaume, part of which is reproduced in this article in figure 9, there is a large (35 by 20 m) rectangular structure visible in the field where our *sondage* was located, somewhat north of our test pits. The structure was linked by a small road to the *Route Départementale*. Though the character of the structure is unclear (it does not have the ink infill that houses have on his maps, it could be a wooden barn), it might explain the presence of this – yet elusive – pebble floor in the field. The map is displayed in the Forschungsstelle Altsteinzeit of the Römisch-Germanisches Zentralmuseum at Monrepos, Germany (Übersichtsplan der prähistorischen Fundstätten No. 1-41 und Font de Gaume in der Umgebung von Les Eyzies im Tale der Vézère. Plan de Stations Préhistoriques Nos. 1-41, et Font de Gaume dans les environs des Eyzies. Vallée de la Vézère. Dordogne, France 1908. Aufgenommen u. gezeichnet April 1907-Mai 1908 von Th. Baumgartner, Ingenieur u. Konkordatsgeometer Seebach-Zürich).

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Patterns of Middle and Upper Palaeolithic land use in Central Lazio (Italy)

Hans Kamermans and Jan Sevink

The Italian Agro Pontino and surroundings are well known for their archaeological and palaeo-environmental research. This paper presents the results of interdisciplinary research in that area that started in the 1970's and continued into this century. After a description of the geology and soils of the Agro Pontino and the Monti Lepini, this data is used in a predictive model for land use during the Middle and Upper Palaeolithic. The model predicts that Middle and Upper Palaeolithic inhabitants of the area exploited only the Agro Pontino and not the surrounding mountains. They did this as generalist hunter-gatherers practising residential mobility.

1 Introduction

The difference in land use between Middle Palaeolithic and Upper Palaeolithic hunter-gatherers is a well-studied research topic (e.g. Mellars and Stringer 1989). One of the more rarely used tools to analyse this difference is predictive modelling (Kamermans 2006). To apply predictive modelling to archaeology, a number of conditions must be met, in particular, adequate data on the archaeology and the palaeo-environment.

Predictive modelling is a technique used in archaeology to predict, in a region, locations of material evidence of past human behaviour on the basis of observed patterns of archaeological and environmental material or on assumptions about human behaviour. The goal is either to predict archaeological site locations to guide future spatial developments in the modern landscape – an archaeological heritage management application – or to gain insight into former human behaviour in the landscape – an academic research application. We use the technique here for the latter purpose.

The Agro Pontino is a coastal plain along the Tyrrhenian Sea approximately 80 km southeast of Rome (fig. 1), in the North and East bordered by the Monti Lepini and the Monti Ausoni, which largely consist of limestones. The geology is well known. In the past decades, geologists, physical geographers, and palynologists studied the area intensively (Segre 1957; Sevink *et al*. 1982; 1984; 1991; Kamermans 1991). Half of the Agro Pontino consists of a low-lying graben filled with peat and fine-grained sediments; a complex of marine terraces forms the other half.

The archaeology of the region is also well known and most of it is collected in a controlled way by field surveys. Field surveying has for a very long time been a well-respected method to gather archaeological data for regional studies. The archaeological data used in this study has been collected through various surveys in the Agro Pontino in the 1980s (Holstrom *et al*. 2004) and through recent surveys in the Monti Lepini (van Leusen, forthcoming).

In archaeology, one of the problems with regional studies is the delimitation of the region. How big should the region be to allow for viable conclusions regarding archaeological cultures? Of course this depends, among other things, on the economic system in the past. For example, the size of an area exploited by hunter-gatherers differs from one exploited by pastoralists or agriculturalists. In this study we try to establish whether during Middle and Late Palaeolithic times the coastal plain of the Agro Pontino could support permanent habitation by hunter-gatherers or whether these hunter-gatherers also had to exploit the surrounding mountains. The results could be of wider importance since this question of scale is a general archaeological problem.

2 Previous work

2.1 Archaeological survey

Surveys are a cheap and non-destructive method way to collect archaeological data from a large area. Most surveys only visit a sample of the study area. Field walking is the most common way of doing a survey. A group of people usually crosses a field at a certain distance from each other and collects or registers all the archaeological material. Both projects described below used this technique.

2.1.1 Surveys in the Agro Pontino

There is a long tradition of Dutch research in the Agro Pontino and its surroundings. Between 1966 and 1984 the Laboratory for Physical Geography and Soil Science of the University of Amsterdam (the Netherlands) had a research project in Southern Lazio and adjacent Campania (Sevink *et al*. 1984). During a soil survey in 1978 in the Agro Pontino archaeological material was encountered (Sevink *et al*. 1982), and in 1979 the Instituut voor Pre- en Protohistorische

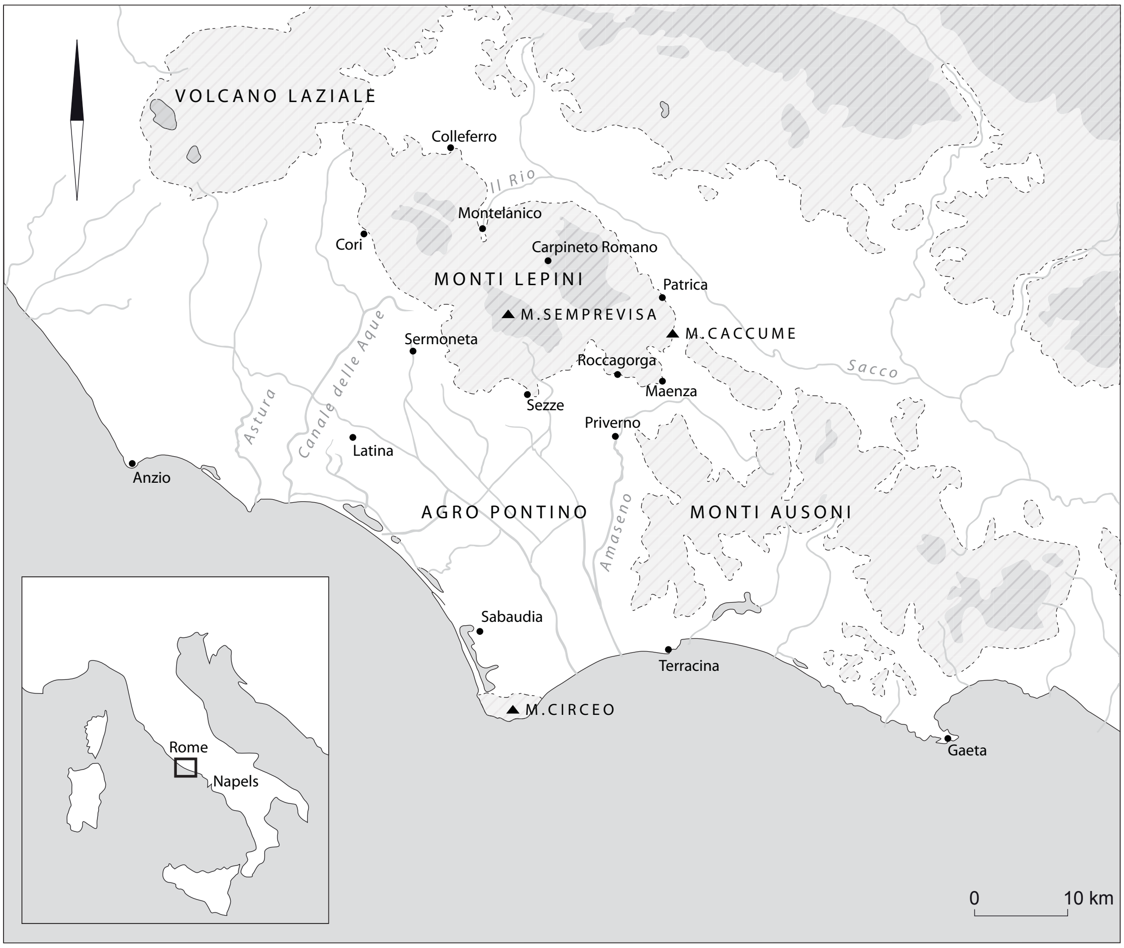

Figure 1 The study area in Central Lazio (Italy).

Archeologie Albert Egges van Giffen (IPP) of the University of Amsterdam started a study project in the Agro Pontino directed by Susan Holstrom Loving, Albertus Voorrips and Hans Kamermans (Voorrips *et al*. 1983; 1991; Holstrom *et al*. 2004). The two main research themes of the project were the transition from the Middle to the Upper Palaeolithic (Holstrom Loving 1996; Loving *et al*. 1990/91; 1992; Loving 1996) and the application of land evaluation in archaeology (Kamermans *et al*. 1985; 1990; Kamermans 1993; 1996; 2000; 2006).

Since it was not possible to survey the entire Agro Pontino, a sampling programme was required. It was decided to use a systematic unaligned transect sample, with transects crossing the area width-wise, from the southwest coast to the mountains. The sampling unit would be the agricultural field. After estimating that a single transect would cross about 150 fields and calculating that the minimum number of fields needed to answer the project's archaeological questions ranged up to 670, it was decided to draw five transects. The area was subdivided into 5 equally wide blocks and the location of the transect within each block was selected using a random method. An additional 727 fields were surveyed outside the transects.

Between 1979 and 1989 the project carried out seven surveys, three small ones with two to four people (1979, 1980, and 1989) and four larger ones with a crew of up to twenty scholars and students (1982, 1984, 1986, and 1988). In 1986 the Archaeology department of the University of Leiden joined the project. In 1980 and 1981 material for palynological research was collected. Methods used and results were published in Voorrips *et al*. (1991) and various other publications (Holstrom Loving 1996; Kamermans 1993; 1995; 1996; 2000; 2003; 2006; Kamermans *et al*. 1985; 1990; Kamermans and Voorrips 1986; Loving 1996;

Loving *et al*. 1990/91; Voorrips *et al*. 1986; 1989). In 2004 an annotated and illustrated catalogue of all the data collected was published on a CD (Holstrom *et al*. 2004).

The University of Groningen started the Pontine Region Project in 1987 with the objective to gain insight into the developments and changes in the organisation of the Pontine region during the first millennium BC (Attema 1993, Attema and van Leusen 2004, Attema *et al*. forthcoming). Various environmental and archaeological field surveys were carried out. The University of Groningen's archaeological research is still continuing. Relevant details are described in the next section.

2.1.2 Surveys in the Monti Lepini

As an offspring of its research, the University of Groningen developed a project named 'hidden landscapes' aiming at a full survey of the adjacent mountains and the border of the Agro Pontino plain, and paying particular attention to the development of the landscape over time and the interaction with human land use. Systematic surveys, in which all archaeological material was collected, were executed as part of the project (for an extensive description of the methodology employed, see van Leusen 2005; forthcoming). As to the Palaeolithic material, specific surveys were executed in 2005 and 2006. The soil map produced by Sevink *et al*. (1984) was used to establish the areas with surfaces that potentially have remained stable since the Middle Palaeolithic and to identify possible sources of flint or flint-like material in the mountains. A small team of physical geographers and archaeologists using the same techniques as for the Agro Pontino survey surveyed these areas. Fields were only surveyed when the visibility was sufficient (little or no vegetation, recent rain, etc.).

Additionally, prior to the survey, Palaeolithic materials that had been found in earlier studies by professionals as well as amateurs were evaluated for their technique and the nature of the lithic material. Furthermore, we tried to assess all sites where Palaeolithic material has been reported and visited these to check their occurrence and the origin of the lithic material.

2.2 Land evaluation as predictive modelling

One of the first definitions of predictive modelling is by Kohler and Parker: "Predictive locational models attempt to predict, at a minimum, the location of archaeological sites or materials in a region, based either on a sample of that region or on fundamental notions concerning human behaviour" (Kohler and Parker 1986, 400). The most common distinction in predictive modelling is a methodological one between inductive and deductive methods. The inductive method is dominant, but many methods and techniques are available. With the inductive approach a model is constructed based on the correlation between known archaeological sites and attributes from (mostly) the current physical landscape. On the basis of correlation, causality is assumed, and the model is then used to predict site location. These predictions in turn can be used for planning purposes. Often external expert knowledge is used to evaluate and adjust the models. With the, more rarely used, deductive approach the model is constructed on basis of *a priori* knowledge (social, mainly anthropological, historical and archaeological knowledge) and the known sites are then used to evaluate the model.

Land evaluation is a technique developed by soil scientists to generate different models for land use, as defined by the socio-economic context, on the basis of environmental and ecological information. In archaeology, land evaluation can be used as a deductive form of predictive modelling. After an initial inventory of the palaeo-environment, socio-economic models are constructed using ethnographical, historical, and archaeological data. Land units are ranked according to their suitability for a certain type of land use, and finally an expected form of land use is compared with the archaeological record.

Kamermans (2000; 2006) published the results of previous predictive modelling studies for the Agro Pontino. His conclusion was that land evaluation as predictive modelling could be a useful tool for research into land use for palaeotechnic peasant ecotypes but did not work for hunter-gatherer societies. Between the defined land units for the Palaeolithic, no differentiation in find spot density was found. Significant variations in find spot density between the defined land units is a condition for the proper application of predictive modelling, even for deductive predictive modelling. The study area must be large enough to have this variation. It could be that hunter-gatherers, in this particular case, operated on a different scale than palaeotechnic peasants and did not only exploit the Agro Pontino plain but also the adjacent mountains (Monti Lepini and Monti Ausoni).

3 Data

3.1 Geology and soils

3.1.1 Agro Pontino

The area consists of an inner, low-lying graben filled with peat and other fine-textured sediments, and an adjacent complex of stable marine terraces, which date from the Middle to Late Pleistocene (Segre 1957; Sevink *et al*. 1982; 1984; 1991; Kamermans 1991). A full summary of the extensive available information on the geology and soils of the Agro Pontino has been given in Voorrips *et al*. (1991). Recently Van Joolen (2003) and Smith (2007) studied the Late Quaternary history of the graben. Results conform with those from the earlier studies by Sevink *et al*. (1984) and Kamermans (1991).

Soil maps of the Agro Pontino generally have a scale 1:100.000 (Sevink *et al*. 1984) with some areas being mapped in more detail (e.g. De Wit *et al*. 1987). Related information on the genesis and properties of the soils served as a basis for the prehistoric land evaluation carried out by Kamermans (1993) and Van Joolen (2003).

3.1.2 The Mountains

Whereas quite a few geological studies exist on the Mesozoic to early Tertiary rocks, detailed studies on its Quaternary geology and its soils are largely limited to those by Sevink *et al*. (1984, with soil map with a scale of 1:100.000) and Arnoldus-Huyzendveld *et al*. (1985, with detailed soil maps of some basins). Also the scarce archaeological literature barely provides information on the geology and soils of these mountains, for which reason an extensive summary is given here.

Geology

The Monti Lepini are a topographically clearly delimited mountain range, consisting of predominantly NW-SE oriented chains and valleys, and divided into two parts by the large synclinal valley of Montelanico-Carpineto Romano (fig. 1 and 2). A large limestone massif forms the NE part, resembling a dissected plateau with altitudes generally over 1000 m. In the SW part limestones also dominate, constituting a large mountainous range with pronounced relief that culminates in the Monte Semprevisa (altitude up to about 1600 m). In the SW and S, this range is flanked by a series of less elevated limestone plateaus and hills. Drainage is largely subterranean, the area having pronounced karst features and lacking permanent rivers.

In the SE and E, the intermontane Priverno and Amaseno basins with a thick infill of Quaternary deposits separate the Monti Lepini from the Monti Ausoni. The latter consists of ridges and irregular plateaus, marked by a well-developed karst relief, with elevations generally between 500 and 850 m. To the SW and NE the Monti Lepini are abruptly bordered by the Agro Pontino and Valle Latina, respectively, with more or less linear, very steep slopes resulting from major faulting. In the NE, later volcanic deposits from the Volcano Laziale mask these major faults, but even here the boundary between the limestones of the Monti Lepini and the volcanic rocks stands out sharply. In the mountains, drainage is largely subterranean and karst features abound. In the low-lying intermontane basins, however, larger rivers carry water throughout the year, most notably the Amaseno River.

Major rock types distinguished in the Monti Lepini and Ausoni are: a) Mesozoic to Palaeocene carbonate rocks; b) Syn- and tardi-orogenic Tertiary rocks, and c) Quaternary rocks. The description of the first two groups is largely based on Parotto and Praturlon (1975), and that of the Quaternary rocks on Sevink *et al*. (1984).

a: The carbonate rocks comprise limestones and dolomites in shelf facies, ranging in age from Upper Trias to Palaeocene. They are dense, fine-grained, and coarsely bedded rocks, very low in terrigenous material. Other types, however, also occur such as for example detrital breccia and conglomerates. Limestones containing chert or related silicified material are of very subordinate importance.

b: The syn- and tardi-orogenic Tertiary rocks predominantly comprise flyschoid deposits of Miocene age, rocks such as olistostromes, nappes and olistoliths of the Sicilide complex, and finally a number of deposits of presumed Pliocene age.

Flyschoid deposits are relatively common in the Montelanico-Carpineto Romano valley and predominantly consist of calcarenites of which the habitus ranges from hard and dense coarse-bedded limestone to soft highly schistose marly limestone that is frequently interbedded with calcareous shales.

Rocks of the Sicilide complex are scarce and largely limited to the Monte Caccume area (a ‘Klippe’) and the Amaseno basin. They comprise a range of sedimentary rocks (shales to limestone). Contents of chert (‘diaspri’) tend to be very low or nil and ophiolitic material (serpentine/gabbro) lacks.

Sediments dated with more or less certainty to the Pliocene occur mostly transgressive on the Flysch succession, but locally also as isolated bodies. They comprise two marine formations (Catenacci and Molinari, 1965): an older, presumably Early Pliocene conglomerate and a younger rock type, presumably Pliocene s.l., consisting of clay with fragments of hard older strata and strongly resembling the clayey Flysch. The older conglomerates have some intercalations of finer textured beds and consist of limestone pebbles and very subordinate pebbles of Miocene sandstone and acid crystalline rocks. It is these older conglomerates, notably in the vicinity of Roccagorga, that contain some chert-like material in the form of angular strongly silicified limestone fragments.

c: Quaternary rocks can be subdivided into 4 groups: limestone weathering residues (‘terra rossa’), rocks of volcanic origin, fluvial deposits (mostly alluvial fan deposits), and marine-lacustrine-aeolian deposits. The latter two types are largely limited to the lower parts of the Monti Lepini.

Terra rossa abounds in the dolines and related karst depressions. Often the upper layers are largely volcanic in origin, being composed of a mixture of weathered volcanic ashes and limestone weathering residue. In some places, intercalated volcanic ash layers can be distinguished, but generally the superficial deposits are clearly colluvial in origin, the ashes and terra rossa being intimately mixed. It is only extremely occasional that the terra rossa contains gravel

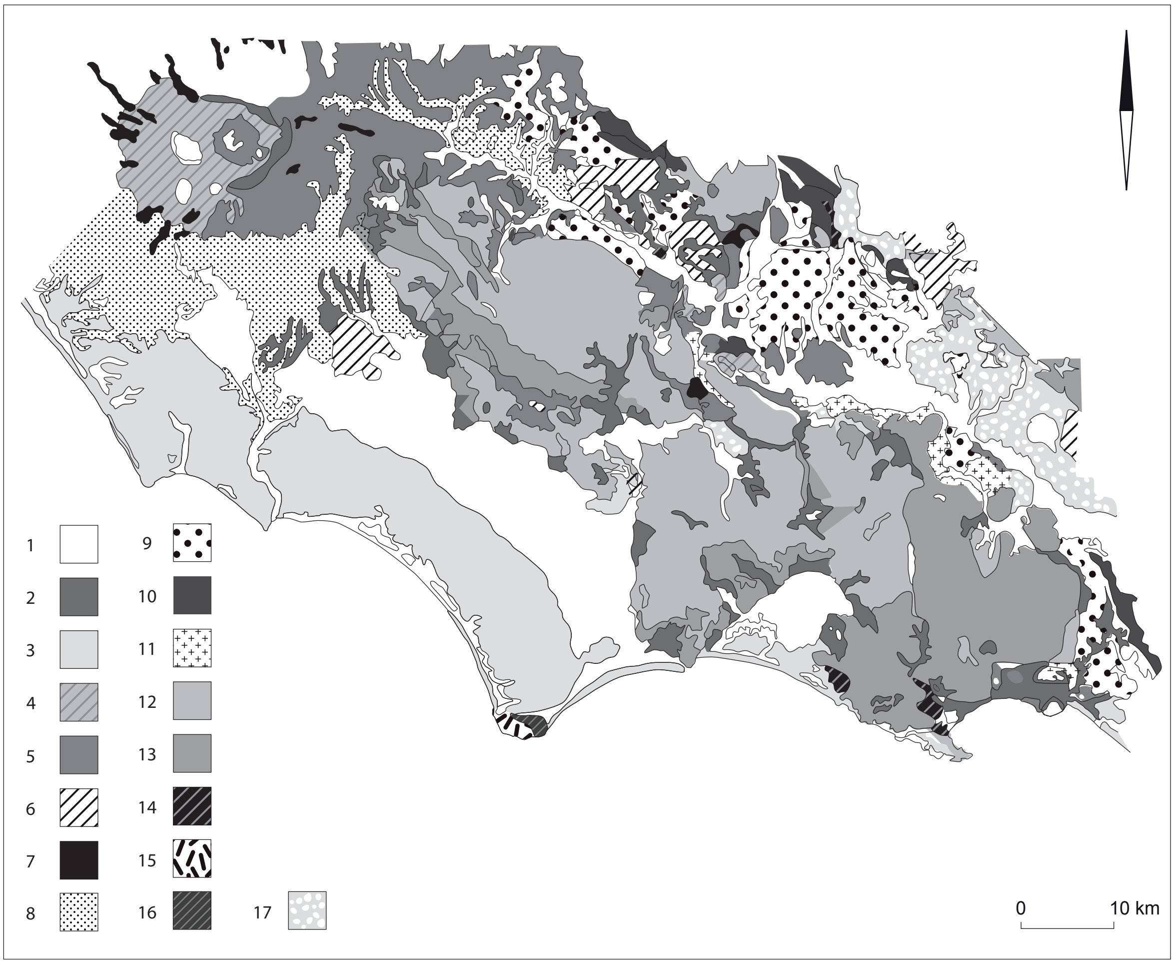

Figure 2 Geological map of Central Lazio (Italy) (after Bigi, Cosentino and Parotto 1988).

1 Holocene fluvio-lacustrine deposits and alluvial valley fills.
2 Holocene/Pleistocene slope deposits, alluvial fans and limestone weathering residues (terra rossa).
3 Holocene/Pleistocene beach ridges and dunes.
4 Upper Pleistocene phreatomagmatic pyroclastics
5 Middle to Upper Pleistocene pyroclastics
6 Travertines
7 Middle Pleistocene tephritic to leucitic lava flows
8 Middle Pleistocene pyroclastic flows.
9 Tortonian-Serravallian clayey-sandy turbidites.
10 Serravallian-Langhian bryozoae and litotamnae limestones
11 Eocene-Upper Cretaceous chaotic complex, variegated clays
12 Paleocene-Upper Cretaceous shallow marine limestones
13 Lower Cretaceous-Jurassic shallow marine limestones
14 Lower Liassic limestones and dolomitic limestones
15 Aquitanian sandstones of the Monte Circeo
16 Lower Liassic limestones and dolomitic limestones of the Monte Circeo.
17 Middle and Upper Pleistocene lacustrine deposits.

sized or coarser, mostly angular residual silicified limestone fragments, while residual chert was not observed.

Rocks of volcanic origin largely comprise air-born volcanic ashes from the Colli Albani, which in the western part of the Monti Lepini on relatively flat surfaces (e.g. near Sezze) may reach considerable thicknesses (several tens of metres) and in that case can be described as clearly stratified volcanic ashes with abundant intercalated palaeosols, largely dating from the Tuscolano-Artemisio phase (0.6-0.3 MY ago). Moreover, pyroclastic flows from the Colli Albani locally reached the lower river valleys in the northern Monti Lepini, where they formed thick, largely unstratified pozzolano-type deposits ("Pozzolane nere") as e.g. North of Montelanico.

At larger distances from the Volcano Laziale, thicknesses of these ashes decline. However, in the East, near the Amaseno basin and around Maenza, local eruptions have in places led to major volcanic ash deposits such as in this basin and its tributary valleys and, incidentally, to small lava-dominated volcanoes (Giuliano di Roma), and to lithoid tuff layers (e.g. Eastern Priverno basin). In the SE of the Monti Lepini and adjacent Monti Ausoni volcanic rocks are scarce, being limited to some air-born ash mixture in topsoils. All of these volcanic rocks are of Mid-Pleistocene age.

Fluvial deposits largely comprise coarse gravelly alluvial fan deposits, notably in the large valley between Roccagorga and Maenza where several phases can be identified of which the older have intercalated volcanic ashes and are locally strongly cemented. Similar cemented fan deposits are also encountered in the Amaseno basin and in the hills to the W of the Priverno basin. More recent fan deposits abound in the border zone of the Monti Lepini, such as the fans near Cori, Sermoneta, Sezze and Fossanova in the SW, and the series of fans along the NE border between Colleferro and Patrica. Truly fluvial deposits are largely restricted to the riverbeds of the Amaseno and Il Rio and these are largely matrix-supported gravels. In all deposits, the coarser fragments (gravel and coarser) consist dominantly of limestone and, very subordinate, sandstone. Fragments of silicified limestone or chert are extremely rare.

Marine-lacustrine-aeolian deposits are restricted to the Priverno area, where a complex of quartzitic aeolian sands rests on presumably lagoonal/lacustrine finer textured deposits with some thin volcanic ash intercalations. Deposits largely date to the Middle Pleistocene. Fine textured lagoonal/lacustrine deposits of Mid Pleistocene age are also encountered in the eastern part of the Priverno basin, with intercalated lithoid tuff, and in the adjacent Amaseno basin. It is only in the latter basin that these deposits contain some gravel-size material. This is partly composed of chert and silicified limestone (e.g. near Amaseno) that apparently are derived from the older Argille Scagliose in that basin.

Soils

Regarding soils, the following observations are relevant. Soils on relatively steep slopes have commonly suffered from accelerated soil erosion resulting from deforestation and long continued agriculture, and completely lost their top soil, while on lower slope sections and in depressions this eroded soil material accumulated in the form of poorly sorted largely colluvial deposits. Thus most of the steeper limestone slopes are severely eroded and lower sections of alluvial fans often consist of (sub-) recent sediments, burying older surfaces that upslope crop out. Thus, large tracts of the Priverno basin have been filled in during Post-Roman times with at least several metres of recent colluvium and similar phenomena occur in the outer zone (e.g. the fan near Sezze).

Less steep slopes and relatively stable, permeable soils often suffered far less from this human induced erosion. Thus deep, old soils are well preserved on the relatively stable, rather undulating surfaces of the aeolian/lacustrine complex of Priverno, in the larger karst depressions and on relatively gentle lower slopes in limestone (as for example in the Montelanico-Carpineto-Romano valley), in the larger volcanic ash complexes as e.g. encountered near Sezze, and in the older alluvial fans, both within and in the outer zone of the Monti Lepini.

3.2 Sources of lithic material

In the Agro Pontino, relevant sources of lithic material are gravels in the beach ridges to the W of Latina, notably the Eemian beach ridge and adjacent outcrops of its lagoonal deposits, underlain by gravels. During cold phases of the Last Glacial they probably were also extensively exposed on the now flooded parts of the plain. These gravels largely consist of well-rounded chert pebbles, which may be up to 10 cm in diameter, and gave rise to the Pontinian type lithic culture (Blanc 1937; 1939). Ansuini *et al*. (1990/91, 485), Kuhn (1995, 44), Holstrom Loving (1996, 507) and Riel-Salvatore and Negrino (2009, 220-221) give an extensive description of this material and its sources. But still the original source of the flint is not truly known.

In the mountains, chert and related rocks are extremely rare. They occur in small quantities near Roccagorga as minor component of some rare and small outcrops of presumably Early Pliocene deposits and as a very minor component of some lacustrine/lagoonal deposits in the Amaseno Basin, where they are probably derived from the Argille Scagliose.

3.3 Archaeology

The Agro Pontino is an archaeologically well-studied area. The earliest traces of human activity date from the Middle Palaeolithic. The area has been inhabited ever since. In this paper, we will focus on the Palaeolithic period. Research in

Palaeolithic archaeology in the Agro Pontino started before the Second World War. The region is famous for its Neandertal finds from the caves of Monte Circeo (e.g. Blanc 1957; Ascenzi 1990/91). Later excavations in other caves in Monte Circeo and in the Monti Ausoni yielded a wealth of archaeological and palaeontological material (see for an overview Mussi 2001). In more recent years, this material has been reanalysed by American researchers (Stiner 1994; Kuhn 1995). During the 1980s a team of Dutch, American and Italian scholars and students studied the archaeology and past environment of the Agro Pontino (Voorrips *et al*. 1983; 1991). This project was called the Agro Pontino Survey. The two main research themes were the transition from the Middle to the Upper Palaeolithic (Holstrom Loving 1996; Loving *et al*. 1990/91; 1992; Loving 1996) and the application of land evaluation in archaeology as predictive modelling (Kamermans *et al*. 1985; 1990; Kamermans 1993; 1996; 2000; 2006). The complete results of the survey of the Agro Pontino are published in Holstrom *et al*. (2004).

Many open-air sites dating from the Palaeolithic are known from the plain (Zampetti and Mussi 1988). Some were even excavated (Bietti 1984). This evidence, together with the data collected by the Agro Pontino Survey, showed clearly that humans intensively exploited the plain, from Middle Palaeolithic times onwards.

One of the main conclusions of all earlier research in the Agro Pontino is that there is a clear distinction in many aspects of human behaviour between the Middle and Early Upper Palaeolithic inhabitants of the plain. The most striking difference is the toolkit. There are two Early Upper Palaeolithic industries: the Uluzzian and the Aurignacian. Both differ in technology and typology from the Middle Palaeolithic Mousterian. The Uluzzian industry is seen as a continuation of the Mousterian and is commonly connected with Neandertals. In the same view the Aurignacian industry belongs to anatomically modern man (Mussi 2001).

For the adjacent mountains no systematic survey or reconnaissance had been carried out so far, finds being very much site-based and rather scattered over the area, lacking a systematic description. A first attempt at a more systematic survey has been started by the Hidden Landscapes project of the University of Groningen. This research started in 2005 and makes use of a geo-archaeological evaluation of the area, based on the earlier studies on the soils and geomorphology described above. The project concentrates on historical archaeological periods. No Palaeolithic open-air sites were discovered during these surveys.

The first attempt to locate Palaeolithic artefacts in the Monti Lepini was made in July 2005. Several areas were visited but without success. In 2006 a number of geologically speaking ‘stable’ areas were visited in the Monti Lepini. In January one site with flint and two sites with flint-like material (chert) were discovered. No tools were present. In the area of Roccagorga a natural outcrop of chert-like material was prospected. In July 2006 other areas were visited, but again without success. In almost none of the fields surveyed in the Monti Lepini was any lithic material found, while the material from later periods was often abundant. Discussions with local archaeologists and amateur archaeologists, and the study of local literature (Casto and Zarlenga 1997; Casto 2005) revealed that no confirmed Palaeolithic sites are known in the Monti Lepini.

4 Analyses

The research question is whether there was a difference in land use between the Middle and Upper Palaeolithic inhabitants of the Agro Pontino and adjacent mountains. To answer this question a deductive form of predictive modelling, land evaluation, has been used. The following analysis is similar to the one published by Kamermans in 2006. The data used comes from the Agro Pontino and the SW part of the Monti Lepini.

4.1 Deductive predictive modelling

For the analysis, two socio-economic models were constructed: the generalist practising residential mobility and the specialist practising logistic mobility. A semi-quantitative land classification was formulated for these two models.

The characteristics of a generalist are: hunting various species of animals in an area with a great variability in land units and a high residential mobility. In order to be able to identify the generalist, land units are grouped together in order to construct units with a great variability. The smaller marine terraces along the coast are grouped together, as are the younger inland lagoonal deposits, and the volcanic and travertine deposits. The Terracina level and the more recent alluvial/colluvial deposits are left out of the analysis since they did not exist during the Palaeolithic. The only areas with stable surfaces in the Monti Lepini are the relatively flat parts covered with volcanic material. These are the only areas with potentially Palaeolithic material on the surface. The rest of the mountains had to be left out of the analysis.

Land unit	Predicted Rank
Coastal terraces	1
Small lagoonal	2
Volcanic & travertine	3
Latina lagoonal	4
Aeolian	5
Monti Lepini	6

Table 1 Semi-quantitative land classification for the generalist hunter-gatherer during the Palaeolithic (see also figure 3).

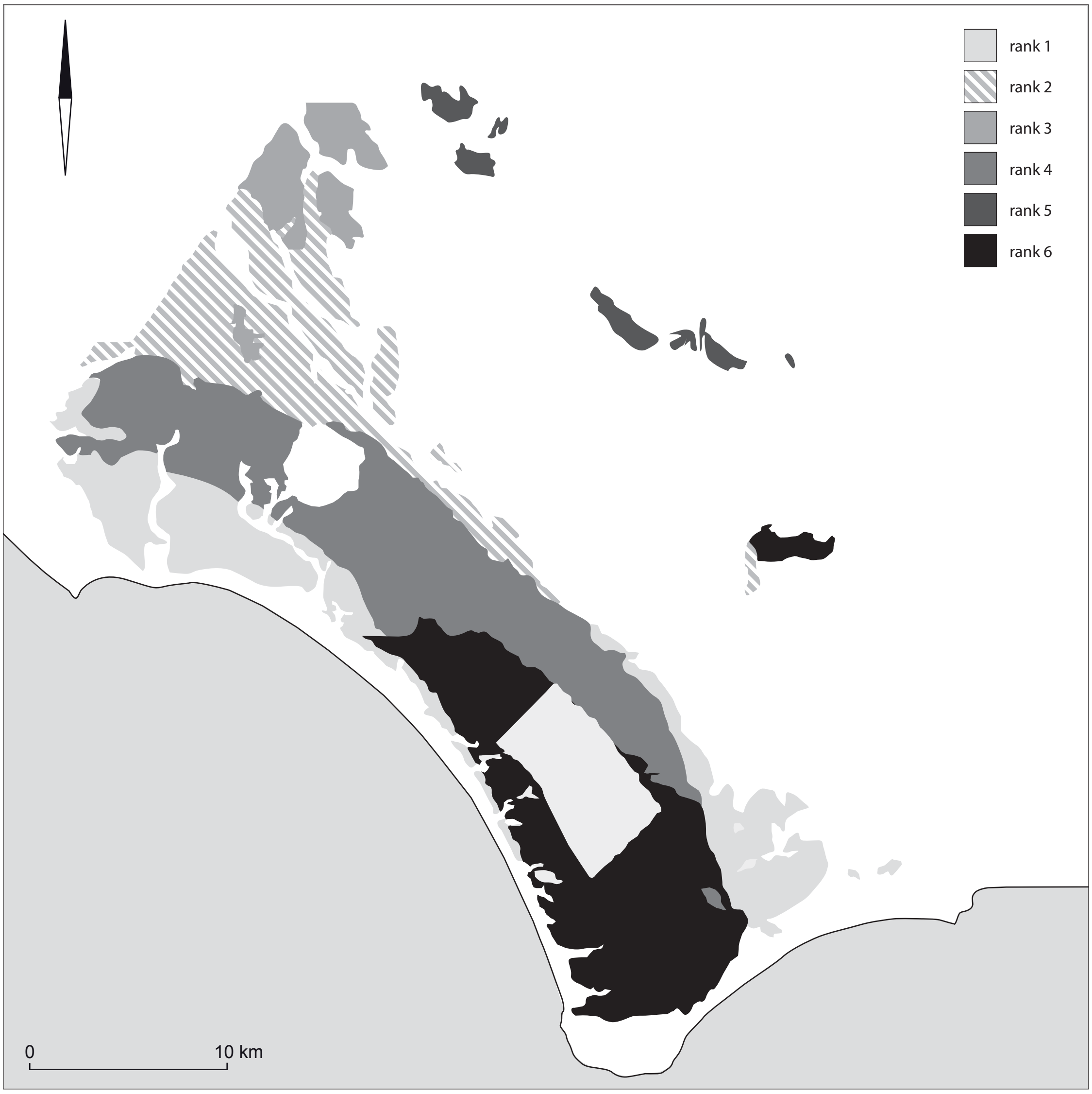

Figure 3 Semi-quantitative land classification for the generalist hunter-gatherer during the Palaeolithic. Predicted rank. (see also table 1).

Figure 3 and table 1 give the semi-quantitative land classification for the generalist hunter-gatherer during the Palaeolithic. The most suitable area would seem to be a combination of the younger marine terraces characterized by a diverse environment, i.e. sandy ridges alternating with clayey plains. Also the more inland lagoonal areas would be suitable for the general hunter-gatherer, followed by the volcanic and travertine deposits and the large lagoonal and aeolian units. The isolated areas in the Monti Lepini are considered the least suitable for generalist hunter-gatherers.

The characteristics of a specialist hunter-gatherer are: high logistic mobility, foraging in large land units. The environment in the land units should be less diverse than for the generalist hunter-gatherer. In this case, the smaller marine terraces along the coast, the younger inland lagoonal deposits and the volcanic and travertine deposits are not grouped together. Table 2 shows that the large Latina lagoonal deposit would be the most suitable land unit for the specialist hunter-gatherers during the Palaeolithic and the Monti Lepini the least suitable (fig. 4).

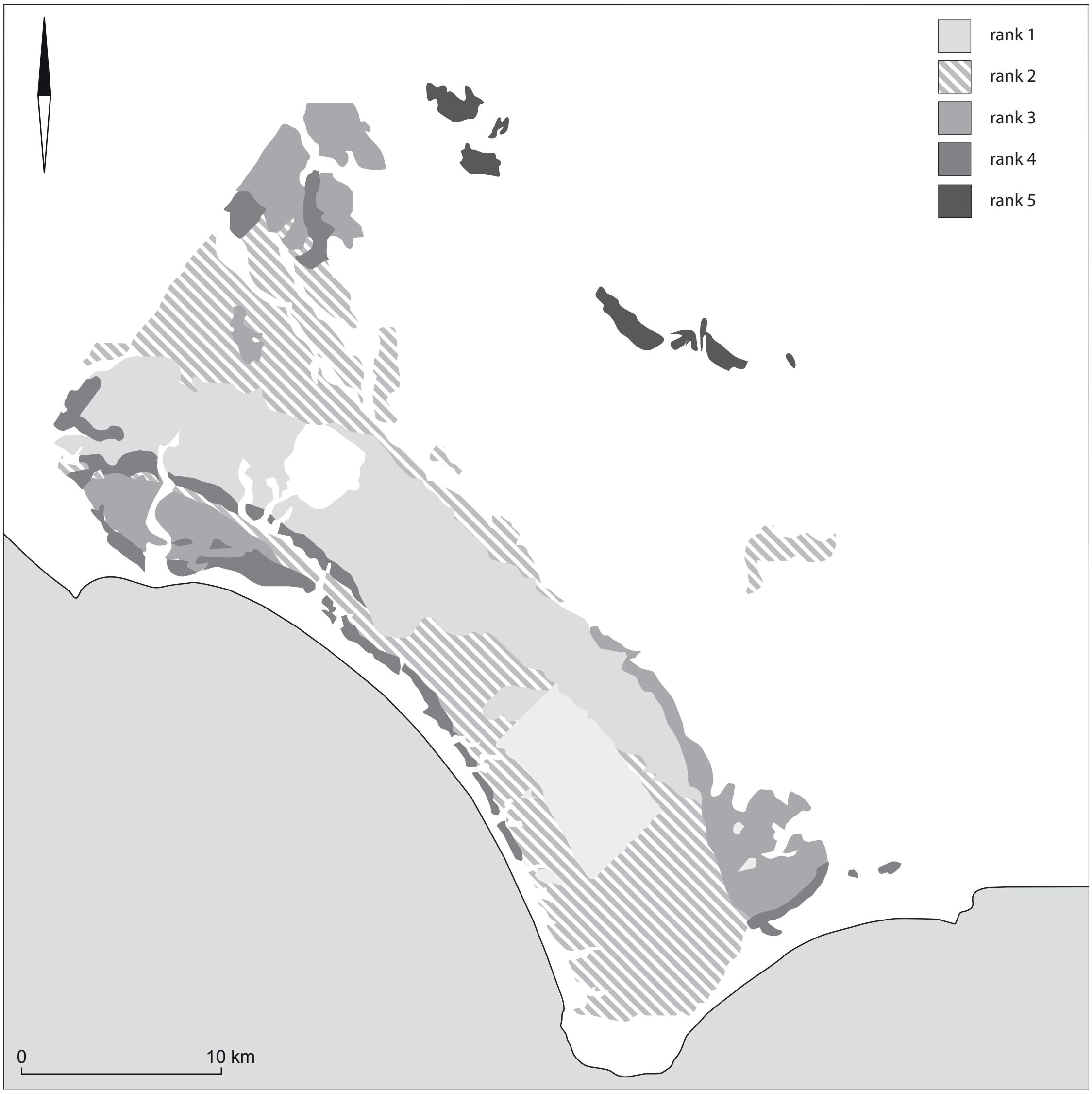

Figure 4 Semi-quantitative land classification for the specialist hunter-gatherer for the Palaeolithic. Predicted rank. (see also table 2).

Land unit	Predicted Rank
Latina lagoonal	1
Borgo Ermada inland lagoonal	3
Minturno beachridge	3
Aeolian	3
Borgo Ermada lagoonal	6
Volcanic	6
Travertine	6
Borgo Ermada beachridge	9.5
Minturno lagoonal	9.5
Minturno inland lagoonal	9.5
Monti Lepini	11

Table 2 Semi-quantitative land classification for the specialist hunter-gatherer for the Palaeolithic (see also figure 4).

The rank order of the different land units, based on data on find spot density collected during the survey, was compared with the expected rank order of the land units for the

Land unit	Predicted rank	Observed Middle Palaeolithic	Observed Upper Palaeolithic
Coastal terraces	1	4	4
Small lagoonal	2	2	1
Volcanic & travertine	3	3	3
Latina lagoonal	4	1	2
Aeolian	5	5	5
Monti Lepini	6	6	6

Table 3 Comparison of predicted and observed preferences for general hunter-gatherers during the Middle and Upper Palaeolithic.

Period	Spearman test			Kendall's test		
	R	t(3)	signif.	Tau-c	ASE1	t
Middle Palaeolithic	.486	1.111	.329	.333	.407	.818
Upper Palaeolithic	.600	1.500	.208	.467	.361	1.292

Table 4 Spearman's and Kendall's test for the data in table 3.

different models. In addition, a test was carried out to see whether there was significant difference in find spot density between the different land units for every separate time period.

Table 3 gives the expected and observed rank order for the generalist hunter-gatherer during the Middle and Upper Palaeolithic. Both the Spearman test and Kendall's test were used to test the rank order (table 4).

With an α of 0.1 none of the rankings was significant which means that none of the observed rankings correspond to the predicted ranking for general hunter-gatherers.

Table 5 gives the expected and observed rank order for the specialist hunter-gatherer during the Middle and Upper Palaeolithic. Table 6 gives both the Spearman test and Kendall's test to test the rank order.

Land unit	Predicted Rank	Observed Middle Palaeolithic	Observed Upper Palaeolithic
Latina lagoonal	1	2	4
Borgo Ermada inland lagoonal	3	3	3
Minturno beachridge	3	6	5
Aeolian	3	10	8
Borgo Ermada lagoonal	6	8	7
Volcanic	6	4	9
Travertine	6	9	2
Borgo Ermada beachridge	9.5	5	6
Minturno lagoonal	9.5	7	10
Minturno inland lagoonal	9.5	1	1
Monti Lepini	11	11	11

Table 5 Comparison of predicted and observed preferences for specialised hunter-gatherers during the Middle and Upper Palaeolithic.

Period	Spearman test			Kendall's test		
	R	T(8)	signif.	Tau-c	ASE1	t
Middle Palaeolithic	.161	.490	.636	.154	.316	.487
Upper Palaeolithic	.285	.891	.396	.242	.282	.859

Table 6 Spearman's and Kendall's test for the data in table 5.

Again, with an α of 0.1 none of the rankings was significant which means that none of the observed rankings corresponds to the predicted ranking for specialised hunter-gatherers.

For the Middle and Upper Palaeolithic none of the expected rank orders for either the generalist or the specialist fits with the observed rank order.

4.2 Inductive predictive modelling

In order to explain the failure of land evaluation to detect differences in land use in the Agro Pontino and Monti Lepini between the Middle and the Upper Palaeolithic, an inductive approach is used to see whether there is a correlation between find spot density and land units.

The archaeological hypothesis for the Middle Palaeolithic is that hunter-gatherers had no preference for any of the constructed land units. The null hypothesis is that there is no difference in find spot density between the defined land units.

The Attwell-Fletcher test was used to test this hypothesis. This test (Attwell and Fletcher 1985; 1987) is designed to test the existence of a significant association between a point pattern distribution and categories of an environmental variable. It compares an observed pattern with a simulated random pattern. Two sets of hypotheses are tested. The null hypothesis for the first set is no association, the alternative hypothesis is that at least one category is favoured. In the other case the null hypothesis is of course the same but the alternative hypothesis is that at least one category is avoided.

Table 7 shows that two land units, the Latina lagoonal and the Small lagoonal, have a category weight similar or higher than the 95th percentile. This means that the density of find spots is higher than can be expected on the basis of chance. One land unit, the areas in the Monti Lepini covered with volcanic material, has a value below the 5th percentile such that the null hypothesis of no association is rejected, i.e. there is an association. This means that there are fewer than expected find spots in the area. This is hardly a surprise since no Palaeolithic find spots have been found in the Monti Lepini.

Land unit	number of find spots	expected proportion	observed proportion	category weight
Coastal terraces	13	0.2492	0.23	0.16
Small lagoonal	12	0.1273	0.21	0.30
Latina lagoonal	23	0.2376	0.40	0.31
Aeolian	2	0.1210	0.04	0.05
Volcanic & travertine	7	0.1231	0.12	0.18
Monti Lepini	0	0.1418	0.00	0.00

Table 7 Attwell-Fletcher test to compare the find spot density and geomorphological land units for hunter-gatherers during the Middle Palaeolithic in the Agro Pontino. Number of find spots = 57, number of categories = 5, number of simulations = 1000. 95th percentile = 0,30 ± 0,005, 5th percentile = 0,04 ± 0,006.

For the Upper Palaeolithic the hypotheses are the same. The archaeological hypothesis is that hunter-gatherers had no preference for any of the constructed land units. The null hypothesis is that there is no difference in find spot density between the land units. Table 8 shows that for the Upper Palaeolithic no category weight is above the 95th percentile and the category weight of the land unit in the Monti Lepini is, again, below the 5th percentile.

Land unit	number of find spots	expected proportion	observed proportion	category weight
Coastal terraces	7	0.2492	0.22	0.15
Small lagoonal	7	0.1273	0.22	0.30
Latina lagoonal	12	0.2376	0.38	0.28
Aeolian	2	0.1210	0.06	0.09
Volcanic & travertine	4	0.1231	0.13	0.18
Monti Lepini	0	0.1418	0.00	0.00

Table 8 Attwell-Fletcher test to compare the find spot density and geomorphological land units for hunter-gatherers during the Upper Palaeolithic in the Agro Pontino. Number of find spots = 32, number of categories = 5, number of simulations = 1000. 95th percentile = 0,35 ± 0,015, 5th percentile = 0,03 ± 0,013.

5 Discussion

The Agro Pontino has a high density in Palaeolithic find spots. The finds consist almost exclusively of material made from flint beach pebbles. If we analyse the distribution of find spots in the Agro Pontino without the adjacent mountains, the outcome is that these sites are distributed randomly over the area (Kamermans 2006); there is no difference in both Middle and Upper Palaeolithic site densities between the distinguished land units. If we include the Monti Lepini, then the outcome for the Middle Palaeolithic is different. In the coastal lagoonal areas the density of find spots is higher than expected and the land units in the mountains have a lower density (table 7). However, neither the ranking for the model for general hunter-gatherers nor for specialised hunter-gatherer fits the encountered rank order. For the Upper Palaeolithic period there is only significant difference in find spot density for the land units in the mountains, there are fewer find spots than expected. Again, none of the rank order predicted by the models fits the observed order.

The interpretation of these results is not easy. First we have to deal with the assumption that find density is an indication of human activity in a particular area. This general assumption among archaeologists stems from the observation that human activity in the landscape produces a spatial pattern of material culture. So patterning is taken to be evidence for behaviour. The spatial arrangement of archaeological material in a region reflects the utilization of space in the past (e.g. Hodder 1978). There are not many ethnographic studies devoted to this topic that we could use for comparison. A study on the discard of stone tools in Papua New Guinea Highlands shows that most of the tools were discarded around houses and a small proportion in gardens, along tracks, in rock shelters and other locations (White and Modjeska 1978). So in general the tools are discarded in the areas where the activities take place.

We may assume that the density of find spots with flint material in the Agro Pontino and the adjacent mountains is an indication of the intensity of the exploitation of that area. Given the number of find spots, it looks as if the plain has been used intensively during both Middle and Upper Palaeolithic times. The spatial pattern of the find spots, however, gives no indication for a difference in land use (Kamermans 2006). If we change the scale of our research and include the adjacent mountains, our results only change slightly. There are no known Palaeolithic find spots in the mountains. Is this a consequence of human behaviour or of taphonomic processes?

If we consider the information we have from our own survey in the stable areas and from other sources that there are no sites in the mountains as a good indication of the use that Palaeolithic men made of the mountains, we can conclude that this use was not very intensive. The sources of flint are all in the coastal area of the Agro Pontino. In the mountains there are no flint sources at all, and only a few places where poor quality chert can be found. The availability of water sources in the mountains is low. Water is only available in the intermontane basins. The conditions for food and shelter in the mountains during the end of the Pleistocene were often poor.

On the other hand the areas on both sides of the mountains, the Agro Pontino in the south and the Valle Latina in the north had very favourable conditions. The conclusion must be that Palaeolithic men living in the Agro Pontino and the Valle Latina had no need to exploit the Monti Lepini. The resources (including flint material) were in both quality and quantity sufficient for habitation.

However other researchers made other observations in the same area. During the late 1980s two American scholars studied, respectively, the faunal and the lithic material from the cave sites of Monte Circeo. Both Stiner and Kuhn (Kuhn 1991; 1995; Stiner 1990; 1991; 1994; Stiner and Kuhn 1992) see a major change in subsistence during the Middle Palaeolithic in Latium. Before 55,000 BP scavenging was the main activity for subsistence, while after 55,000 BP hunting was. They base their conclusions mainly on the fact that head parts of medium-sized ungulates dominate the pre-55,000 collections. The range of formal tool types in the Mousterian sample stays the same across the 55,000 year boundary, but the reduction technique changes. Mussi (1999) expressed surprise that scavenging continued until that late a date in the Agro Pontino and ascribes the differences in notably the faunal material to differences in excavation techniques. Indeed, all the sites dated before 55,000 BP were largely excavated before the Second World War, the later sites after the war.

One of Steven Kuhn's observations (1995) is that the percentage of tools made of non-local flint is higher in the Upper Palaeolithic layers than in the Mousterian layers. Combined with the evidence of Mary Stiner (1994), he concludes that Middle Palaeolithic inhabitants of the Agro Pontino had a tendency towards very frequent residential moves, while the Upper Palaeolithic population may have had a highly differentiated pattern of seasonal movement (Kuhn 1995, 178). The Mousterian population apparently lived and foraged exclusively along the coast and the coastal plain. The Upper Palaeolithic populations made trips more inland to other sources of flint than the flint pebbles found along the coast.

6 Conclusions

Kuhn (1995) assumes that his Middle Palaeolithic toolmakers practised residential mobility and Upper Palaeolithic foragers had a very high mobility. We find indeed a higher than expected density of find spots for the Middle Palaeolithic in the coastal area. This agrees with Kuhn's hypothesis that the Mousterian population lived and foraged exclusively along the coast and in the coastal plain. There is, however, no evidence of exploitation of the Monti Lepini during the Palaeolithic, which means no support for the theory of Upper Palaeolithic seasonal transhumance. The Agro Pontino formed during the Palaeolithic a more densely exploited 'autarchic area'. On the question of difference in land use between the Middle and Upper Palaeolithic, we must come to a slightly different conclusion than the earlier conclusion by Kamermans (2006). We agree with Stiner and Kuhn that the Middle Palaeolithic inhabitants practised frequent residential moves, but we do not see any evidence for the highly differentiated pattern of seasonal movement for the Upper Palaeolithic. We think that both the Middle Palaeolithic Ancients and the Upper Palaeolithic Moderns considered the whole of the Agro Pontino as one land unit and used the same way of exploiting the area: as generalist hunter-gatherers practising residential mobility.

Acknowledgements

We should like to thank Martijn van Leusen for his valuable contributions to our research, not only as a discussant but also for granting us hospitability during our fieldwork in the Monti Lepini. His research is sponsored by NWO (grant 016.054.327).

The Agro Pontino survey project was a joint venture of the Instituut voor Pre- en Protohistorische Archeologie Albert Egges van Giffen (IPP), of the University of Amsterdam, and the Instituut voor Prehistorie of the State University of Leiden (both The Netherlands). It was under the auspices of the Istituto Olandese in Rome and supported by various research grants from the Netherlands Organisation for Scientific Research (NWO). The following institutes cooperated in the project: Soprintendenza Archeologica del Lazio, the Department of Anthropology of the Universitá di Roma "La Sapienza", the Laboratory for Physical Geography and Soil Science of the University of Amsterdam, the Museo Nazionale Preistorico Etnografico "Luigi Pigorini" in Rome, the Istituto Italiano di Paleontologia Umana in Rome, DIGITER geo-informatica in Rome, and the Hugo de Vries Laboratory of the University of Amsterdam.

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Crops grown on the sandy soils of Eastern Brabant (the Netherlands) before, during and after the Roman occupation

Corrie Bakels

*Discussed is the effect of Roman occupation, and its subsequent disappearance after some 250 years, on the crops grown by native farmers living on the sandy soils of Eastern Brabant. The Romans introduced the cultivation of beet (*Beta vulgaris*). Other crop plants may have been introduced as well, but, probably due to taphonomic problems, such plants have not been found. The other newcomers retrieved during excavations: dill* (Anethum graveolens*), celery (*Apium graveolens*), coriander (*Coriandrum sativum*), parsley (*Petroselinum crispum*), savory (*Satureja hortensis*), plum (*Prunus domestica *var.* insititia*) and walnut (*Juglans regia*) were only found in connection with higher-status dwellings and may have been imported. It is not certain that the owners of such farms did grow them in their own gardens. Another change is that the rural population left more remains of wild fruits and nuts, which is interpreted as an indication of an increased importance of gathering, possibly due to the relative shortage of men to do heavy farm work. Many men would have left to serve in the Roman army.*

*The disappearance of Roman rule brought the arrival of Germanic people and with them a new cereal: rye (*Secale cereale*). Rye must have been part of Germanic culture. The 'Roman' vegetables, fruits and condiments remained.*

Analysis of carbonized harvests showed that crops were grown as monocrops. The existence of maslins could not be demonstrated. The weeds in the harvests are indicative of poor, acid soils.

1 Introduction

For many years archaeologists of Leiden University have carried out excavations in the eastern part of the province of Noord-Brabant (the Netherlands). From 1996 onwards the private firm Archol, associated with Leiden University and founded to carry out contract research, was and still is active in the same region. Others, for instance the University of Amsterdam and the Free University of Amsterdam, have been digging there as well.

A considerable part of the excavations was devoted to rural settlements, consisting of traces of farmhouses, granaries and other outhouses, pits, wells and an occasional fence. Almost all structures above ground were built in wattle-and-daub which does not withstand decay, and only postholes, pits, wells and other features dug into the subsoil will have been left to be discovered today. They appear as discolorations in the subsoil because they were, intentionally or not, filled in with a dark-coloured sediment which stands out against the lighter background. The difference in colour is attributable to a difference in pollution with organic substances. Exceptions to this general picture are provided by one or two farmhouses erected in the Roman period after a Roman style of building which implied the use of stone and brick in its lower parts.

Many of the excavated sites date back to the Middle to Late Iron Age, Roman period and Early and High Middle Ages. This is the period 500 BC – AD 1250. During this long stretch of time two important events took place which left their marks in the region. The first was the arrival of the Roman army of occupation around 19 BC and the subsequent incorporation of the region in the Roman Empire. The regions northern and eastern limits became part of the Roman frontier, the so-called *limes*. The second event was the collapse of Roman rule, which in this region set in halfway the 3rd century AD. By and by authority was taken over by Germanic tribes which had crossed the *limes*, first by invitation and later on their own initiative. Both events are archaeologically visible.

Whenever possible, the excavated features were sampled for botanical remains. In general such remains are carbonized, because most of the features are well above the watertable. Uncarbonized plant matter would not have been preserved under such circumstances. Wells offer the exception. If they still reach below the watertable, fruits and seeds are preserved by waterlogging. Unfortunately not every well bottom was lying deep enough to have stayed wet since the well was dug. Lowering of watertables in the distant, but more often in the fairly recent past has destroyed the organic contents of quite a number of old wells. Nevertheless, enough wells with waterlogged contents were found. This is fortunate, because remains of vegetables, condiments and fruits are better preserved in this way. Carbonized matter provides mostly insight into cereals, pulses and, to a lesser extent, oil seeds.

The result of all the sampling is that a number of data have become available to answer questions. The questions put forward in this paper refer to the events mentioned earlier:

- Did the inclusion of the region in the Roman Empire have any impact on the choice of crops cultivated by the indigenous population?
- What happened to crop cultivation after the collapse of the Roman Empire?

The region covered in this paper is bordered on its northern and eastern side by the river Meuse, which implies that not only parts of the province of Noord-Brabant are studied but a small part of the province of Limburg as well. Its southern and western limits are rather arbitrarily drawn (fig. 1).

2 The geological and geographical background

The deeper subsoil of the region consists of gravels and sands deposited by the river Meuse during the Early and Middle Pleistocene. During the cold phases of the Late Pleistocene these deposits were covered by wind-blown sands originating from surfaces lying bare of vegetation. Such sands are called ‘cover sands’. They are wanting in lime and loam, though the loam fraction may vary from place to place. Nevertheless it is nowhere very important. At present cover sands lie at the surface in most of the region, as they did during the entire Holocene. Holocene additions are loamy deposits in the valley of streams, an important stretch of oligotrophic peat, relatively small patches of wind blown sands caused by deforestation, and the man-made *plaggen* soils. The latter are the result of manuring fields with sods (*plaggen*) mixed with dung and household waste. This kind of manure contains a considerable amount of mineral matter and its use has raised the surface of the fields noticeably, but as this practice dates from a period after the period considered in this paper, *plaggen* soils were not yet in evidence at that time (Spek 2004, 800 and 807).

Since their deposition the cover sands have undergone the process of podzolisation. The resulting podzol type depends on the vegetation history of the different parts of the region and its history is still a subject of research.

The region is drained by a series of small streams which discharge into the large river Meuse. They are arranged in two systems, one running in a northerly direction and one in a more easterly direction. Most of the cover sand plateaus between the streams are characterised by a low watertable. Only near the streams is the watertable higher. But there are two exceptions. The most important one is the watershed between two drainage systems. Because the cover sands were delivered by winds blowing from the North and did not settle evenly but in low east-west running ridges, the streams running in a northerly direction were not successful in draining the parts of their area in their upper courses. The result was stagnation of run-off, which in its turn led to peat growth. During the period under review a vast peat, known as De Peel, covered this part of the region.

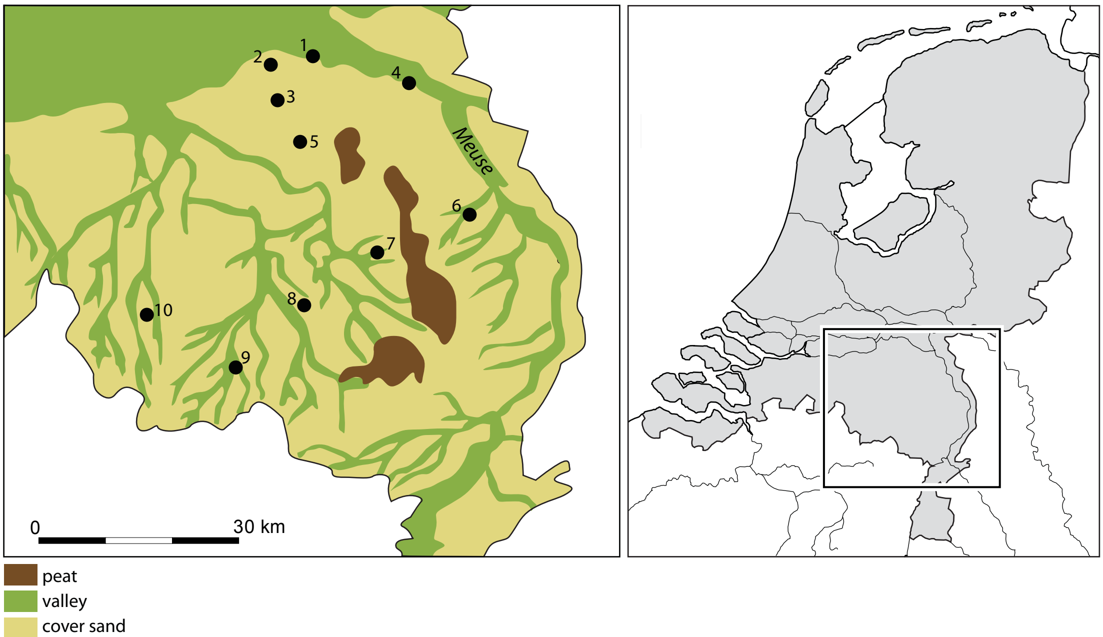

Figure 1 Map with the location of the sites mentioned in the text. 1 Herpen, 2 Oss, 3 Nistelrode, 4 Cuijk, 5 Uden, 6 Venray, 7 Bakel, 8 Geldrop, 9 Dommelen, 10 Hoogeloon.

The other exception are places where artesian seepage maintains marshy patches in the landscape. This seepage has its origin in the tectonics of the region, where deep-lying faults provide discontinuities in the sediment layers. Tectonic movements are still occasionally felt, but they are not strong enough to have had a serious effect on the population's lives and actions.

In the period 500 BC – AD 1250 the rural population lived on the cover sand plateaus, not exactly in their centres but also not on their immediate edges. Streams were never far off, but nevertheless the people did have to rely on wells for their water. If there was anything to choose, they opted to settle on cover sands with some content of loam (Roymans and Gerritsen 2002).

3 The plants grown

3.1 The Middle and Late Iron Age (500 BC – 19 BC)

The crops grown by the Iron Age farmers were emmer wheat (*Triticum dicoccum*), spelt wheat (*Triticum spelta*), hulled multi-rowed barley (*Hordeum vulgare* var. *vulgare*), oats (*Avena sativa*), broomcorn millet (*Panicum miliaceum*), pea (*Pisum sativum*), horsebean (*Vicia faba* var. *minor*), flax (*Linum usitatissimum*), gold of pleasure (*Camelina sativa*), rape seed (*Brassica rapa*), and opium poppy (*Papaver somniferum* var. *setigerum*) (Bakels and van der Ham 1980; Bakels *et al*. 1997).

In some settlements the status of oats as a crop plant is questionable, because identifiable chaff remains are lacking. Grains of oats cannot be distinguished from wild oat (*Avena fatua*), a weed in cereal fields. Rye (*Secale cereale*) in this region was not yet a crop, as distinct from sites north of the river Meuse (Lauwerier *et al*. 1998-99).

All plants are known from carbonized and/or waterlogged remains, whilst additional information is provided by impressions of seeds and chaff in ceramics. They present quite a list, but what strikes the eye is that all plants are annuals. Of course, the list is biased because the ways of preservation exclude the discovery of plants grown for their leaves, roots and bulbs, which are neither preserved by carbonization nor by waterlogging, but this fact does not explain why perennial species have not been found. What is also clear is that the crops were grown to provide cereals, pulses, oil seeds and fibers. Plants grown for flavour or medicinal use are absent from the records. Missing too are plants providing dye stuffs. It is possible that such plants are not found, because they are used in the form of leaves or roots, but if they were grown on any scale at least some of their seeds, for instance seeds destined for sowing or seeds from plants run to seed, might have been preserved. Also, some condiments and medicines are seeds. The conclusion must be that the Iron Age farmers grew only staple crops. Other products, such as fruits, nuts and herbs were obviously collected from wild stands, if and when needed.

3.2 The Roman period (19 BC – AD 250)

Mediterranean habits were quite different. Farmers in Italy, for instance, planted fruit and nut trees, and cultivated vegetables in gardens. Some of their products, especially condiments, arrived together with other southern products such as luxury ceramics in regions north of the Mediterranean long before the arrival of Roman armies (Bakels 2009, 104). They are found in northern France and southern Germany and are considered as medicine. Instances of such plants are celery (*Apium graveolens*) and fennel (*Foeniculum vulgare*). There are no indications that these were actually grown in these regions.

The arrival of Roman troops altered this situation. The army people, and especially their officers, could obviously not live without their customary foods. Immediately after the Roman invasion exotic plants turn up in the archaeological records, a phenomenon observed in many European sites which before were situated well outside the sphere of Mediterranean influence (Bakels and Jacomet 2003). The civilian administrators who followed shortly after, shared the culinary demands of the army people.

At first all products foreign to the conquered regions had to be imported, and this phase lasted some 50 to 70 years. But later on everything that could be grown locally, was grown locally. Roman style farms sprung up, known as *villae rusticae*. This new development is found almost everywhere, but there are regions where the *villa rustica* did not take. One of these is the region under review here. One reason put forward is that Brabant formed a hinterland of the Roman frontier, the *limes* (Slofstra 1991, 137). But against this explanation can be said that elsewhere in Europe the *villa rustica* became very popular in regions along the *limes*. Slofstra offers another possibility, namely that the nature of the soil hampered the rise of the Roman style farm. A development in the direction of a *villa* took place during the 2nd century, but the process seems to have come to a standstill at the level of the so-called *native-style villa*, which is a traditional type of house with some external features of a *villa* such as a wooden portico and a tiled roof. Formerly these buildings were called *proto-villa*, i.e. something that never reached the stage of a true *villa*, but now they are considered to represent a new local architectural design (Slofstra pers. comm.). Only one farmstead has the characteristics of a true *villa rustica* of modest size: the *villa* of Hoogeloon.

Farmers producing in a classic *villa rustica* setting planted orchards and maintained vegetable gardens (Bakels and Jacomet 2003). Such specialized plots of land were neither detected in connection with the *villa* of Hoogeloon, nor with the *native-style villae*. Nevertheless, the indigenous farmers did incorporate some 'Roman' food plants into the range of plants to be grown. The most reliable evidence of this is provided by finds of fruits of beet (*Beta vulgaris*) (fig. 2).

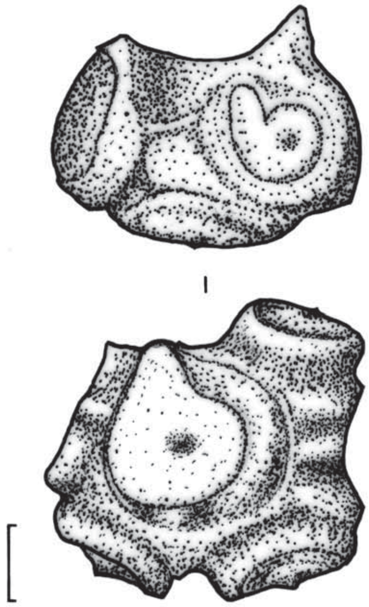

Figure 2 Fruit of beet (*Beta vulgaris*), provenance Oss. Scale bar 1 mm. Drawing W.J. Kuijper.

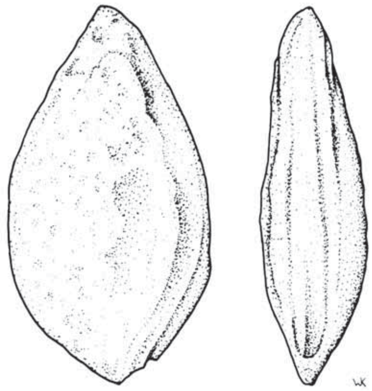

Figure 3 Plum stone (*Prunus domestica* var. *insititia*), provenance Oss. Length 16 mm. Drawing W.J. Kuijper.

Although wild beet does grow in specific places along the North Sea coast, it does not occur in Brabant and was certainly not gathered in the natural environment. The origin of the cultivated beet lies around the Mediterranean Basin and it is common opinion that the Romans introduced beet north of the Alps (Zohary and Hopf 2000, 201). Beet fruits were found in several Roman Iron Age settlements, Oss-Zomerhof, Oss-Vijver, Oss-Westerveld and Hoogeloon for instance. As beet is cultivated for its root and/or leaves, and harvested before seed-setting, it is supposed that its remains have hardly any chance to be found during an excavation. The fact that its fruits were found at all is an indication that beet was much more common than the find of a few fruits seems to suggest.

Beet is not the only 'Roman' species in rural contexts. Also found were dill (*Anethum graveolens*), celery (*Apium graveolens*), coriander (*Coriandrum sativum*), parsley (*Petroselinum crispum*), savory (*Satureja hortensis*), plum (*Prunus domestica* var. *insititia*) and walnut (*Juglans regia*) (fig. 3). Unlike beet, these plants have only been found in connection with a *villa* or *native-style villa*. They may have been imported as seed or nut and it is therefore not certain that the owners of those *native-style villas* did cultivate condiments and planted trees. But as these plants were being cultivated at that time elsewhere in a *villa* setting, it is quite possible that they were cultivated in Brabant too. Nevertheless, some products must have been imported. The fig seeds (*Ficus carica*) retrieved from Hoogeloon cannot have been a local product, because the local climate is not very well suited to the ripening of figs. However that may be, it seems that local farmers adopted some of the new food plants, though perhaps slowly.

Romanization of the rural population is held to have been brought about mainly by local people who had served in the Roman army and had returned after a considerable number of years of service (Slofstra 1991). Service in the army was a common phenomenon and the removal of many able-bodied men must have had a considerable effect on the farming communities as Van Driel-Murray (2008) has pointed out. Typical male tasks such as ploughing would have caused grave problems. Cultivation of large fields may have become difficult. Van Driel-Murray thinks that cultivation shifted from farming fields to an emphasis on horticulture. Small plots are manageable by women, children and elderly people, precisely those who were left behind. This shift to gardening is not recognized in the archaeological records, but a lightly fenced garden and its crop may not have left any trace at all. Nevertheless one remarkable change is noticed: the rural population left more remains of wild fruits and nuts behind than their Iron Age predecessors (fig. 4). It may be going too far to explain the repeatedly occurring remains of black berries (*Rubus fruticosus*), raspberries (*Rubus idaeus*), bilberries (*Vaccinium myrtillus*), sloe plums (*Prunus spinosa*), and hazelnuts (*Corylus avellana*) as deriving from horticulture, but it looks as if gathering had become more common than before.

The essential crop plants – cereals, pulses and oil seeds – remained the same as before the arrival of the Romans but for one species: gold of pleasure (*Camelina sativa*) disappears from the records as a main crop. The reason is not clear, but the decline of gold of pleasure cultivation is not restricted to Brabant. It is a common phenomenon in Central and Western Europe (Knörzer 1978).

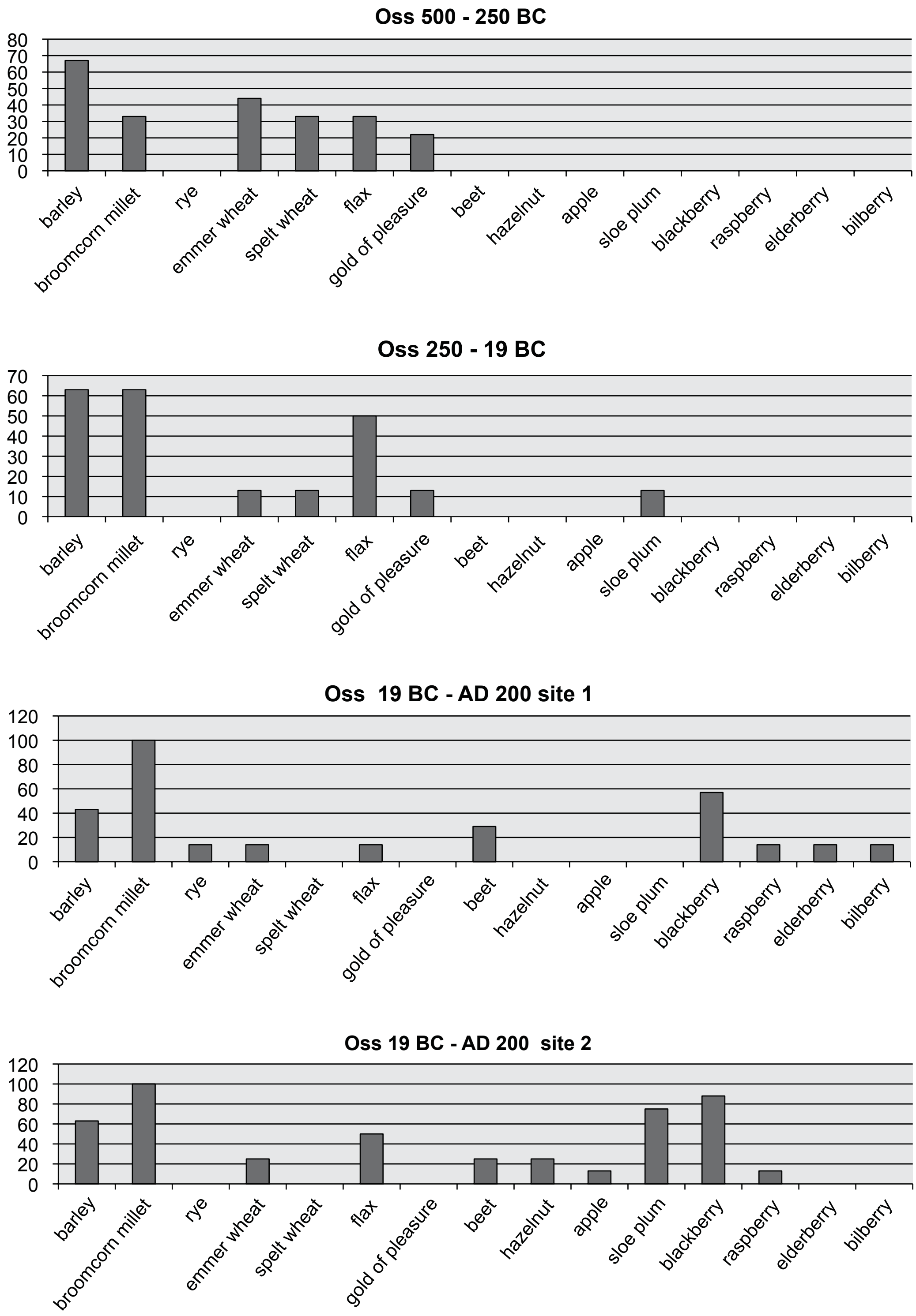

Figure 4 The occurrence and importance of cultivated and gathered plants in Oss at four different residential units belonging to three different periods. The importance is expressed in frequency i.e. the percentage of samples in which the plant was found.

One site revealed two grains of bread wheat (*Triticum aestivum*), prompting the thought that another cereal was added to the list of staple crops, but this is probably a false conclusion. This bread wheat was found in Hoogeloon, which is the site with the highest level of Romanization and presumably the richest inhabitants of the region (van Beurden 2002b). Bread wheat is a rather exacting cereal and does not do well on the local sandy soils. It is a wheat considered always and everywhere as a kind of superior cereal and was probably a luxury in Brabant. It may have been imported from other parts of the Roman Empire, upstream the river Meuse for instance, where conditions for wheat growing were optimal.

3.3 The Early and High Middle Ages (AD 500 – AD 1250)

The title of this section suggests a gap of some 250 years between the end of Roman rule and the beginning of the Middle Ages. The problem is that our knowledge of what happened exactly in the countryside during the period of the decline of the Roman Empire is still somewhat hazy. Rural settlement close to the northern border of the region under review disappears around AD 250 (Wesselingh 2000, 248). Pollen diagrams show that part of the land returned to woodland, but human presence did not entirely disappear (Teunissen 1988; van Beurden 2002a). More inland, a farming population lingered on, but the only Late Roman site unearthed and archaeobotanically investigated, Geldrop-'t Zand, is a settlement of newcomers: members of a Germanic tribe, presumably Franks (Bazelmans 1990). It is known that Germanic tribes crossed the Roman border, invited to do so to help in maintaining the peace, or not invited at all.

The Germanic tribes introduced a new staple crop: rye (*Secale cereale*). Although some grains of rye were detected before this time, it is only from the late 4th-5th century onwards that this cereal has to be regarded as a main crop. Geldrop-'t Zand provided an example (Luijten 1990). The connection German tribes – rye is not restricted to Brabant. The advance of this cereal associated with the decline of Roman authority is also seen in other regions such as the German Rhineland and northern France (Bakels 2009). Although rye does very well on poor soils, the principal reason for the success of rye must not be attributed to the sandy soils of Brabant. The consumption of rye must have been part of the Germanic culture.

The settlement of Geldrop-'t Zand further revealed remains of hulled multi-rowed barley (*Hordeum vulgare* var. *vulgare*), broomcorn millet (*Panicum miliaceum*) and bread wheat (*Triticum aestivum*).The first two mentioned were already grown earlier in the region. As mentioned before bread wheat is another matter. Just as in Roman period Hoogeloon it is considered an import (Luijten 1990). The Frankish settlers in Geldrop obviously maintained good connections with people living in regions where bread wheat was a common crop. Possibly some members of the Geldrop families were still very mobile, presumably as military men.

It is unfortunate that not much more is known about crops grown during the 4th and 5th centuries. The thread is picked up again at the end of the 6th-beginning of the 7th century. Rye (*Secale cereale*) is firmly established as a main crop and has held this position not only during the Middle Ages, but also well into the 20th century. Rye is the commonest find, followed by hulled multi-rowed barley (*Hordeum vulgare* var. *vulgare*) and oats (*Avena sativa*) (table 1). From two-rowed barley (*Hordeum distichum*), which was known in Europe at that time, there is no trace. The oats is, as far as could be ascertained from the chaff, *Avena sativa*. Wild oat (*Avena fatua*) was present as well, but a second possible cultivated oats species, bristle oat (*Avena strigosa*), has not been detected so far. From medieval written sources it is known that bristle oat was grown in Brabant, but as these sources date to the 14th century and later, they are not of much relevance to our study.

Broomcorn millet (*Panicum miliaceum*) came far after the three main cereals. The great absentees are the wheats. Spelt wheat (*Triticum spelta*) has vanished from the records. One fragment of emmer wheat chaff (*Triticum dicoccum*) in a 11th century context and one single grain in a 12th century context cannot be considered as proof of emmer cultivation. This wheat may have dwindled into a weed in cereal fields. Bread wheat (*Triticum aestivum*) provides a different story. Two of the sites lie at the edge of the area with the sandy soils where these border the loams deposited by the river Meuse. It is quite possible that the farmers of these sites, Herpen-Wilgendaal and Cuijk-De Beijerd en 't Riet, tilled also land on the river-loams in the higher parts of the Meuse valley. Soils there must have been better suited to bread wheat growing. The few grains retrieved from Dommelen are as yet unexplained.

Pea (*Pisum sativum*) and horse bean (*Vicia faba* var. *minor*) are occasionally found, indicating that those pulses, already grown in the Iron Age, were still being grown. New is lentil (*Lens culinaris*), a pulse that is not very well suited to the climate of the region. As lentil was found in 11th century Herpen, a site not far from the river Meuse, it may be questioned whether it was perhaps not grown locally but imported from more southern regions. Much traffic went by water. By the way, this may also apply to the bread wheat mentioned earlier. The fact that pulses are only occasionally found, leads to the assumption that pulses were only of secondary importance. Their relative absence cannot easily be attributed to a different kind of preservation in comparison with the cereals, because in other regions of Western Europe pulses were much more in evidence (Bakels 2005).

Linseed, and with it flax (*Linum usitatissimum*), is also not frequently present in the archaeobotanical samples, but its remains are more common than those of pulses and come second after the cereals. Written sources dating from the late Middle Ages tell us that flax and linseed were important products, and this may have been the case in the high Middle Ages as well (Bieleman 1992, 99). Rapeseed (*Brassica rapa*) seems to have remained a fairly common crop too, but finds of opium poppy (*Papaver somniferum*) are restricted to Dommelen for the moment.

Table 1 lists two crop plants which have not been mentioned earlier: buckwheat (*Fagopyrum esculentum*) and hop (*Humulus lupulus*). The status of buckwheat in this period is still open to debate. Found was only one fruit and some pollen. As buckwheat is considered to have become a true crop in Brabant not earlier than in the Late Middle Ages, the few buckwheat remains are hard to interpret. The inclusion of hop in the list may be questionable too. On the one hand, written sources tell us that growing hop was of considerable importance during the late Middle Ages. It was cultivated for flavouring and preserving beer. On the other hand, natural stands of hop can be found in the valleys and on the wetter fringes of the sandy region.

What survived of the Roman vegetables and fruit trees? Beet (*Beta vulgaris*), dill (*Anethum graveolens*), celery (*Apium graveolens*), savory (*Satureja hortensis*) and amaranth (*Amaranthus lividus*) are witnesses to the existence of kitchen gardens. Amaranth has not yet been mentioned, but this plant, used as spinach, belongs also to the Roman set of vegetables.

The remains of fig (*Ficus carica*) and grape (*Vitis vinifera*) are presumably not of local origin. As remarked earlier, figs do not ripen readily in the region and the pips must be the remnants of imported dried figs, valued because of their intense sweetness. In the same light the presence of grape pips may be explained. Although it cannot be excluded that vines were cultivated, it is much more probable that the grape pips came from imported raisins. The orchard remains a questionable part of the farms. It is surprising how few remains of cultivated fruits and nuts are found in rural sites. A few plum stones (*Prunus insititia*) reveal the presence of plum trees. Some apple pips (*Malus* sp.) may have come from cultivated apples, but as their pips cannot be distinguished from those of the wild crab apple, it cannot be proven that the farms boasted apple trees. Of walnuts there is no trace so far. It may be wondered whether the medieval farms in Brabant had orchards at all. Perhaps a restricted number of fruit trees was growing in their yards. The remainder of the fruits still came from harvesting berries and nuts from wild shrubs in the local environment.

Taking all together, it may be concluded that the main crops grown by the early-medieval Brabant farmers were rye, barley and oats. They are the crops most often found, not only in numbers but also when looking at the percentage of features and samples in which they were discovered. Flax/linseed may also have been of some importance, but the remainder was grown as a sideline.

4 More about crops

4.1 Monocrops or maslins

Farmers can sow one type of crop on a field or a mixture of crop plants. In the first case a monocrop is being produced whilst the second practice leads to mixtures called maslins. Mixed sowing is a way to avoid risks. When one component fails another may still do well.

To learn whether maslin or monocrop growing was practised remains of single harvests are needed. Such finds are rare, but some instances of concentrations of carbonized seeds may be interpreted as such. One is a concentration of emmer wheat (*Triticum dicoccum*) found in Roman period Oss-Horzak. It was retrieved from a well and therefore not in primary position, but as almost all other plant species found in its fill were waterlogged it can be safely concluded that they are not related to the wheat concentration (Chen 2005). The only other carbonized components were barley, which amounts to 0.2 % of a total of over 50,000 cereal grains, and four grains of oats. The emmer wheat was still enclosed by its husks. The conclusion is that this find represents a monocrop of emmer wheat. The other cereals may have been lying around in the place where the emmer was exposed to a damaging heat, or may have grown in the emmer field as offspring of the crop of the year before. Grains lost during harvesting may germinate next year and thrive as a kind of weed in the next crop.

Another instance is a burnt-down outhouse in Roman period Venray-Hoogriebroek (Hänninen 2000). Its postholes were filled with carbonized matter that is considered to represent the crops stored there (fig. 5). In one corner they revealed a concentration of barley (*Hordeum vulgare* var. *vulgare*), in another place a concentration of broomcorn millet (*Panicum miliaceum*), and in a third place wild herbs. Emmer wheat (*Triticum dicoccum*) was more evenly distributed. Hänninen's conclusion is that barley and broomcorn millet were stored separately, in bags or baskets, and that emmer wheat was lying more dispersed, because it was stored in loose heaps and became scattered. It is clear that barley and broomcorn millet were kept apart and were also harvested apart, which does support the status of monocrop for both.

Analysis of a burnt-down house in Hoogeloon revealed a posthole filled with unthreshed barley (*Hordeum vulgare* var. *vulgare*). Other postholes contained remnants of hay (van Beurden 2002b). The find demonstrates that the barley was grown as monocrop.

century	end 6th start 7th	merov	merov	carol	carol	8th-9th	end 9th start 10th	10th	10th-11th	second half 10th - 11th
site	Cuijk	Geldrop	Dommelen	Geldrop	Dommelen	Uden	Bakel	Bakel	Dommelen	Nistelrode
cultivated										
oats	–	–	■	■	■	■	–	■	■	■
barley	■	■	■	■	■	■	–	■	■	■
rye	■	■	■	–	■	■	■	■	■	■
bread wheat	–	–	■	■	■	–	–	–	■	–
broomcorn millet	–	–	–	■	■	–	–	–	–	■
emmer wheat	–	–	–	–	–	–	–	–	–	–
buckwheat	–	–	■	–	–	–	–	–	–	–
lentil	–	–	–	–	–	–	–	–	–	–
pea	–	–	–	–	■	–	–	–	–	–
horsebean	–	–	■	–	–	■	–	–	■	–
linseed/flax	–	■	■	■	■	–	–	–	■	–
opium poppy	–	–	–	–	■	–	–	–	–	–
rapeseed	–	■	–	–	–	■	–	–	■	–
hop	–	–	–	–	■	–	–	–	–	–
cultivated Roman origin										
beet	–	–	–	–	–	–	–	–	–	–
amaranth	–	–	–	–	–	–	–	–	–	–
dill	–	■	–	–	–	–	–	–	–	–
celery	–	–	–	–	–	–	–	–	–	–
savory	–	■	–	–	–	–	–	–	–	–
plum	–	–	–	–	■	–	–	–	–	–
grape	–	–	–	–	–	–	–	–	■	–
wild fruits and nuts										
hazelnut	–	–	–	–	■	■	–	■	–	■
sloe plum	–	–	–	–	–	–	–	–	–	–
raspberry	–	–	–	–	■	■	–	–	■	–
blackberry	–	■	–	–	■	■	–	–	■	–
elderberry	–	–	–	–	–	–	–	–	–	–
blueberry	–	–	–	–	–	–	–	–	–	–
possibly wild										
gold of pleasure	–	–	–	–	–	–	–	–	–	–
apple/pear	–	■	–	–	■	–	–	–	–	–

Table 1 The cultivated and gathered plants found in medieval sites on the sandy soils of Eastern Brabant.

end 10th 11th Bakel	11th Cuijk	11th Nistelrode	11th Herpen	first half 12th Uden	second half 12th Nistelrode	second half 12th Cuijk	12th Dommelen	first half 13th Cuijk	13th Dommelen	
■	■	■	■	–	–	■	■	■	■	Avena sativa
■	■	■	■	–	■	■	■	■	■	Hordeum vulgare, hulled
■	■	■	■	■	■	■	■	■	■	Secale cereale
–	■	–	■	–	–	■	–	■	■	Triticum aestivum
–	■	–	–	–	–	–	■	–	–	Panicum miliaceum
–	–	■	–	–	■	–	–	–	–	Triticum dicoccum
–	–	–	–	–	–	–	■	–	–	Fagopyrum esculentum
–	–	–	■	–	–	–	–	–	–	Lens culinaris
–	–	–	■	–	–	–	■	–	■	Pisum sativum
–	–	–	–	–	–	–	■	–	■	Vicia faba var. minor
■	–	■	–	–	–	■	■	■	–	Linum usitatissimum
–	–	–	–	–	–	–	■	–	–	Papaver somniferum
–	■	–	■	–	–	–	–	–	–	Brassica rapa
–	■	■	■	–	–	–	■	–	–	Humulus lupulus
–	–	■	■	–	■	–	–	–	–	Beta vulgaris
–	–	■	–	–	–	–	–	–	–	Amaranthus lividus
–	–	–	–	–	–	–	–	–	–	Anethum graveolens
–	–	■	–	–	–	–	–	–	–	Apium graveolens
–	–	–	–	–	–	–	–	–	–	Satureja hortensis
–	–	–	–	–	–	–	■	–	■	Prunus insititia
–	–	–	–	–	–	–	–	–	–	Vitis vinifera
–	–	■	■	–	■	–	■	■	–	Corylus avellana
–	■	–	–	–	–	–	–	–	–	Prunus spinosa
–	–	–	■	–	–	–	■	–	–	Rubus idaeus
–	■	■	■	–	■	–	–	■	■	Rubus fruticosus
–	■	■	■	–	■	–	–	–	■	Sambucus nigra
–	–	–	–	–	–	–	■	–	–	Vaccinium myrtillus
–	–		–	–	–	–	–	–	■	Camelina sativa
–	–	■	–	–	–	–	■	–	–	Malus sp.

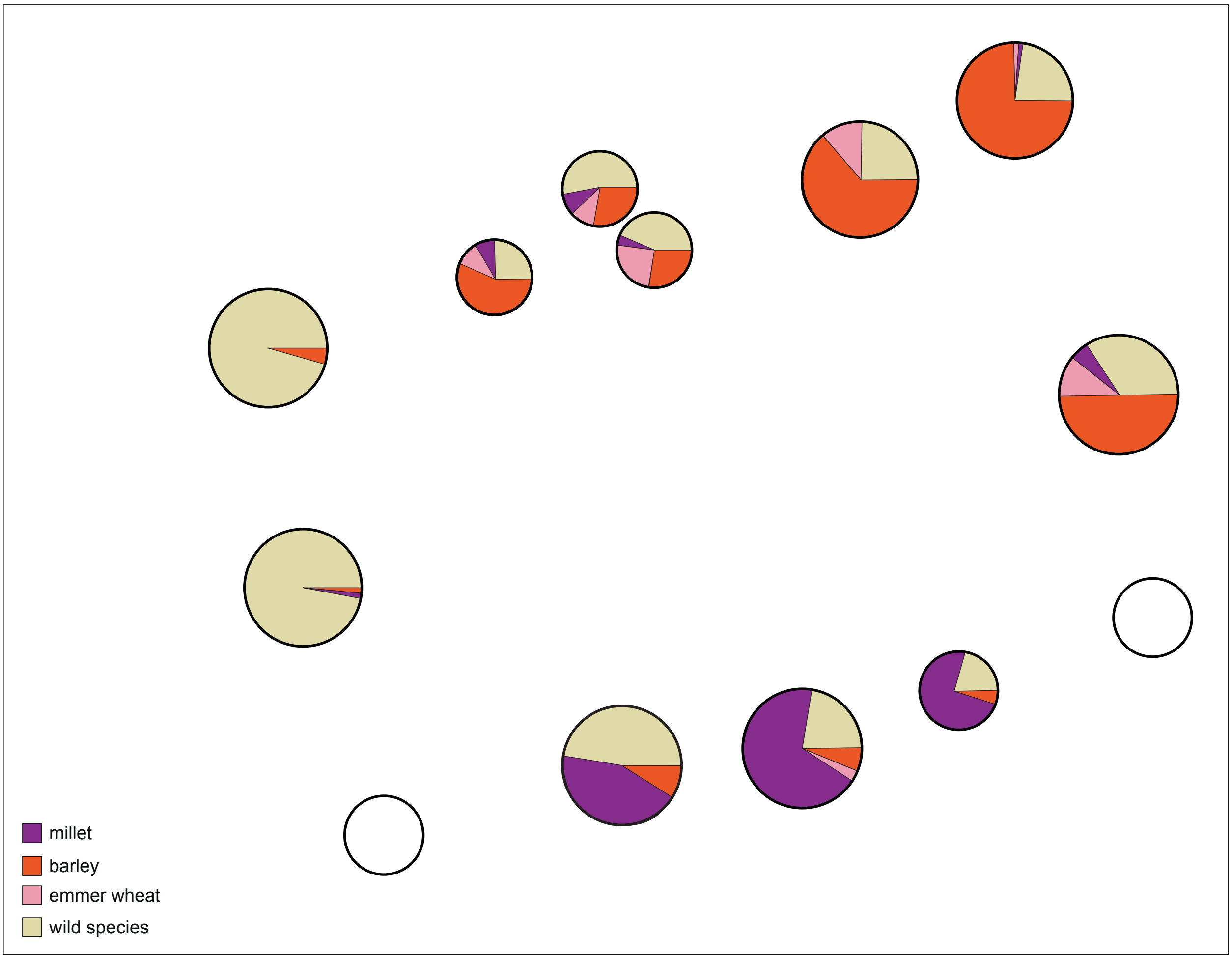

Figure 5 The composition of the plant remains found in the postholes of the outhouse at Venray-Hoogriebroek. Postholes left white were not sampled.

Postholes of a burnt-down outhouse in 8th-9th century Uden show that oats (*Avena sativa*), rye (*Secale cereale*), and, less obvious, barley (*Hordeum vulgare* var. *vulgare*) were stored apart (fig. 6). There is no question of maslins (Bakels 2007).

Other instances of charred harvests were retrieved from Bakel-Achter de Molen, Herpen-Wilgendaal and Dommelen. The outhouse in Bakel, mid 10th century, contained only barley (*Hordeum vulgare* var. *vulgare*). Two other structures in Bakel contained rye straw (*Secale cereale*) and hay (Bakels 2007). The 11th century find from Herpen consisted of oats (*Avena sativa*) and the 12th century find from Dommelen rye (*Secale cereale*) (Bakels 2007; Pals 1988). These finds show that the growing of maslins was not practised, at least not regularly.

Remains of pure harvests may also offer indications of crop rotation, as was mentioned earlier concerning the emmer wheat found in Oss-Horzak. The slight contamination with barley – the oats may represent the weed wild oat – may refer to an earlier crop of barley on the same field. Nevertheless, the indication is too weak to allow conclusions. As there are no other instances of ‘closed’ finds of harvests – none of the concentrations mentioned above having this quality – reliable information on any form of crop rotation is lacking.

4.2 Poor soils?

Single harvests offer another opportunity: the weeds mixed in offer an insight into the quality of the soil on which they were grown. For this kind of analysis the quality of ‘closed find’ need not to be applied as strictly as for the identification of crop rotation, as long as the crops are considered to have been grown on the same field or set of fields. The rye from

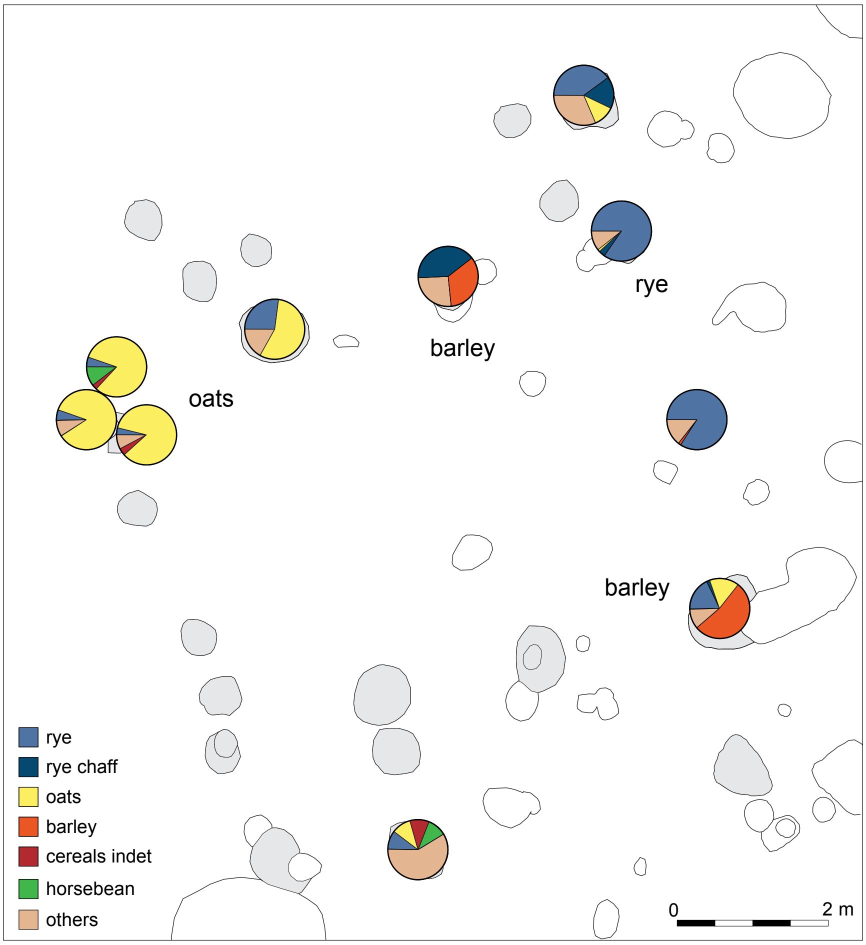

Figure 6 The composition of the plant remains found in the postholes of the outhouse at Uden.

Uden, barley from Bakel and oats from Herpen held a sufficient number of weeds identified to species level, to try an identification of the weed flora.

It is sometimes stated that the modern phytosociological classifications are not valid when dealing with former vegetations, especially when these are of a man-made nature, such as the weed vegetation of fields. Essentially this view is correct. Weeds are thus dependent on the way fields are tilled and crops are handled that changes in these practices in the course of time are causing changes in the composition of the weed flora. Viewed in this light, it is astonishing that in practice fitting medieval weeds into modern classifications appears to make sense. Most of the diagnostic species were present by that time and tillage seems not have been that different from the first half of the 20th century practices, which was the period in which the basis of the phytosociological weed classification was laid down.

The result of the fitting is shown in table 2. The Roman period site of Hoogeloon is entered as well. The best fit for the harvests discussed in this paper is found in the class *Stellarietea mediae* Tüxen, Lohmeyer et Preising in Tüxen 1950. The species entered are few in number because only such can be expected to be found during excavations in settlements as were brought in with the harvest, survived contact with fire or heat, and could after carbonization still be identified. The short list of diagnostic plants contains several species characteristic of the class as a whole, namely *Fallopia convolvulus*, *Stellaria media*, *Chenopodium album* and *Bromus secalinus* (Haveman *et al*. 1998). The others belong to its order B: *Sperguletalia arvensis* Hüppe et Hofmeister 1990, with an emphasis on its alliance *Digitario-Setarion* Sissingh in Westhoff et al. 1946 em. Hüppe et Hofmeister 1990. Such vegetations are indicative of non-alkaline, mostly acid sandy or loamy soils, which

Class 30									
Order	**A**	**A**	**A**	**A**	**A**	**B**	**B**	**B**	**B**
Alliance	**a**	**a**	**b**	**b**	**b**	**a**	**a**	**b**	**b**
Association	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**1**	**2**
Hoogeloon, 2nd c., barley									
Fallopia convolvulus	■	■	■	■	■	■	■	■	■
Stellaria media	■	■	■	■	■	■	■	■	■
Spergula arvensis	■	■	■	■	■	■	■	■	■
Hypocharis glabra								■	
Uden, 8th–9th c., rye									
Fallopia convolvulus	■	■	■	■	■	■	■	■	■
Vicia hirsuta						■	■		
Galeopsis segetum						■			
Hypochaeris glabra								■	
Bakel, 10th c., barley									
Fallopia convolvulus	■	■	■	■	■	■	■	■	■
Spergula arvensis						■	■	■	■
Scleranthus annuus									
Raphanus raphanistrum								■	
Echinochloa crus-galli									■
Herpen, 11th c., oats									
Chenopodium album	■	■	■	■	■	■	■	■	■
Spergula arvensis						■	■	■	■
Scleranthus annuus						■	■	■	■
Centaurea cyanus						■	■		
Vicia hirsuta						■	■		
Echinochloa crus-galli									■
Dommelen, 12th c., rye									
Fallopia convolvulus	■	■	■	■	■	■	■	■	■
Chenopodium album	■	■	■	■	■	■	■	■	■
Bromus secalinus	■	■	■	■	■	■	■	■	■
Spergula arvensis						■	■	■	■
Scleranthus annuus						■	■	■	■
Vicia sativa subsp. nigra						■	■		
Arnoseris minima						■			
Hypochaeris glabra								■	
Echinochloa crus-galli									■

Table 2 Weed species, characteristic of the *Stellarietea mediae* and its orders, alliances and associations, found in connection with crops retrieved from excavations.

tallies with the sandy soils of Brabant, when not heavily manured. It is a historical fact that manuring fields was always a problem in Brabant as dung was never available in the quantity demanded. Only artificial fertilizer could change, and did change, this situation (Bieleman 1992, 219).

From table 2 can therefore be concluded that the 2nd to 12th century farmers had difficulties in maintaining soil fertility. Iron Age farmers must have encountered the same problem, but no harvests with a sufficient number of weeds were available to prove this.

5 Discussion and conclusion

The first question put forward was whether the arrival of the Roman troops and the subsequent inclusion of the region in the Roman Empire had any effect on the crop choice of the local farmers. The answer is yes, but one effect was not expected beforehand and that was the rise in gathering activities. It is tentatively attributed to the absence of able-bodied men. More emphasis may have been put on a horticulture-like kind of agriculture. But the gardens were not stocked with a number of species introduced by the Romans. Only beet (*Beta vulgaris*) seems to have been generally adopted. Perhaps some plum trees (*Prunus domestica* var. *insititia*) and a few apple or pear trees (*Malus* sp./*Pyrus* sp.) were planted as well. It is striking that most finds of 'Roman' plants are associated with a *villa* or *native-style villa*. Even the parsley (*Petroselinum crispum*) of Venray-Hoogriebroek belongs to this class. Although no villa was excavated at the site, its debris – building stone, tiles etc. – were found in the excavated area and the original building must have been situated close by (Enckevort *et al*. 2000, 74.). Condiments, walnuts – and bread wheat – should probably be regarded as imports. As far as can be concluded, common local people did not adopt them. They may have nurtured a cultural aversion against new crops, but it is also possible that they shifted their activities to other subjects than crop growing.

Serving in the army may have been one thing, shifting to keeping more livestock may have been another, although of the latter there is no proof. Bone has problems with preservation in the sandy region. Nevertheless, ground-plans of farms provide some indication. Until the 2nd century ground-plans of farm houses remained the same; if they differ at all, it is in their length. From the 2nd century onwards part of the floor of the farmhouses in the southern part of the region is seen to have been deepened (fig. 7). Sunken floors are not observed everywhere in the region but they are a rather general phenomenon in farms built on the sandy soils of Brabant (van Beurden 2002b). The part where the floor was deepened is considered to represent the stable part of the house. A generally accepted interpretation is that lowering the floor would allow the accumulation of more

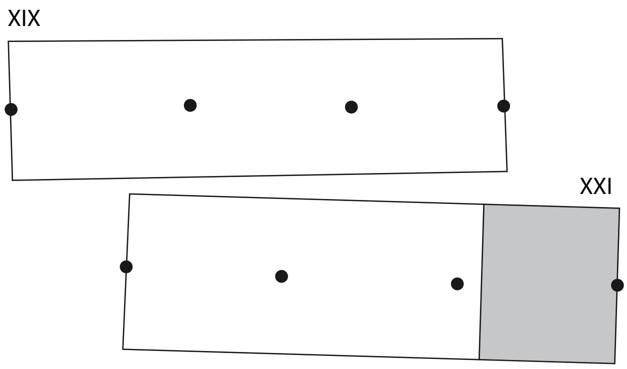

Figure 7 The plan of two farmhouses excavated at Hoogeloon. Indicated are the contour of their walls and the position of the roof-bearing posts (black dots). House XXI is the younger house and has presumably replaced house XIX. Part of its floor has been deepened (shaded area). House XXI measures 30 by 9 metres and house XIX 30 by 8 metres. Drawing after van Beurden 2002.

dung and making the collection of this dung easier (van Enckevort *et al*. 2000). Seen in this light it would have been a technological innovation and not a switch to an increasing emphasis on livestock keeping. But it may not have been a technical innovation alone. It may present a parallel to the increase of emphasis on horticulture. When there are no people available to look after herds grazing in the woods and rough pastures in the environment, the livestock should be kept at home, perhaps even for a prolonged time under the roof of the farmbuilding.

The second question concerned the withdrawal of direct Roman influence. Its first effect was a collapse of ordinary life in the rural hinterland of the Roman border. What happened exactly is not clear at all, but when the mist lifts farmers have abandoned wheat cultivation in favour of rye (*Secale cereale*) (fig. 8). This is a Germanic influence with roots in the culture of the Germanic tribes, in this instance the Franks. The shift is sometimes attributed to a change in climate around AD 250. Indeed, a change towards lower rainfall and/or lower temperature was demonstrated by, for instance, dendrochronology in Western Germany (Schmidt and Gruhle 2005). The period lasted until c. AD 400. Rye is a hardy cereal, but emmer wheat (*Triticum dicoccum*) is hardy too and has always remained a main cereal during all ups and downs of the climate since the beginning of crop cultivation in the region. A temporary worsening of the climate around AD 250 cannot have been the sole reason, if a reason at all, for the switch from emmer wheat to rye.

The plants introduced by the Romans were not quite lost. Old Frankish laws, such as the *Lex Salica* written down in the 6th century but as oral law much older, mention fruit trees outside and inside kitchen gardens (Eckhart 1969). But as

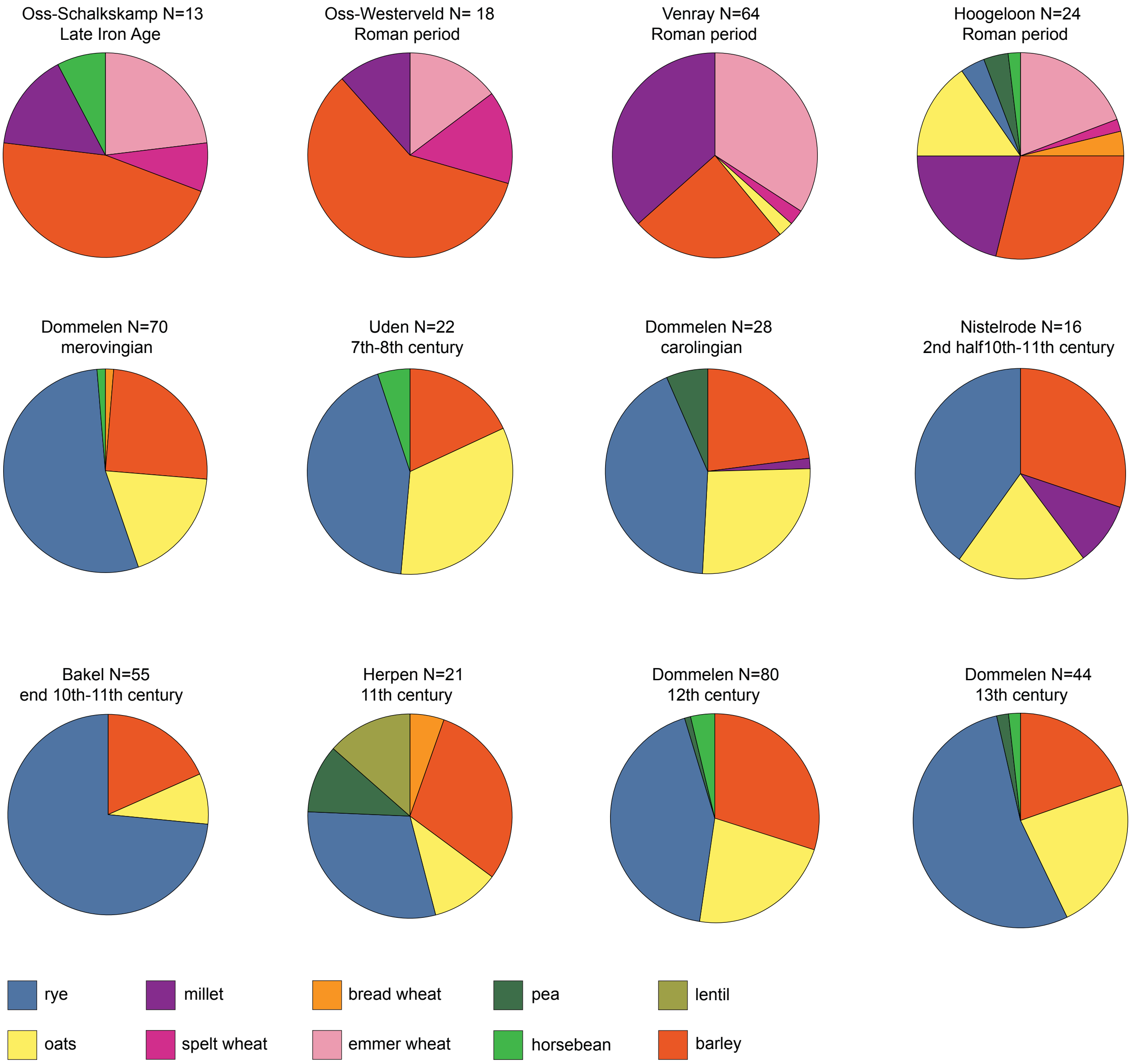

Figure 8 The composition of crops, based on their frequency, found during excavations in twelve sites. N represents the number of samples.

herbs and fruit trees were already not very popular during the Roman Period in the region, it remains to be seen whether and to which extent they were truly present on the farms on the sandy soils of Brabant. Probably the larger gardens and orchards were to be found attached to monasteries. Local farmers cultivated rye, barley, oats and flax and therefore still annual plants, not perennials, just as their prehistoric forebears.

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Coffee, cacao and sugar cane in a shipwreck at the bottom of the Waddenzee, the Netherlands

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At the bottom of the sea east of the island of Texel (the Netherlands), a shipwreck was found dating from the second half of the 18th century AD. Botanical analyses have revealed the presence of coffee (in barrels) in the wreck. Also cacao and sugar cane (the latter used as a valve) were present. Apart from analysing the important cargo, we also investigated all other plant and animal remains in the botanical samples, including egg cases of cockroaches.

Detailed information is supplied on the ship itself, as well as the identifications and the history of some plants.

1 Introduction

In 1984, local divers discovered a shipwreck on the Burgzand in the Waddenzee, off the east coast of Texel (fig. 1), at a depth of 7 metres. They called this the Water barrel wreck as many large wooden barrels were found on the ship (Kley 1991[1]; Habermehl 2000), and it was believed that these barrels had been used for the transportation of water (so-called "*leggers*"). In the days that the roadstead of Texel was crowded with ships awaiting departure to distant destinations, water from the Weesputten (wells) on the island of Texel was transported to the ships by lighters. These were small shallow-draft boats which were also used to transport goods from and to ships from the warehouses in Amsterdam. The wreck was codenamed BZN 4.

During a first non-intrusive evaluation in 1999 and a subsequent intrusive evaluation with trial trenches, executed in 2000 by the Dutch Institute for Shipwrecks and Underwater Archaeology (Nederlands Instituut voor Scheeps- en onderwater Archeologie – NISA; presently the maritime research department of the State Service of Cultural Heritage), the story of the water barrel wreck was further examined.

2 The research

During the 2000 investigation, two trial trenches were dug to gain more insight into the construction and the cargo of the ship (fig. 2). In the centre of the ship, where the mast blocks of the main mast were expected, a 2 m wide and 8 m long trench was dug, perpendicular to the longitudinal axis of the wreck. This trial trench had a maximum depth of 1.60 m. A second trial trench was dug in the stern: 1.20 m deep and 4 m wide, following both sides of the ship and therefore ending in a triangle. In addition, a small trial trench was made in the bow. The finds from the ship only gave a rough indication of its age: 1700 to early 19th century.

Dendrochronological dating of a piece of wood with which most of the ship was made gave a more precise date of 1744 ± 6 (Hanraets 1999) as youngest date. The oak originates from central and northern Germany. The ship is 35 m long and 6 m wide. It was a heavily built ship, witness the riders on the ceiling (= inner planking of a vessel) that were found in the ship. These were probably already installed during construction and were meant to additionally strengthen the vessel across-ship. The ship has been preserved to just under the first deck. The stern was sheathed with copper sheets. As the construction is far too big and too solid to have been from a lighter, it was concluded that the BZN 4 is the wreck of a large 18th century seafaring merchant vessel (Manders 2007 a and b).

After the investigation of the ship by means of trial trenches, the wreck was covered with polypropylene nets. In some places in the ship, the findlayers are at least 1.5 m thick, and it may well be possible that in the future we would like to investigate these layers with more targeted questions.

During the investigation, much attention was given to the cargo of the ship. The position of the barrels was recorded, and samples were taken in different places for botanical investigation. In most cases these samples were taken from the barrels, and only in a few cases were stray samples taken in the ship but it is believed that these remains originated from barrels that lost part of their contents by having been crushed. All samples are contaminated by sediments and by botanical and animal material of local origin (Waddenzee). As a rule, the samples were taken underwater with resealable plastic bags. The samples were scooped up with these bags, and subsequently all excess water was very carefully squeezed out. Next the bags were sealed and transported to the surface. Only in the palaeobotanical laboratory of Leiden University were these bags opened again. From one barrel (TC 1), which was raised in its entirety, the whole contents was sampled and transported to the palaeobotanical laboratory.

In total 41 samples were investigated with a combined volume of more than 19 litres. Separate samples were

Figure 1 shipwreck BZN4, findspot in the Waddenzee (the Netherlands)

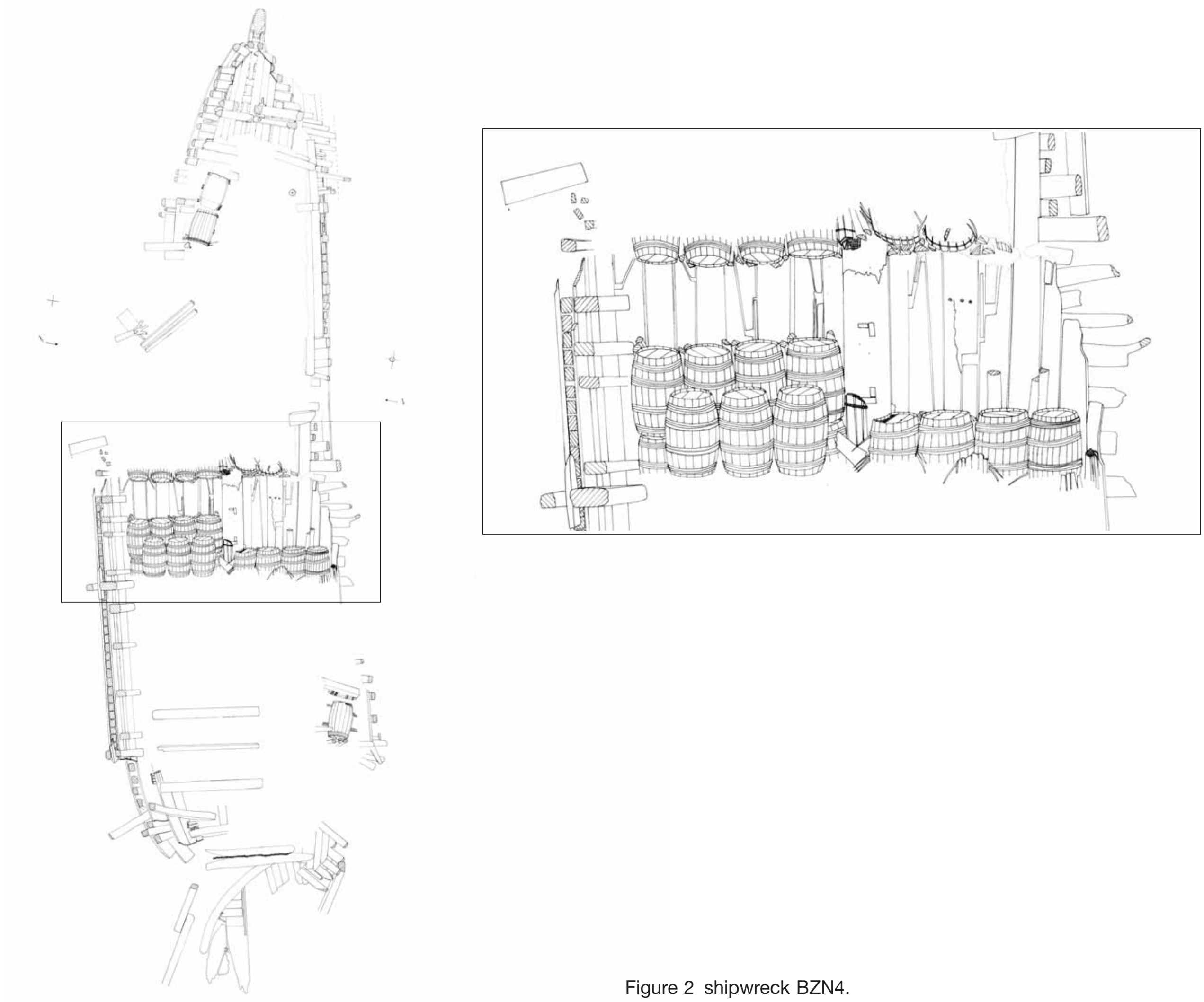

Figure 2 shipwreck BZN4.

collected from 7 places in the vessel. The material was gently rinsed with tapwater on sieves with a 0.5 mm mesh. A small part of the samples was sieved on 0.25 mm but this did not supply additional information. The sieve residue was examined in water under a microscope.

3 The barrels and their stowing

The barrels were found in the ship starting at 4 m from the stern. Probably all these barrels had been stowed in the hold, lying directly on the ceiling, secured and supported by stowage blocks (fig. 3). Two layers of barrels were found in the trial trench in the centre of the wreck. Along the keelson of the wreck, so-called sheaves were discovered: barrels that had been taken apart and the staves of which having been tied together into more compact parcels for transport. A total of 20 barrels have been investigated, while probably over a hundred barrels had been present in the ship[2].

The barrels are 120 cm high, with a length of 110 cm between the grooves for the heads. The diameter of the heads is 56 cm, and the diameter of the bulge is 90 cm. This would result in a capacity of about 500 litres.

The barrels are marked with both scratch marks and brand marks. An in-depth study has not yet been undertaken of these markings, but we do know that scratch marks were often applied to barrels by merchants and that brand marks could have to do with the quality control of a brand master. Two of these brand marks show a warehouse and the letters SD. At the moment we assume that these letters stand for Santo Domingo, the capital of the Dominican Republic in the Caribbean, which would tally with their contents (see below) which was coffee. The Dominican Republic is an important coffee producer. This is an interesting detail as the wood from which the barrels were made comes from the northeastern part of South America (Luckers 2002). The

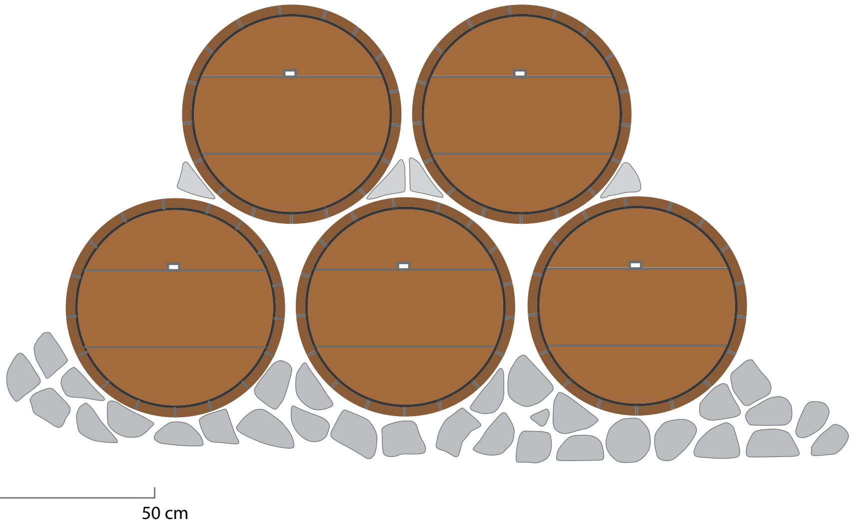

Figure 3 BZN4, reconstruction of the stacking of barrels with stowage wood

wood variety Wallaba (*Eperua falcata*) is present in the investigated barrels (staves) and would be ideal for barrels for liquids because of its split-fastness and oil-secretion. Other types of wood also found such as Bacuri (*Platonia insignis*) would also have good properties. The two other types of wood used proved to be Vinhatico (*Plathymenia reticulata*) and Andiroba (*Carapa* sp.) (Luckers 2002).

The stowage blocks have also been examined. Twenty-seven samples were taken from the about 150 pieces of wood recovered, which consisted of branches and treetrunks of about 1 metre long and with a maximum diameter of 20 cm. The 12 different identified types of stowage blocks seem to have had no other qualities than to serve for stowage and burning.

A total of 79 samples has been investigated, resulting in 21 wood species[3]. Nearly all these species can be found in the northern Amazon basin. An exception is *Plathymenia reticulata* which at present does no longer grow that far north. Possibly this was different 250 years ago, perhaps it is a remnant of an earlier South America trip (Brazil), or it came on board during embarkation in a different way.

Also found in the wreckage was a loose piece of wood with processing traces of coopering, and was identified as *Manilkara* sp. (possibly *M. bidentata*). No barrel parts made of this wood were found though. The hoops that surround the barrels have also been investigated. Most of them were made of a tough type of tropical liana. These could however not be determined to species level. However, willow hoops (*Salix* sp.) were also found in the wreck, sometimes still encircling the barrels, sometimes as waste in the stern. Evidently the barrels were partly repaired with Northwest European material. In the trial trench of the stern were also found, apart from cut hoops, wood shavings, split wood, semi-finished barrel parts, and tools, which all point to the repair of barrels on board ship. Also the method of attachment with the so-called "fish mouth method" (Dutch: vissenbekjes) is a typical (Northwest) European custom (Manders 1996).

The processing traces on the barrel staves and heads paint an interesting picture. These were made following the prevailing North European tradition. However, because the wood had properties to which the crew was not accustomed, many barrels were never watertight, let alone airtight. Also the fact that the barrel staves were finished in such a way that sapwood was still present, thereby negating the high durability of the wood, seems to confirm the unfamiliarity with the wood.

4 The contents of the barrels and other finds

The largest part of the ship's cargo consisted of large wooden barrels filled with unroasted coffee beans (table 1). Apparently the ship was on its way with a largo cargo of coffee. The remains of coffee beans were abundantly present in the wreck. In addition there were cacao beans, dispersed and in small numbers. Other cultivated types found were a single grain of buckwheat, remains of a possible broad bean, two fragments of a pod of peanut and chaff of oat.

4.1 Coffee (Coffea arabica *L.*) – fig. 4

The plant

Wild coffee is a shrub that can reach a height of 15 to 20 metres. Coffee varieties (genus *Coffea*) belong to the Rubiaceae family. After flowering, red fruits appear after several months. These almost 2 cm long fruits are egg-shaped, and are also called berries. Two seeds will develop in a fruit, with their flat sides touching. Occasional there is only 1 seed in the berry, this seed is then egg-shaped. Every seed lies in a sturdy horn-like hull (= endocarp, seedcase, parchment). Its wall consists of clear, irregular pentagonal (4-6) cells. These cells measure on average 30×50 μm, the cell walls are straight and thin (1-2 μm thick). Between the seed and the parchment is a silverskin, which is the silver-like seed coat (epidermis) with stone cells. These cells are oblong in shape, pointed or rounded at the ends, and have dozens of perforations. Their slightly undulating walls run parallel and are c. 5 μm thick. The cells have a clear light yellow colour. On average the measurements of these cells are 30×255 μm. After removal of the berry, seedcase and silverskin, we can see the well-known coffee bean (Robbrecht 1995).

The finds

Due to their long stay in the water, the seeds no longer had their well-known coffee bean shape but were transparent, flattened skins: the epidermis (fig. 4d). Only a few beans in the cargo had retained their original shape (figs. 4a and b). This shape retention was caused either by the complete outer hard layer (parchment) still enveloping the bean or by the bean having been lightly mineralized, thus preventing the seed from having been flattened. Small fragments of the hard outer layer were regularly found in small numbers (fig. 4c). Rarer were finds of some unripe berries and fragments of berries.

The measurements in mm of the whole beans were:

– with parchment

11.9×8.8×5.0; 10.7×8.1×5.0; 13.0×8.0×4.8; 9.0×6.5×5.5; 14.2×7.6×4.7; 11.7×7.0×6.9; 12.7×7.9×4.5; 12.7×9.0×5.0; 6.5×5.5×4.9 (from a 1-seeded berry); 11.9×8.5×6.0; 12.3×9.0×5.1; 9.7×6.9×3.9; 9.3×6.7×4.2; 8.8×6.0×3.0; 12.0×8.0×4.0; 10.4×7.5×7.0

13.0×flat; 12.3×flat; 12×flat.

– without parchment

8.8×7.0×4.6; 9.3×7.0×4.0; 11.4×7.9×4.0; 10.5×8.3×4.9; 8.5×5.9×4.9; 10.0×7.4×4.3; 9.0×6.0×6.2.

The cargo

From one of the barrels (TC 1), the whole contents has been collected in order to ascertain how much coffee there was in one barrel. In total 25 litres of silt-containing sand with plant remains was recovered from this barrel. Of this sediment small samples were taken from different places, and analysed. Thus a total of 1 litre has been carefully examined.

This sample of 1 litre contained 0.52 lt of plant remains after sieving on a 0.5 mm mesh. It was estimated that 95% of this over half a litre of plant remains consisted of coffee bean skins, which constituted the remains of 5471 beans. Extrapolation leads to 25×5471 = 136,775 coffee beans in the barrel. The dimensions of some whole beans correspond with those of modern coffee beans. This enabled us to calculate an approximation of the volume.

In a modern pack of roasted coffee beans (100% Arabica) were 1960 beans, which filled a space of 650 ml. Returning to our barrel, the beans would have required a space of (136,775 : 1960)×650 ml = 45.359 ml = well over 45 litres.

To give an indication of the weight, we weighed some unroasted beans: c. 0.15 gram per bean. Forty-five litres would then weigh over 20 kg.

A second quantity of roasted coffee beans from a different brand resulted in: 220 gr = 600 ml = 1670 beans. In this case the beans would require a space of (136,775 : 1670)×600 ml = 49,141 = well over 49 litres.

The barrel involved was also measured. It was about 110 cm high with – in the middle – a diameter of c. 90 cm. This would give a volume of c. 3.14×(40×40)×100 = 500 litres.

With rounding off and some assumptions, the calculated numbers and measurements made above give an indication of the volume. The difference (of a factor 10) between the calculated volume of the coffee and the barrel contents is however so large that we assume that a lot of coffee beans have disappeared through the slits between the staves and at the head while lying on the seabed or during the raising of the barrel.

Although many uncertainties played a part in the calculation of the total quantity of coffee in the vessel, we can give an indication here:

a. Assuming the presence of about 100 barrels on board, and assuming that the contents of the one intact examined barrel (TC 1) represented the entire contents, we are dealing with 100×136,775 beans = 13,667,500 beans.

b. If the barrels were filled entirely, we are dealing with a maximum of 10 times as many beans.

In the latter case, full barrels, the barrels could contain a maximum of c. 220 kg. If 100 barrels had been on board, there would have been a cargo present of about 22,000 kg coffee.

The historical background

One of the questions raised with such a find is where this coffee originated from. Hence a brief history.

The species comes originally from the highlands in Ethiopia (formerly known as Abyssinia), and has been cultivated for centuries in the rest of this country. From the Arab world, coffee spread to the rest of the world. Arabic texts from c. 900 already mention the effect of coffee. But when the custom of coffee consumption began will probably always remain unknown (Robbrecht 1995).

findno.	sample volume in cm3	**Coffee** (*Coffea arabica*) seed epidermis, flattened	parchment fragment	seed not flattened	berry fragment	**Cacao** (*Theobroma cacao*) seed complete	seed fragment	**Buckwheat** (*Fagopyrum esculentum*) seedcoat fragment	**cereals** (Cerealia) seedcoat fragment	**bean** (Fabaceae) seedcoat fragment
202	50	xxx	–	1	-	2	xx	-	-	-
516	6000	xxxx	xx	–	–	x	xx	2	–	–
562	250	xxx	1	–	–	3	xx	–	–	–
563	100	37	–	–	–	–	–	–	–	–
564	150	10	–	–	–	3	xxx	2	–	–
565	100	2	–	–	–	–	x	–	–	–
566	50	–	–	–	–	–	xx	–	–	–
605	200	xxx	3	–	–	9	xxx	–	–	–
606	500	xxxx	6	1	2	3	xxx	1	–	1
706	100	–	–	–	–	3	x	–	–	–
717	150	xxx	–	–	–	–	x	1	–	–
748	500	xxx	xx	–	1	–	–	2	–	2
760	500	xxxx	xx	–	1	–	1	1	–	1
778	250	x	–	–	–	10	xx	–	–	–
781	200	–	–	–	–	–	–	–	–	–
782	400	xxxx	xx	3	x	–	–	–	–	x
806	500	xxxx	xx	–	1	9	x	–	–	1
909	500	xxxx	xx	–	1	–	1	2	–	3
924	500	xxxx	xx	1	–	–	x	–	–	–
953	300	xx	2	–	–	18	xxx	–	–	–
957	500	xxxx	1	–	2	–	–	2	–	1
995	500	xxxx	xx	1	8	–	x	4	–	–
1072	500	xxxx	3	–	–	–	–	–	–	5
1134	25	xx	–	–	–	–	–	1	–	–
1242	250	xxx	xx	–	–	1	–	1	–	–
1252	200	–	–	–	–	–	–	–	–	–
1253	500	xxx	1	–	–	25	xxx	–	–	–
1286	500	xxxx	xx	–	–	1	–	3	–	–
1314	500	xxxx	xx	–	2	3	xx	1	–	1
1340	500	xxx	xx	–	1	2	x	1	–	–
1414	500	xxx	xx	3	x	1	xx	1	–	–
1415	400	xxx	x	–	–	–	x	1	–	–

1574	100	xxx	x	1	–	1	x	–	–	–
1575	500	xxxx	x	3	2	2	x	–	1	6
1632	500	xxx	1	–	–	1	x	2	–	–
1673	150	xxx	x	–	x	–	–	4	1	1
1674	100	xxx	x	–	–	–	–	–	2	–
1674b	200	–	–	–	–	20	xxx	1	x	–
1675	200	xxx	x	–	1	–	–	1	1	1
1731	250	x	–	–	–	–	xxxx	–	–	–
x	1000	xxxx	xx	3	4	2	20	2	–	2

As well: in 1340 – **oat** (Avena sp.) 1 chaff; 516 – **peanut** (Arachis hypochaea) 2 podfragments
Legend: x = some, xx = some to many tens
xxx = some to many hundreds, xxxx = some to many thousands

Table 1. Shipwreck BZN4. Waddenzee, the Netherlands. Cultivated plants in the samples.

Figure 4 BZN4, various forms of coffee

a. Original form, flat side
b. Original form, convex side
c. parchment
d. epidermis

After the Arabs became acquainted with coffee, they took it across the Arabian peninsula. Especially in Yemen did the coffee (arabica) grow well. Coffee was traded from the port city of Mocha (Mokka). Around 1500 there were coffee houses all over the Arabian world. But the use of coffee also encountered opposition. After various developments, there is a first report from 1552 by a European on the drinking of coffee by the Turks.

Pieter van den Broecke had seen black beans in Mocha in 1616, from which 'black water' was made which was drunk hot (Godee Molsbergen 1939). In the 17th century coffee drinking became known in the western world, and the first European coffee house was opened c. 1645 in Venice. The first Northwest European coffee house was opened in The Hague around 1663, and subsequently coffee houses were started in many large cities. From the 18th century coffee was a much consumed stimulant, first as a luxury article, later by all strata of society.

From c. 1660 the Dutch East India Company (VOC) became interested in the coffee trade, but the trade was entirely in the hands of the Arabs. The Dutch broke this Arabian monopoly of the trade in and cultivation of coffee (*Coffea arabica*).

With some difficulties plants were obtained. When Johan van Hoorn, as director-general, consulted with Adriaan van Ommen, resident in Suratte (Southwest India) on the production of indigo, they were also negotiating coffee. In 1696 Van Ommen sent some coffee plants from Cananoor (Southwest India) to Batavia (modern Jakarta). Van Hoorn had them planted out, but they were washed away in the earthquake of 1699 and the associated floods. Zwaardecroon who was commissioner on the Malabar coast (Southwest India) brought coffee plants to Batavia again, and Van Hoorn had these planted out in his garden. The cultivation succeeded, and Van Hoorn gave some as a curiosity to some devotees, a.o. to Nicolaas Witsen in Amsterdam, though this was against the order of the Heeren XVII (the board of the VOC). One plant, having been sent on by Witsen, who was commander of the West India Company, became the ancestor of the coffee cultivation in Surinam.

From 1707, coffee plantations were established by the VOC in the mountain areas of Java and later Sri Lanka. Already in 1720 did the VOC bring many cargos of coffee to Europe (Amsterdam).

In the meantime, also the French had managed to get hold of some coffee plants, via Amsterdam (in 1714). They started cultivation on Martinique. Soon thereafter, coffee cultivation began in the Caribbean and Central and South America. In 1718 the first coffee plants were shipped to Surinam (Thorn 1999), and the first cargo of Surinam coffee was traded in the Netherlands in 1723. Around 1750 this coffee constituted already 50% of the market share in coffee in the Netherlands. Towards the middle of the 19th century, Indonesia, Sri Lanka and Brazil were the most prominent coffee producers. Other well-known producers were Cuba, Haiti, Santo Domingo (Dominican Republic) and the Congo. Because of the boom in the trade in coffee in the 18th century, coffee was soon also available to the less well-off (McCants 2008), especially in France (Montanari 1994). It became the symbol of the rationalism of that time, of its pursuit of clarity, shrewdness and freedom of thought. However, in the Netherlands and England tea had already mainly superseded coffee (Montanari 1994).

It was Linnaeus who first described the variety scientifically in 1753. After the discovery of the well-known coffee – *Coffea arabica* – various other wild coffee varieties were discovered in Africa. Certainly mentioned should be robusta coffee – *Coffea canephora* – (discovered in Gabon in 1897) and liberica coffee – *Coffea liberica* – (discovered in Liberia in 1876). These varieties were also cultivated.

Possible origins for the cargo of coffee of BZN 4 are Central America, northern South America and the Caribbean. This is based on the origin of the stave wood.

Other archaeological finds

Coffee is a rare find in archaeological investigations. Only a few reports are known to the authors. There is a find of *Coffea arabica* beans in a cannon on the seabed off Padstow in England. The bronze had ensured the good conservation of the seeds. The cannon is dated to the 17th century, the beans themselves have not been dated (Greig 1991). In Bremen (Germany) four coffee beans were discovered in the filling of a cesspit. The beans were not roasted, and are dated to the end of the 18th century (Rech 2000). In Amsterdam (Netherlands) coffee beans were also found in an 18th century cesspit (H. van Haaster pers. comm. 2007).

Fruit and seeds (beans) were common in a shipwreck at the bottom of the Red Sea (Sadana Island) in Egypt. The cargo is dated to c. 1765 (Ward 2001).

4.2 Cacao (Theobroma cacao *L.*) – fig. 5

Regularly but usually in very small quantities we found seeds of cacao among the coffee beans. From the stern, stray finds were made of 5 seeds and some fragments, and an iron concretion was found with about 10 seeds.

It is possible that these seeds have become dispersed in the wreck over the centuries. It is thought that the cacao possibly came along in (burlap?) sacks and was stored on the first (and lost) deck (Wennekes 1996).

The plant

Cacao is a tree that reaches a maximum height of c. 15 m but that on plantations is pruned and thus reaches only 6 m.

Figure 5 BZN4, cacao (find no. 516)

On the trunk large fruits grow which each contain 20-40 seeds (the cacao beans). The seeds are oblate spheres with a length of 16-22 mm, a width of 10-19 mm and a thickness of 3.5-10 mm. More than half the weight of these beans consists of a waxy solid (cacao butter). Apart from the raw material for our chocolate, cacao beans contain a.o. theobromine, which is toxic for small animals (insects).

The finds

The beans are oblate spheres and about 25 mm long, 15 mm wide and 10 mm thick. A seed consists of 2 cotyledons with lobes. Fragments of the contents were regularly found in the samples. The fragile beans were probably broken during the sampling and recent transport. The seed wall is thin, and impressions of veins are visible on its surface. Remarkable is that the contents of the seeds is still present. This was probably caused by the high fat content of the seeds. Dimensions (in mm) of (whole) cacao beans that could still be measured are:

28 × 17 × 10; 27 × 15 × 10; 26 × 14 × 8; 23 × 16 × 10; 23 × 15 × 11; 23 × 15 × 10; 23 × 14 × 11; 22 × 16 × 11; 22 × 15 × 11; 22 × 11 × 11; 18 × 12 × 9.

(highly) oblate seeds (length × width):

27 × 16; 24 × 14; 24 × 12; 23 × 13; 23 × 13; 22 × 14; 22 × 13; 20 × 12; 20 × 11; 19 × 14; 19 × 12.

The historical background

Originally the plant comes from the tropical rain forests of the Amazon and Orinoco Basins in South America. Very small quantities of theobromine in pots excavated in Belize (Central America) indicate that the Mayas possibly already drank cocoa in 600 BC (Hurst *et al*. 2002). During the Spanish conquest of Central America, it was noticed that the local people drank a liquid with cocoa. In 1528 Hernando Cortez brought the first cacao beans from Mexico to Spain. Early in the 17th century chocolate factories were started in Spain and the cocoa drink spread gradually over Europe. In the middle of the 17th century, there were coffee and chocolate houses in Holland where this drink could be bought. In the Netherlands cacao has been traded since the end of the 17th century (Wennekes 1996).

Cacao grows in tropical areas along the equator, especially along the African west coast. In the 1680s the Chartered Society of Surinam (Geoctroyeerde Societeit van Suriname) (founded in 1683 by the Dutch West India Company (WIC) together with the town of Amsterdam and the private investor Cornelis van Aerssen) had established, apart from sugar cane plantations, also cacao plantations in Surinam. In itself not a strange choice as the tropical jungles of the Guyanas were the cradle of *Theobroma cacao*. Incidentally, the cacao seeds planted in Surinam originated in the West Indian islands where cacao production had started earlier. In addition to chocolate drink (first medicinally against diarrhoea), chemists made cocoa butter from the cacao which helped against chilblain and chapped lips. Soap-boilers in their turn processed the cocoa butter into fine toilet soaps (Wennekes 1996). The Society controlled the trade in cacao well into the 18th century[4]. The plant was cultivated in Africa from the end of the 19th century.

Other archaeological finds

We do not know of any other finds of cacao in Europe.

4.3 *Sugar cane* (Saccharum officinarum *L.*) – figs. 6 and 7

The plant is a type of grass which grows to a height of several metres. The sugar is extracted from the juice in the culms. Cultivation is done on well-irrigated fields in tropical areas.

The finds

Sugar cane was present as culm fragments. These fragments measured 7, 12, 12, 16, 16, 25, and 28 cm. The diameter was c. 2.5 cm. There were joints (nodes) every 5-6 cm in the culm fragments.

A few times there were in the samples inconspicuous small flat plant fragments from a few millimetres to c. 2 cm in length. With a coarse-veined pattern, shiny surface and small white hairs at the 'base' of these fragments, they fully correspond with the side buds of modern culms of sugar cane.

During the investigation, sugar cane culms were discovered in a number of barrels; the ends of these culms protruded through a small hole in one of the heads (fig. 6), thus preventing gasification by heating in the cargo of coffee. The problem with transporting unroasted coffee beans is that they produce gases. When the beans are stored in barrels, these beans are protected against water (if they are good-quality barrels of course), but there is a risk that the barrels will explode when the pressure of the released gases becomes too great. An ingenious solution had been found for this problem. The barrels of the BZN 4-wreck apparently had specially prepared sugar cane culms, which protruded through the lid of the barrel and served as pressure-release valves. This way, no water could enter the barrel but the gasses could escape if the pressure became too high.

The historical background

Originally sugar cane came from New Guinea (Indonesia). The plant was possibly first used by man in Polynesia, from where it ended up in India.

Emperor Darius (of Persia) encountered sugar cane in 510 BC during his invasion of India. Already in 327 BC, Alexander the Great mentioned the cultivation of sugar cane in India. Via Persia and Egypt, the plant arrived in Sicily and

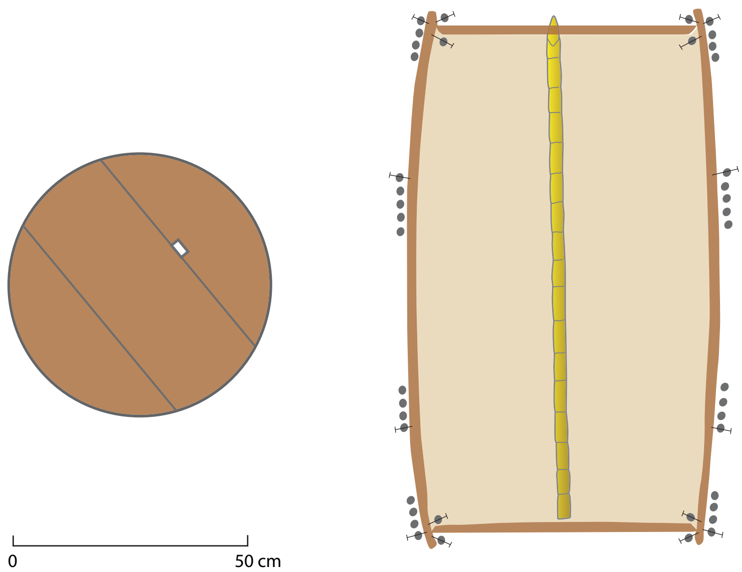

Figure 6 BZN4, reconstruction of a barrel with a culm of sugar cane

Figure 7 BZN4, sugar cane, fragment of stalk 24.5 cm (find no. 1028)

Spain. The substance at stake in the sugar cane – sugar – was first recorded in England in 1099. In 1492 Columbus brought sugar cane from the Canary Islands to Santo Domingo. In 1520 it was first cultivated in Mexico. It was gradually introduced into many areas and presently it grows in all tropical areas.

Other archaeobotanical finds
No other finds are known to us from Europe.

4.4 Peanut (Arachis hypogaea *L.*) – fig. 8

The plant
The peanut is a 30 cm high plant belonging to the Fabaceae family, and is an annual. After flowering, the stalk bends towards the ground and in the soil a pod with some seeds is formed.

The finds
We hesitate slightly to report the find of two fragments of a peanut shell (pod). Recent peanut shells are present at the bottom of the North Sea, and they are regularly washed ashore. We are possibly dealing here with a later contamination of the wreck, but it is also quite possible that this type was on board.

Only in a sample from a large barrel were 2 fragments of a pod found, which possibly came from one pod.

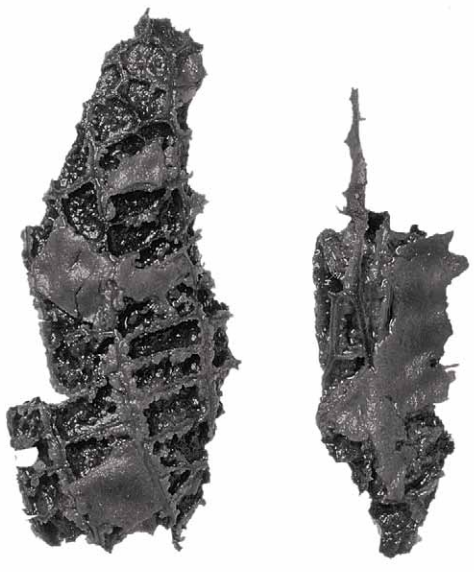

Figure 8 BZN4, peanut, two fragments of a pod (measurements left: 10 × 23 mm)

The historical background
Originally the peanut comes from Brazil. Around 800 BC the peanut was already known in Peru. The plant reached North America via Mexico and the West Indies. In the 16th century the Portuguese brought peanuts to West Africa. The Spanish were responsible for the distribution to the Far East. Nowadays the plant is cultivated in all tropical and subtropical countries.

Other archaeobotanical finds
We are not aware of any reports of archaeobotanical finds.

4.5 Buckwheat (Fagopyrum esculentum *Moench*), *Bean* (*Fabaceae, cf* Vicia faba), *and Oat* (Avena *sp.*)

From time to time the hard seed walls (chaff) of buckwheat were found. These pieces could originate from packing material or such like on board, as for instance in boxes with clay pipes. Or it might be waste from food preparation. We are probably not dealing with a stock of buckwheat but possibly with just ‘litter’ on board.

In the Middle Ages buckwheat was an important foodstuff for many people. It was cultivated in abundance in a.o. the Netherlands, and the ‘chaff’ had many uses (Kok and Kuijper 2001).

Some small fragments with a hilum are from a type of bean. We did not investigate whether there are (sub)tropical types of bean that correspond with our material, which looks very much like a broad bean (*Vicia faba*).

In one case (sample no. 1340), a fragment of oat chaff was found. It is not certain whether we are dealing here with cultivated oat.

4.6 Other finds of seeds
All remains in the samples have been collected. Among these are also some seeds and the like of plants that do not belong to the vessel. It concerns seeds which grow in saline conditions (6 species, such as *Zostera marina* and *Suaeda maritima*), in freshwater conditions (5 species, such as *Menyanthes trifoliata* and *Potamogeton* sp.), marsh and shore/bank species (12 species, such as *Schoenoplectus* sp. and *Sphagnum* sp.), as well as species from all kinds of damp and dry open terrains (19 species, such as *Chenopodium album* and *Rubus fruticosus*). By nature these are present in and at the bottom of the sea. These remains are washed into the wreck with the sand and silt, and thus say something about the environment in which the ship now lies. Many of the seeds we regard as recent or of insignificant age. The seeds of plants from saline coastal areas undoubtedly come from the edges of the Waddenzee. Other species will have been washed out of the peat layers that can be found in the subsoil of the Wadden area. This

applies in particular to the freshwater species and species from marshes, banks and damp terrains.

With this investigation we had hoped to find species that arrived with the coffee beans. But unfortunately no clear remains of wild plants were found from the source areas of the coffee or cacao.

5 Animal remains

This category can be subdivided into two parts. Firstly, the remains of animals that lived in the cargo or on board. In particular the group of 'insects' falls into this part. Except one, these remains (cocoons, beetles, wing cases, wings, etc.) have not been determined. Hence of most species we cannot say whether they indeed have anything to do with the ship. As with the plant remains, many insect remains can be found on the seabed and can have been washed into the wreck. An exception are the cockroaches which must have lived in the ship. Various parts of these animals were found in most samples. The egg cases (oothecae) were present in half of all samples. Usually there were a few specimens, but once there were 10 and once 20 specimens (per 0.5 litre).

The egg cases are about 8 mm long, 5.5 mm high and 5 mm thick, and have a characteristic shape (fig. 9). They consist of brown chitin, are hollow and have a sturdy thin wall. There is room for two rows of 8 eggs each. Some identified egg cases and fragments of adult animals appeared to come from the American cockroach (*Periplaneta americana*). Originally this animal probably came from Southwest Asia. Cold is lethal: after a few days with temperatures of 5˚C, they will die. And the temperature should not drop below c. 15°C for a continuous period of 6 weeks. In the old days, cockroaches could be found on ships in large numbers (Oudemans 1900).

In one of the pieces of stowing wood/firewood, a not further identified long-horned beetle was found (Luckers 2002).

Another indication of the presence of animals on board are the finds of hairs in the material. These hairs have not been identified, so both people, rats, cats and various pet animals qualify.

The second group concerns finds of animals that are known to live in the Waddenzee. The shells, bryozoans, hydroid polyps, fish and barnacles found had been living locally or in the direct vicinity. The shells derive from species such as mudsnail, common mussel, cockle, Baltic tellin, and periwinkle. They can date from various ages. It is a normal phenomenon that all these remains of the environment end up in wrecks or lived on them.

6 Discussion and conclusion

The Burgzand Noord 4 (BZN 4) wreck was once a large heavily-built seagoing vessel, which was wrecked on the

Figure 9 BZN4, egg cases of cockroaches (measurements lower left: 5.2 × 8.0 mm)

roadstead of Texel. Botanical analysis of wreck BZN 4 samples taken during an intrusive evaluating investigation in 2000 yielded interesting data on the cargo of a ship dating to the second half of the 18th century AD.

Analysis of the contents of various barrels showed that a large part of the cargo consisted of unroasted coffee beans. That the coffee was unroasted is standard practice. The coffee was often – and still is – roasted in the country of destination according to the traditions of taste prevailing there.

The second remarkable species on board was cacao. Several dozens of beans were found. It is not clear how these were transported, nor how much was on board. Sugar cane that was also found was used as pressure release valve in the barrels of coffee beans. Whether the find of a piece of pod from a peanut belongs to the wreck is not certain. Other plants (buckwheat, bean) probably are food remains of the crew.

The find of a cargo with coffee and cacao in an archaeological context is unique in the Netherlands and elsewhere. At the time, the value would have been high and the wrecking of the ship would have constituted a considerable financial loss to the shipowner. In 1730, a ‘pikoel’ of coffee cost 7 rijksdaalders (“coffee from own company land”). The coffee from Cheribon was 5 rijksdaalders, in 1735 increased to 6 rijksdaalders (Godee Molsbergen 1939). One pikoel (pikul = shoulder load, weight – ‘what one man can carry’) is about 62.5 kg (Teeuw 1990). The possible cargo of of 22,000 kg would then represent a value of 352×7 = 2464 rijksdaalders. When we compare this amount (6160 guilders) with for instance the earnings of the middle classes in the most important towns in Holland (about 250 – 300 guilders annually) (Van der Heijden and Schmidt 2007), then we are certainly dealing here with a valuable cargo.

On the basis of the coffee beans themselves, the origin cannot be determined. The wood of the barrels and stowing wood have a Central and South American origin. The marking ‘SD’ on one of the barrels could relate to Santo Domingo. It would appear that the area of origin is the Caribbean (including the northeastern part of South America). In the stern of the ship evidence was found for repairing the barrels on board with a.o. willow hoops which can but come from Northern Europe. The cargo was possibly destined for the market in Amsterdam, but the ship could have been in transit to another destination (in Europe).

The presence of cockroach remains indicates that these animals were on board in abundance. From historical sources we know that cockroaches could indeed be an infestation on ships. The many remains of cockroaches and cocoons of flies etc. would indicate that it was not very clean on board. The hygienic conditions were probably very bad.

Information on the name, the owner, the destination etc. of the ship have not yet been investigated in the archives and it is therefore not yet certain whether the wreck belonged to the West India Company. After the evaluation, the ship was covered *in situ* thus enabling further research in the future.

Acknowledgements

Assistance in the determination was given by J.F. Veldkamp (Leiden), the Nationaal Herbarium Nederland (sugar cane), and K. Huitema (Krimpen aan de IJssel)/Catz International b.v. Rotterdam (cacao). S. Langeveld (Lisse) and W.R.B. Heitmans (Amsterdam) helped us with the identification of the egg cases (cockroaches) which were regularly found in the material. K. Fennema translated the manuscript into English. We are very grateful to them all.

Notes

1. In this publication the Water barrel wreck still has the toponym Burgzand Noord V, which was later changed to BZN 4.

2. This is a very rough estimate.

3. In addition to *Plathymenia reticulata* which occurs further south, two European species were found. These were the hoops of willow (*Salix* sp.) and a loose piece of wood of birch (*Betula* sp., probably *pendula*) from the hold.

4. The Society of Surinam was dissolved in 1795, four years after the dissolution of the West India Company.

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Shipping pepper

Examining botanical contents of a 17th-century shipwreck at Texel Roads, the Netherlands

Cornelie Moolhuizen

*From 1999 onwards, the Dutch shipwreck 'Burgzand Noord 14' has been investigated several times. This merchant ship had sunken between 1675 and 1680 AD. During the investigations, samples for botanical research have been taken from a number of places within the vessel. The samples largely consisted of black pepper (*Piper nigrum*) corns, alongside remains of cereals, crop weeds and other seeds. The large amount of pepper had presumably been meant for trade. The same could not be concluded about the other products, which could have formed part of the crew's diet. The last origin and destination of the shipment and the vessel itself remain unclear.*

1 Introduction

On the Dutch sandbank called 'Burgzand', near the island Texel, the seventeenth-century shipwreck 'Burgzand Noord 14' (BZN 14) was found. During the archaeological investigations of this merchant vessel, the stern was sampled in order to perform archaeobotanical research. The results included, among other things, many black pepper corns (*Piper nigrum*), remains of cereals, other crops and crop weeds. These findings called for a number of questions considering the shipwreck and its contents.

The remains could have been either trade products or meant for consumption on board. One of the aims of the archaeobotanical investigation was an attempt to establish this. Were they once meant for trade at the ship's destination, or a small supply used in the galley?

The second aim was to assess the origins of the remains. Black pepper can not, like the ship, originate from the Netherlands. Therefore, it must have been imported. Where did it come from?

Finally, what can the results of this research contribute to the knowledge of the shipwreck itself? Is it possible to establish the origin or destination of the vessel, with the aid of botanical remains combined with what is already known about it?

To learn more about the products on board of the vessel and their possible purpose, it was necessary to more closely examine the background of seventeenth-century trade, navigation and the products themselves. Furthermore, an analysis of the geographical dispersal of the encountered crop weeds could be carried out.

Unlike black pepper, cereals can be from almost anywhere. The origins of cereals can sometimes be determined with help of the limited dispersal of certain crop weeds. When several weed species are found together, the overlap of their geographical ranges can be put to use, to establish a smaller area as the source of the crops. Previous research such as in the shipwreck Scheurrak SO1 (Manders 1993a), where the place of origin was limited to the Baltic area, has shown this possibility.

2 The shipwreck BZN 14

2.1 Research on Burgzand Noord 14

The vessel 'Burgzand Noord 14' owes its name to the sandbank 'Burgzand' that is located five or six kilometre to the east of Oudeschild, Texel (fig. 1). Many shipwrecks lie here, at the former 'Texel Road' (see chapter 3.1). Many of these ships are affected and eroded by the current conditions in the Waddenzee and therefore urgently need archaeological investigation (Vos 2003). The shipwreck was surveyed during the summer of 1999 by NISA (Netherlands Institute for Ship- and underwater Archaeology), and more thoroughly investigated in 2004. The investigations formed part of the extensive project '*Waardestellende verkenningen in de Waddenzee, Burgzand Noord*'.

2.2 The archaeological site

The site is approximately 50 meters long and 14 meters wide. The vessel itself measures 33,5 meters from stern to stem. As the wreck has collapsed, the maximum width, as measured at the stern, is 10,5 meters (fig. 2).
The shipwreck was covered with characteristic stones that were used as ballast ('*potters*'), which provided the ship with its nickname '*potterwrak*' among local divers. Many artefacts were found at the shipwreck (Overmeer 2004; NISA A 1999).

2.3 Age and origin of the vessel

The ship was dated by means of dendrochronology, ceramics and numismatics, which showed the ship originated from 1675-1680 AD (Vlierman 1999; NISA: B 2004; Kleij 2004; Hanraets 2004). The dendrochronological examination also demonstrated the ship's Dutch origins.

Figure 1 Location of shipwreck BZN 14

2.4 *Archaeobotanical samples*

At the stern, several fragile-looking wooden barrels were noticed. Three samples for botanical research were taken during the investigations in 1999. These were analysed by W. Kuijper (2000). In 2004 ten samples were taken from five barrels (barrels B, C, E, F and G) and three additional samples were taken from the stern.

3 Trade and navigation in the 17th century

3.1 *Texel Road*

In 1602 the VOC (Dutch East India Company) was founded. Amsterdam became a trade centre for products from the Eastern Indies, the Western Indies and the Baltic area. Merchandise such as spices and chinaware was imported and resold.

The waters before Amsterdam (Pampus) were too shallow to allow large trade vessels to enter. Products from abroad were therefore transhipped to smaller vessels at the island of Texel, which transported the goods to Amsterdam. Not only did this method make the local economy on the island flourish during the seventeenth and eighteenth century; it also became responsible for the large amount of shipwrecks in this specific area. The ships, often loaded with cargo, would be awaiting favourable wind to sail off. However, a rising storm would sometimes cause the waiting vessels to founder (Manders 1993b; Reinders 1992; Schaik 2002; pers. comm. M. Manders 2006). This combined with the fine sediments of the Waddenzee caused the bottom of Burgzand to become covered with still preserved shipwrecks (Manders 1992).

3.2 *East Indiaman*

The vessels used by the VOC during the height of their trade journeys, would usually be of the type East Indiaman (in Dutch *spiegelretourschip*), fluyt, frigate, galiot, '*hoeker*' or pinnace (Haalmeijer and Vuik 2002). The East Indiaman was mostly used for trade expeditions to Asia. An example is the Batavia, that was rebuilt in the 1980's (fig. 3). These three-masters were 40 meters long.

In the bottom the hold could be found (1), where an extra deck (2) could be added. Only 1,5 meter above the extra deck the gun deck (3) would be situated. This was where the galley and bottling room were situated, usually near the prow at the front (Haalmeijer and Vuik 2002). It was the crew's main abode, and furthermore the heavy artillery was located here (VOC-Kenniscentrum).

3.3 *Daily life on board*

It would take an East Indiaman approximately seven months to reach the far east. Daily life on board usually brought poor conditions for the crew. The quality of food declined rapidly, their diet showed little variation, consisting of rye bread, buckwheat porridge, beans and salted meat. Scurvy often occurred before the Cape of Good Hope was reached (Blussé & Ooms 2002; Magelhaes 1998). Cases of beriberi, caused by a diet of mainly white rice, also arose (Kalkman 2003). Out of almost one million Europeans who sailed to the East Indies, less than four hundred thousand returned. Some of them had settled in Asia, but the majority died during their service (VOC-kenniscentrum).

4 Botanical remains of the shipment

4.1 *Treatment of the samples*

Six samples for botanical investigation were taken from four barrels, four samples from under or near a barrel and three more from elsewhere in the stern (table 1). The samples were sieved with water, using four different mesh openings: 5mm, 2,5 mm, 1 mm and 0,5 mm. The botanical remains were identified with a magnification of 6-50 times. The cereal

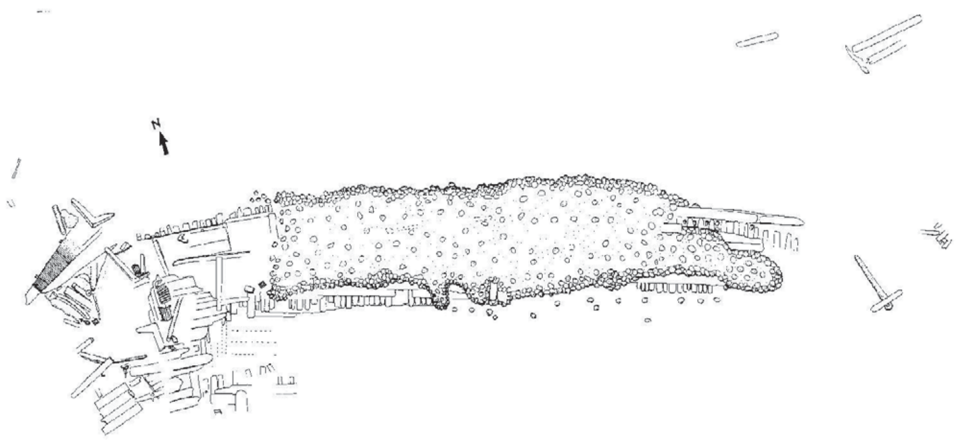

Figure 2 Shipwreck BZN 14, approximately 40 m. long. On the left: the stern. (drawing provided by NISA).

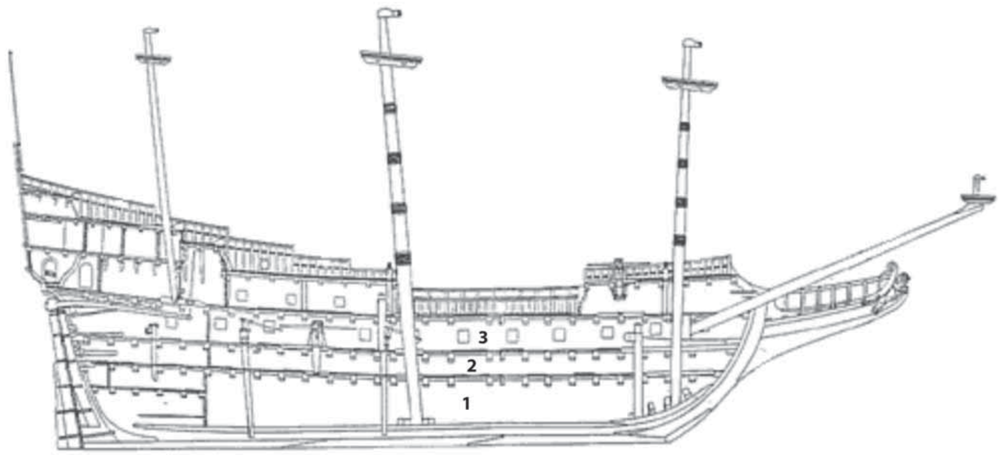

Figure 3 Example of merchant ship (after www.voc-kenniscentrum.nl)

Barrel	Sample	Positie	Main contents
B	PW-466	In barrel B	Gunpowder? Rust?
	PW-327	In barrel B	Cereals, weeds
C	PW-328	On barrel C	Black pepper
E	PW-535	Near barrel E	Black pepper
	PW-543	In barrel E	Cereals, weeds
	PW-546	Under barrel E	Black pepper
F	PW-544	In barrel F	Beans or peas
	PW-604	In barrel F	Beans or peas
G	PW-541	In barrel G	Wicker with ground cereals
	PW-545	Near barrel G	Beans or peas
No barrel	PW-309	Staves at stern	Black pepper, beans?
	PW-495	Put alongside north deck	Wicker with ground cereals
	PW-496	Put alongside north deck	Fish bones, cereals, black pepper

Table 1 Context of samples BZN 14

remains were examined more closely with a light microscope. The contents were thousands of black pepper corns, tens of thousands of cereal remains with many crop weeds, buckwheat, a dense substance consisting of legumes, and small quantities of rice and cucumber (table 2).

4.2 *Products and their background*

4.2.1 *Black pepper* (Piper nigrum)

Out of thirteen samples, eleven contained remains of black pepper. It mostly concerned large quantities, up to several hundreds or even thousands of corns per sample, with remarkable preservation (fig. 4). Small stalks with unripe berries of pepper were also present (fig. 5).The total amount of pepper corns from the samples lies somewhere around 6000.

Black pepper is a tropical climber requiring shade, high humidity and high temperatures. The berries are green when unripe, then turn red. They are harvested in different stages and processed accordingly. The unripe berry is salted or pickled to preserve its color, resulting in green pepper. Black pepper is obtained by drying and smoking the reddening berries, and white pepper by removing the mesocarp of fully ripened berries. The latter was the most expensive because it was the most labour-intensive, which is why trading companies focused on black pepper (Küster 1987; Ravindran 2000; VOC-kenniscentrum).

Pepper is rare in archaeological finds, due to its high value. Black pepper was expensive but popular in the Roman

Type	pw-309	pw-327	pw-328	pw-466	pw-494	pw496	pw-535	pw541	pw-543	pw-544	pw-545	pw-546	pw-604
Piper nigrum (corns)	6		xx	9	350	300	2000		1	300	xx	xx	100
Piper nigrum (stalks)			x		7	several	several				several	x	
Cerealia		xxx	x		8	800	200	xxx	xxxx	5	xx	1000	xx
Vicia faba/Pisum sativum	?					4	1			xxx	xxx	7	xxx
Oryza sativa			1				2					3	
Cucumis sativus												1	
Fagopyrum esculentum										1			
Weeds													
Cannabis sativa												1	
Fallopia concolvulus		several						1	58	1		1	
Brassica spec.							2						
Sinapis arvensis		several							15	7	5		
Brassica nigra					1	6				3	8		6
Brassica rapa			1			1							
Agrostemma githago		several			7	2	1	5	50		1	1	1
Centaurea cyanus		3				1	1	2	2			3	7
Galium aparine		x							77				
Galium spurium									6				
Persicaria lapathifolia		1							3				
Polygonum aviculare									1	1			4
Galeopsis bifida/ speciosa/tetrahit									4				
Vicia hirsuta									1				
Raphanus raphanistrum		4					1		30			1	1
R. raphanistrum (pod)		2							11	1	1		2
Anthemis arvensis										4			4
Anthemis tinctoria													1
Neslia paniculata									1				
Rinanthus spec.						13	9				9	10	
Ranunculus repens							1						
Rumex spec.						1							
Rumex acetosella										1			
Carex spec.						1							
Erica tetralix						3					4		
Bidens tripartita										1			
Silene spec.										2			
Stellaria media										1		4	
Atriplex spec.												4	
Chenopodium album										8			
Convolvulus arvensis												1	

Type	pw-309	pw-327	pw-328	pw-466	pw-494	pw496	pw-535	pw541	pw-543	pw-544	pw-545	pw-546	pw-604
Knautia arvensis													1
Linum usitatissum							1						
Lapsana communis										1			
Setaria spec.										1			
Coarse chaff											1		1
Apiaceae							2						
Bud							1						
Calluna vulgaris													several
Mentha/Origanum spec.					1								
Indeterminatae							1						
Marine etc.													
Zostera marina												4	
Potamogeton												4	
Sphagnum												4	
Other, not botanical													
Wicker					1			1					
Fishbones							several					x	
Mussels, cockles							several						
Gunpowder				1									
Small ‘net’’, 6mm			1										

x = tens
xx = hundreds
xxx = thousands
xxxx = tens of thousands

NB. Numbers of cereals or beans are difficult to estimate in samples with large quantities of the material. They form the larger part of samples with a content of approximately 1500 cc.
Mere presence of gunpowder and wicker is also indicated with ‘1’.

Table 2 Contents of samples from BZN 14

Age. It was only for the very rich during the Dark Ages. Its purpose was to disguise the smell of meat gone bad.

The Malabar coast (south-western India) has the longest tradition in cultivating black pepper. It was imported via the same route since 400 BC until the late Dark Ages. Alexandria, Rome and later on Venice and Genua played a mayor part in trading pepper. The high prices led to the introduction of illegal substitutes such as grains of paradise (*Aframomum melegueta*), grains of selim (*Xylopia aethiopica*), cubeb pepper (*Piper cubeba*) and hot bell pepper (*Capsicum annuum*). These spices often became permitted alternatives (Hellwig 1992; Küster 1987; Ravindran 2000; website uni-graz.at).

Pepper traders who took the traditional route made profits up to 1000 percent. In European countries the idea sprung to life to eliminate the intermediary and take advantage of the profit. After the Portuguese success stories of Vasco da Gama in Calicut (the Malabar coast), companies as the British East India Company and the Dutch VOC were eventually founded (Magelhães 1998). But is was only from the nineteenth century onwards black pepper came within everyone’s reach (Küster 1987).

4.2.2 Cereal crops (except rice) and their crop weeds

Cereals were found in nine samples. Only the husks of the uncharred and waterlogged grains had been preserved. In one sample the cereal remains were ground, and found attached to large fragments of wicker. The husk of a cereal’s caryopsis consists of several layers, one of which can help to establish the species of grain. In order to do so, the hilum and cell structure are examined (Körber-Grohne 1991; Körber-Grohne & Piening 1980). However this layer was often absent. Two

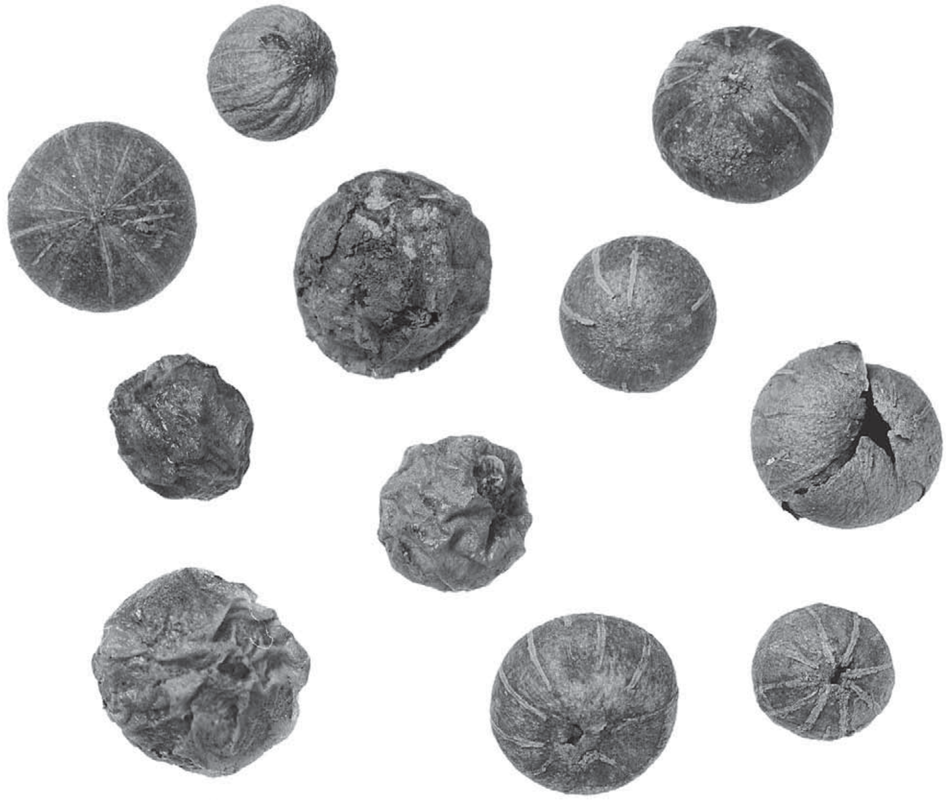

Figure 4 Pepper corns from BZN 14 (photo J. Pauptit)

species could be distinguished with this method. The first was rye (*Secale cereale*), a cereal that was common and regularly eaten in the seventeenth century. The second was rye brome (*Bromus secalinus*). This is not really a cereal, but a crop weed. It is often tolerated because of its likeliness to cereals (pers. comm. W. Kuijper 2006).

Although cereals are grown all over the world, it is possible to identify the place of origin. This can be done by examining the available crop weeds connected with the grain. To establish the origin of the crops, the limited dispersal of crop weeds may be used. Manders (1993a) used this approach for his research on the shipwreck Scheurrak SO1, to conclude its cargo came from the Baltic area. The closed context of a shipwreck is especially suitable for conducting this type of research. Crop and crop weeds are most likely in situ and connected.

In the samples from BZN 14 containing cereals various weed species were found. Many of these are very common and occur globally. There were however several exceptions. Yellow chamomille (*Anthemis tinctoria*) is rare in Western Europe and Asia. False cleavers (*Galium spurium*) does not grow in Spain and Britain. Wild radish (*Raphanus raphanistrum*) is restricted to Europe and cornflower (*Centaurea cyanus*) is rare in Spain, the Near East and Asia. Also rye brome grows within a restricted area, north of Spain and east of Ireland (Kästner, Jäger and Schubert 2001). Nevertheless, unlike the case of Manders's study, the dispersal of these weed species can not point out one specific area in Europe where the cereals were cultivated.

4.2.3 Other crops

Buckwheat (*Fagopyrum esculentum*) was found once, in sample PW-545. Buckwheat is not botanically speaking a cereal (belonging to the Polygonaceae instead of Poaceae), but it had a similar position in a common man's diet during the 17th century. The presence of only one buckwheat seed in the samples could indicate this was brought in accidentally, but it could be a matter of representativeness as well. As the samples were just taken from the stern, more buckwheat might have been present elsewhere in the shipwreck. The crew on ships were often served buckwheat porridge (VOC-kenniscentrum).

A dense substance from samples PW544, PW545 and PW604 was recognized by means of many hilums. The

Figure 5 Stalk of pepper from BZN 14 (drawing M. Oberendorff)

substance appeared to consist of legumes like peas (*Pisum sativum*) or beans (*Vicia faba*). These species are usually preserved through carbonization in archaeological samples, which makes this find quite rare. Just hilums are not enough to distinguish exactly what species is present here. Both peas and beans have played an important role in the European food supply for many centuries. Just like buckwheat, they could be on the daily menu during long travels by ship up to the eighteenth century (Körber-Grohne 1987).

Somewhat more special were the finds of cucumber (*Cucumis sativus*) in sample PW-546 and rice (O*ryza sativa*) in PW-328, PW-535 and PW-546. Cucumber can be transported fresh or pickled. Pickles could be stored longer (Kalkman 2003; pers. comm. C.C. Bakels 2006). Cucumber has been cultivated in India for 3000 years. Although it was grown in the Netherlands in the seventeenth century, fresh cucumbers can hardly be expected to be taken in for travels to the East Indies (Dodoens 1554; pers. comm. C.C. Bakels 2006).

Rice was grown in Asia, but it was not exported to Europe on a large scale. The very rich in the Netherlands would eat it (Haaster and Cavallo 1997), but it was mainly used for trading within Asia and as a food supply on trading posts or ships (VOC-Kenniscentrum). The brans of rice contain thiamin or vitamin B1, which helps to prevent beriberi. This tropical disease occurred where people mainly consumed white rice (Kalkman 2003).

5 Discussion and Conclusions

Black pepper on board of a seventeenth-century ship was not always meant for trade. A small can of pepper in the galley could serve the meals of the (important members of the) crew. In this case however, this is not the most probable option for three reasons. Firstly, the galley of a 17th-century ship that would sail for the East Indies was often situated below deck, near the front of the vessel. This was the case in the East Indiaman as well as frigates, galiots and '*hoekers*' (Haalmeijer and Vuik 2002). However the botanical samples were taken from the stern of the ship. Although food supplies for the crew could be stored in the stern, pepper is only used for seasoning. It may very well be worth the trouble to store larger quantities of food elsewhere, but walking up and down the hold for a small can of spices would not be so. Secondly, the amount of retrieved pepper, which is still less than the amount that could be on board in all at the time of recovery, is larger than what one could hope to consume during one journey. Finally, the ship was found at the location where merchandise was usually loaded and unloaded. These reasons make it plausible that the pepper was meant for trade, not primarily for own use during travels.

The grain on board of the ship could partly be identified. It consisted of rye and rye brome, the latter of which can easily be taken for cereals. Cereals on a ship could either be meant for trade or as nourishment for the crew. Amsterdam was a distribution centre for all sorts of products in the 17th century, and grain was one of them. For the greater part this came from the Baltic region, the European 'granary' of that time.

With the help of the distribution of crop weeds, it can be possible to establish the region of origin of cereals. By determining the overlap of their range, one smaller area where all species occur remains. Crop weeds that might limit the possible places of origin are *Galium spurium, Centaurea cyanus, Anthemis tinctoria, Raphanus raphanistrum* and *Bromus secalinus*. Unfortunately, these species do not exclude enough places to identify one specific region, such as the

Baltic. Excluded areas are Asia, the Near East, Spain, Britain and Ireland. The rest of Europe is a possible place of origin, however a smaller, more specific area can not be pointed out.

A trade expedition is not a small undertaking, and requires well organized logistics. A great deal more rye than a crew could consume, would have to be taken on for a profitable trade in cereals. For someone to export both pepper and rye on the same ship is not inconceivable yet refutable.

This does not explain the presence of rice and cucumber on the ship. Rice was mainly eaten on the trading posts in the East Indies and on board of the merchant vessels. More wealthy people would consume rice in the Netherlands, but there was no vast import and trade of this product during the 17th century. Cucumber as a product was mostly imported. The cucumbers cultivated in the Netherlands were not likely to be found on board of a merchant ship.

Both rice and cucumber were found in very small quantities on the ship: six grains of rice and one seed of cucumber. This is off course not the whole shipment, but in comparison with the rest of the finds it is a relatively small amount. When the preserved grains form an exception to a shipment of threshed rice, this might have been taken on for consumption on board. This would be less plausible with a shipment of rice with the chaff still attached. Rice and pickled cucumber could be preserved for a long period of time and were possibly suitable for further trade after their journey from the East Indies.

The destination of the Burgzand Noord 14 can not be established with certainty with the help of botanical remains only. It is certain that the amount of pepper on board was substantial. Several products of exotic origins were present on the vessel, which forms a contrast with the more mundane shipment such as rye, buckwheat and horse beans or peas.

When the cargo of a shipwreck can be established, its goal can still be debated. Geographical analyses can be useful in establishing the origins of the cargo and thereby the ship's last point of departure. Without further knowledge of the vessel, information can be obtained through archaeobotanical studies. However, the combination of these data and their context are still the most valuable.

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